"Restoration project: How the creation of biological corridors could affect the presence of butterflies and environmental variables"

St. Luke's College HSM, Loma Verde , Escobar , Buenos Aires , Argentina

Senior 4 students

Aquilini, Camila; Andreola, Agustina; Arenaza, Sofia;

Herdegen, Santiago and Vergara, Avril.

Teacher: Maria Marta Gutierrez

Date: 03/04/2024

ABSTRACT

The original aim of this study was to understand the relationship between some environmental variables and the presence of butterflies in our school grounds. Observations started in September 2022 and three months later a biological corridor was created by using the "stop mowing" method in the border of the athletics field. In March 2023, the aim was expanded into how the creation of biological corridors could affect the presence of butterflies and some environmental variables. The area was divided in quadrants (1m x 1m) in order to follow changes in land cover and richness of species. A database was created and all observations and measurements were included there. Environmental variables (clouds, land cover, air and surface temperature) were measured following GLOBE'S protocols in the biological corridor and compared with those in a "mowed" area called "Control". Butterflies were monitored and sightings were recorded. In June 2023 we decided it would be beneficial to share the investigation through social media, and so the findings were documented through an account on the platform Instagram. The posts consisted of pictures of butterfly sightings, pictures of the changes in the biological corridor, and other details about the investigation. All posts were kept light-hearted and not extremely scientific as a way to engage people and educate more on the importance of grassland restoration and preservation. You can find this account by searching for The Butterfly Project HSM or clicking here. In October 2023 the biological corridor was properly signalized for environmental education purposes. In December 2023 results were analysed: 42 plant species were registered, 26 of them native. 100 butterfly sightings were recorded, through which 11 species have been identified. Air temperature and surface temperature were always different in the biological corridor and the control. Surface temperature was found to have more visible differences between the biological corridor and the control. The increasing butterfly frequency was related to the increase in plant richness. However, this was not the only factor that affected the presence of butterflies. It was also found that the air and surface temperature were closely related to the amount of sightings. Higher temperatures led to more sightings of butterflies. As a conclusion, biological corridors could be a viable solution to tackle some climate change effects, with low cost and overwhelming benefits.

KEYWORDS: Restoration. Biological corridor. Biodiversity. Butterflies. Environmental variables. Climate change.

RESEARCH QUESTIONS

1. How can the creation of biological corridors change the frequency of occurrence for butterflies?

2. How plant species richness could be modified by implementing the "not mowing" method?

3. How could environmental variables change with this type of restoration?

HYPOTHESIS

"The creation of a biological corridor will increase the frequency of occurrence for butterflies as host plant richness and plant cover will be increased by the stop mowing method."

OBJECTIVES

Main objective:

- Restore a grassland area by creating a biological corridor via the "Stop mowing method" and study the changes in biodiversity and other environmental variables.
- Investigate the relationship between the presence of Lepidoptera species with air temperature, surface temperature, cloud cover and the identification of associated flora.
- Collaborate with the knowledge and preservation of native species.

Specific objectives:

- Record and photograph sightings of Lepidoptera and their associated flora.
- Identify species in the biological corridor.
- Measure and record air temperature, surface temperature, cloud cover, trees and plant cover using GLOBE protocols.

INTRODUCTION

"Climate change is affecting ecosystems on all scales from individual genotypes to entire communities…Lepidoptera have proved useful in monitoring ecological and evolutionary responses to climate"(Hill.et al. 2021).

This investigation took place in St. Lukes College HSM, located in Loma Verde, Escobar, Buenos Aires, Argentina from September 2022 to December 2023. (Image 1 and 2)

Image 1 - Argentina, Buenos Aires | src: google earth (Airbus satellite)

Image N°2 - St Luke's college (Left) - Biological corridor (Right) | src: Google earth (Airbus satellite)

Our school is located in "Pampa ecoregion" *(Burkart et al., 1999)* and natural vegetation (grassland) was removed in 2010 in order to build the school campus. Nowadays the land cover could be considered as MUC 821 (Parks and athletic fields). The school campus has almost 5 hectares and the grass is kept short to facilitate daily activities.

In May 2022 we carried out a Biology project called "Pollinators in Escobar", which included bibliographic research and a poster exhibition in order to learn about local pollinators and associated plants. (Image 3)

Image N° 3 - "Pollinators in Escobar" project

After that project, the idea of studying and monitoring butterflies came to our minds. Curiosity and initial questions appeared: "Where were they?"..."When did they appear?"..."Which species?..." "Was their presence or absence related to environmental variables?". The need to find answers arose and we decided to start researching.

In September 2022, the butterflies that appeared in our school garden and some environmental variables at the time of sighting began to be recorded. After three months, we realized that butterflies appeared almost exclusively near a ditch that can be found at the back of the school yard. We hypothesised that this was because native plants inside the ditch were able to grow free of mowing. (Image 4)

Image N°4 - Students working near the ditch

We decided to start a "Restoration project", creating a biological corridor near the ditch by the "stop mowing" method and letting plants spread from the ditch into our yard free of interference.

In December 2022, the school authorities were asked for permission to stop cutting the grass in a sector parallel to the ditch in order to allow original vegetation to be restored.

In March 2023 we started monitoring butterflies and recording variables inside the biological corridor (land cover, air temperature, surface temperature, clouds and trees using the GLOBE Observer App) in order to study the progress and restoration of the area (Image 2).

Restoration of native vegetation in urban areas is not yet a frequent practice in our country. Although there are "intentions", there are no systematic studies with published data or results. There is a local project called "Biocorredores urbanos de la fragmentación a la bio conectividad" but no results have been published yet (https://www.escobar.gob.ar/biocorredores/). Also the University of Buenos Aires has started, in September 2023, a biological corridor in their Agronomy school (Rosende, 2023) in order to attract pollinators, but no scientific results have been published.

As new urbanizations have impacted original ecosystems and have produced great loss of biodiversity it is essential to find new ways of restoration.

"In many ways, known and unknown, climate change will affect species distributions, life cycles, phenologies, and ultimately survival. Lepidoptera are among organisms that have been shown to be strongly impacted by climate change and their conservation presents challenges that are both unique and unprecedented " (Caldas, 2014).

When this investigation started the aim was to understand whether or not some environmental variables affect the presence of butterflies, but as time passed we realized that we could contribute to tackle some climate change effects in our local ecosystem with simple and affordable actions: "Stop mowing" and implementing closures to develop biological corridors.

METHODOLOGY

Study Site:

St. Luke's College HSM is located in Loma Verde, Escobar, Buenos Aires, Argentina (Images 1 and 2).

Latitude : 34° 34' 44" S Longitude: 58° 84' 84" W Altitude:15 m.s.m

Climatic conditions:

In Belén de Escobar, the summers are warm, humid, wet, and mostly clear and the winters are cold and partly cloudy. Over the course of the year, the temperature typically varies from 5.6°C to 30°C and is rarely below -1.1°C or above 34.4°C.

Materials:

- GLOBE Sampling Site Sheet.
- Integrated Atmosphere Data Sheets.
- GLOBE Land Cover Data Sheets.
- Metric flexible tape for measurements of circumference (trees).
- Mobile phones with Globe observer app.
- Excel data sheet specifically designed for the project in order to create our own database.
- GLOBE Butterflies Fact Sheet. The associated flora will be recorded in "Observations" and photographs will be taken of the same Keys/applications to identify butterflies and local plants.
- Cloud chart.
- MUC Guide.
- Calibrated thermometer.
- GPS.
- Field notebook.
- Devices to upload data to GLOBE Observer, Inaturalist, Google Lens and the GLOBE website.
- Airbus satellite images from Google Earth.

Method:

From September 2022 to November 2022, we started training ourselves in using GLOBE Clouds and air temperature protocols. We went to the field at noon, measured those variables and spent 15-20 minutes observing, in silence, and took preliminary notes. We didn't have enough data to produce a complete report so we decided to organize the findings that were available and restart the investigation in 2023. However it was an extremely useful experience to provide training and kick start our 2023 investigation (Image 5).

Image N°5 - Students taking observations (2022)

In December 2022, school authorities accepted the idea of our "Restoration project" and creation of a biological corridor. They told gardeners not to mow an area of 1m wide, next to the ditch, along the athletics field.

In March 2023 we started studying the biological corridor in a systematic way and improved the closure using marking tapes. We delimited a wider area (4m x 30m) in the east corner and determined quadrants (1m x 1m) in order to study changes and progression in land cover and biodiversity (Image 6 and 7).

Image N°6 | 4 x 30 sector from the biological corridor on the 24th of April.

Image N°7 | 4 x 30 sector from the biological corridor on the 19th of May.

During April (14/04/2023), a "Control quadrant" was determined as a control sample in the middle of the field, where the grass was still mowed. Since the creation of this control quadrant, cloud cover and air/surface temperature have been measured in that area (Image 8). This control helped us see the differences between atmospheric variables and land cover (Image 9).

Image N°8 | Agustina Andreola and study partner measuring variables and land cover for the "control" (23/05/2023).

Image N°9 | 1 x 1 quadrant in the biological corridor (23/05/2023).

All senior 3 students were assigned pairs to closely report on two or more quadrants. We visited the biological corridor every 14 days, but sometimes we could not follow this sampling frequency due to other school duties and projects that were included in our school program. Butterflies were followed at a distance of 0–5 m. Each individual was followed for 5 min, or until lost from sight.

From April 2023, all data obtained in the field was written down and in June a file named restoration report (Image 10) was developed in order to standardise our field notes. The data was transferred into excel sheets to form a general database of everything recorded in the school and thus be able to use it when necessary. Our classmate, Pilar Bartrons, took the time to upload the findings into the document and organise them in an excel file (Image 11).

Name:..... Classmate:.....
Date:..... Latitud : ..... Longitud :.....

Quadrant N°	Land cover GLOBE App YES /NO	Estimated Land Cover (%) Total :100%	Quadrant photo (labelled before inserting here)	Plant Species present	Height (cm)	Temp (°C)	Labelled Photos of plants species (date / QN°/ Species)	Butterflies Seen (described) Photos (Labelled)	Other organisms Arthropoda Birds Mammals Mollusca others
>	Used:.... Sent:....	Grass:.... Other herbs:.... Bare soil:.... Fallen leaves:.... Shrubs:.... Climbers:.... Trees:....		Total Number:.... Names:	Min:.... Max:....	Soil:.... Air		Seen:..... Number ..... Photos:.....	

Image N°10 | File: Restoration report

05/05	Temperatura del aire desde el centro del 4x30:	First take	Second take	Third take	Minimum	Maximum	Temperature
		19.5°C	19°C	19.5°C	19°C	19.5°C	19.5°C
	Temperatura del aire desde el centro del 30x30:	First take	Second take	Third take	Minimum	Maximum	Temperature
		20°C	19.5°C	20°C	19.5°C	20°C	20°C

Image N°11: Screenshot of part of original database | Created by Pilar Bartrons

Click here to access the database

In June 2023, we created our own database in order to improve and organise Pilar Bartrons's database (Image 11). We joined earlier data from Pilar's excel and our new data into a wider file (Image 12).

	23/6							
	QUADRANT A	QUADRANT B	QUADRANT C	QUADRANT D	QUADRANT E	QUADRANT F	QUADRANT G	QUADRANT H (middle of the field)
LENGHT	-58. 8472	-58. 8515	-58. 8469	-58. 8484	-58. 8468	-58. 8485	-58. 8482	-58. 8475
LATITUDE	-34. 3446	-34. 3438	-34. 3449	-34. 3444	-34. 3455	-34. 3454	-34. 3446	-34. 3453
AIR TEMPERATURE	10ºc	10ºc	10º	10º	10º	10º	9.7º	9.6º
GROUND TEMPERATURE	8.9º	8.5º	7.8º	8.4º	8.1º	8.3º	7.5º	9.8º

Image N°12: Screenshot from a part of the database: Atmospheric variables | Created by Avril Vergara

Click here to access the database

Additionally, our class was divided into different study groups to deepen some specific topics. This group made the decision to redetermine 8 quadrants (which we named A - H) in different parts of the field, in order to take samples of different areas in detail (Image 13).

Image N°13 - Areas of Sampling Quadrants A - G in Biological Corridor
Quadrant H: Control Area. | src: Google earth (Airbus satellite)

Rainfall data was obtained from nearby weather stations because the school's weather booth had been misconfigured.

GLOBE protocols used:

Atmosphere:

Clouds

Our training in cloud observation began in September 2022 (Image 5) according to the GLOBE Protocol and uploading the data to the Globe Observer App (Image 14). Since March 2023, cloud observations have been carried out in all field samplings.

Solar Measured At:	2023-04-21T10:32:00	**Measured Date:**	2023-04-21
Cloud Cover:	broken	**Organization Name:**	Argentina Citizen Science
Altostratus:	true	**Site ID:**	310231
Cirrocumulus:	true	**Site Name:**	21HUB300980
Stratus:	true	**Latitude:**	-34.345386
Cloud Cover High:	isolated	**Longitude:**	-58.848263
Cloud Cover Mid:	scattered	**Elevation:**	16.7m
Cloud Cover Low:	scattered	**Measured At:**	2023-04-21T14:26:00
Opacity High:	translucent	**Solar Measured At:**	2023-04-21T10:32:00
Opacity Mid:	translucent	**Cloud Cover:**	broken
Opacity Low:	opaque	**Altostratus:**	true
Non-Spreading Contrails:	1	**Cirrocumulus:**	true
Dry Ground:	true	**Stratus:**	true
Leaves on Trees:	true	**Cloud Cover High:**	isolated
Data Source:	GLOBE Observer App	**Cloud Cover Mid:**	scattered
		Cloud Cover Low:	scattered

Image N° 14 - Cloud observations (2023) | src: Globe observer

Air Temperature

Temperature has been taken since September 2022 with a previously calibrated alcohol thermometer, it was recorded in forms and uploaded into GLOBE webpage (Image 15).

Air Temperature		**Air Temperature**	
Measured Date:	2023-04-14	**Measured Date:**	2023-11-10
Organization Name:	St. Luke's College-Haras Santa María	**Organization Name:**	St. Luke's College-Haras Santa María
Site ID:	333495	**Site ID:**	333495
Site Name:	Biological Corridor, Quadrant 4	**Site Name:**	Biological Corridor, Quadrant 4
Latitude:	-34.3444	**Latitude:**	-34.3444
Longitude:	-58.8484	**Longitude:**	-58.8484
Elevation:	16.6m	**Elevation:**	16.6m
Measured At:	2023-04-14T15:00:00	**Measured At:**	2023-11-10T15:00:00
Solar Measured At:	2023-04-14T11:04:00	**Solar Measured At:**	2023-11-10T11:22:00
Daily Average Temperature:	18.7 °C	**Daily Average Temperature:**	17.4 °C
		GLOBE Teams:	LAC2023

Image N° 15 - Air temperature protocol (2023) | src: Globe observer

Surface temperature

In May 2023 measurements of surface temperature were added in order to see if it influenced the appearance of species. We used a hand-held Infrared Thermometer (IRT) (Image 16). Data was uploaded to the GLOBE website (Image 17) except for three measurements (Image 18) that couldn't be uploaded into the GLOBE Observer App nor into the website due to a system error.

Image N°16 | Students measuring surface temperature using a handheld infrared thermometer

Surface Temperature	
Measured Date:	2023-11-10
Organization Name:	St. Luke's College-Haras Santa Maria
Site ID:	333495
Site Name:	Biological Corridor, Quadrant 4
Latitude:	-34.3444
Longitude:	-58.8484
Elevation:	16.6m
Measured At:	2023-11-10T15:00:00
Solar Measured At:	2023-11-10T11:22:00
Solar Noon At:	2023-11-10T15:39:00
Average Surface Temperature:	15.3 °C
Number Of Samples Taken:	1
Surface Condition:	dry
Surface Cover Type:	tall grass
Homogeneous Site Short Length:	30 mm
Homogeneous Site Long Length:	30 mm
Site Area:	900 m²

Surface Temperature	
Measured Date:	2023-04-14
Organization Name:	St. Luke's College-Haras Santa Maria
Site ID:	333495
Site Name:	Biological Corridor, Quadrant 4
Latitude:	-34.3444
Longitude:	-58.8484
Elevation:	16.6m
Measured At:	2023-04-14T15:00:00
Solar Measured At:	2023-04-14T11:04:00
Solar Noon At:	2023-04-14T15:55:00
Average Surface Temperature:	18.3 °C
Number Of Samples Taken:	1
Surface Condition:	dry
Surface Cover Type:	tall grass
Homogeneous Site Short Length:	30 mm
Homogeneous Site Long Length:	30 mm
Site Area:	900 m²

Image N°17 - Surface temperature protocol (2023) | src: Globe observer

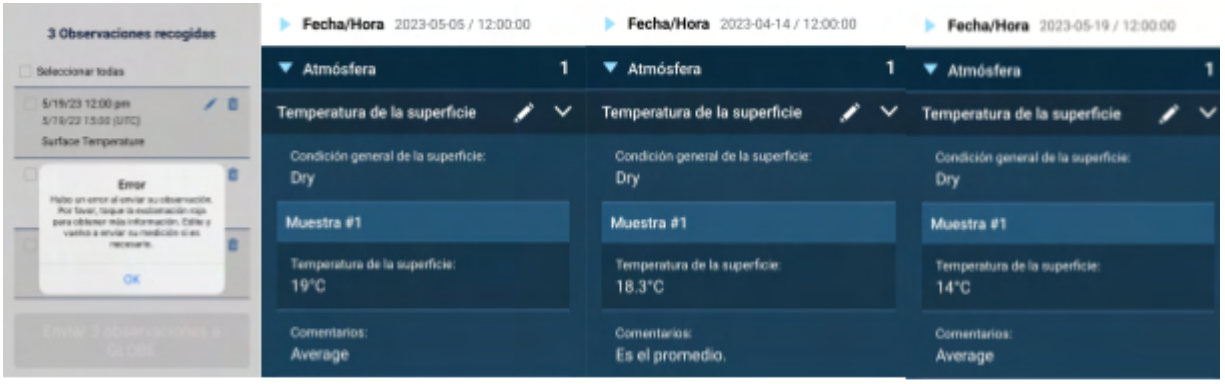


Image N°18 - Surface temperature protocol (2023) | src: Globe observer

Biosphere

Trees

GLOBE Observer App was used to measure height of the nearby trees and upload data. (Image 19)

Measured Date:	2023-03-17	**Measured Date:**	2023-04-28
Organization Name:	San Lucas Haras Santa María	**Organization Name:**	San Lucas Haras Santa María
Site ID:	307382	**Site ID:**	307383
Site Name:	21HUB300981	**Site Name:**	21HUB300980
Latitude:	-34.344484	**Latitude:**	-34.345386
Longitude:	-58.848243	**Longitude:**	-58.848263
Elevation:	16.5m	**Elevation:**	16.7m
Measured At:	2023-03-17T12:48:00	**Measured At:**	2023-04-28T12:39:00
Leaves On Trees:	true	**Leaves On Trees:**	true
Tree Height Average:	18.59 m	**Tree Height Average:**	15.7 m
Circumference:	288 cm	**Circumference:**	224 cm
Dry Ground:	true	**Dry Ground:**	true
Data Source:	GLOBE Observer App	**Data Source:**	GLOBE Observer App

Image N°19 - Tree observations (2023) | src: Globe observer

Land cover

Since March 2023 Land cover has been recorded using the GLOBE Observer App (Image 20) in order to study how it changes as a result of "Stop mowing".

Measured Date:	2023-03-17	**Measured Date:**	2023-06-02
Organization Name:	San Lucas Haras Santa María	**Organization Name:**	San Lucas Haras Santa María
Site ID:	229969	**Site ID:**	307567
Site Name:	21HUB299981	**Site Name:**	21HUB301980
Latitude:	-34.344468	**Latitude:**	-34.345402
Longitude:	-58.84933	**Longitude:**	-58.847176
Elevation:	17.8m	**Elevation:**	15.3m
Measured At:	2023-03-17T12:21:00	**Measured At:**	2023-06-02T14:38:00
Measurement Latitude:	-34.3442	**Measurement Latitude:**	-34.3453
Measurement Longitude:	-58.8489	**Measurement Longitude:**	-58.8468
Measurement Elevation:	16.9	**Measurement Elevation:**	14.8
Dry Ground:	true	**Dry Ground:**	true
Leaves On Trees:	true	**Leaves On Trees:**	true
Data Source:	GLOBE Observer Ap	**Data Source:**	GLOBE Observer App

Image N°20 - Land cover observations (2023) | src: Globe observer

BUTTERFLIES SIGHTINGS

When we started in September 2022, only volunteer students recorded sightings of butterflies through photographs (if possible) or written descriptions (with guided excel) during solar noon. Since March 2023, all senior 3 students went to the field to register butterflies if seen. Although there is no specific protocol right now, "Field guide for butterflies record" edited by GLOBE Uruguay was very helpful.

DETERMINATION OF SPECIES

Species were determined using ArgentiNat's database (=iNaturalist) and specific bibliography .Conosur Flora Catalog was also used to verify the identity of some plants. Facebook publications from a group denominated "Butterflies and moths in Argentina" were also very useful.

RESULTS

Plants:

- ***Richness of plant species:*** 43 species, belonging to 19 families **(Table N°1)**
- ***Status:*** 60.5% Native and 39,5% Exotic **(Graph N°1)**
- ***Habit:*** Herbs 88.4%; Shrubs 7%; Climbers 2.3% ; Trees 2.3% **(Graph N°2)**
- ***Families frequency:*** Asteraceae is the most frequent family with 13 species **(Graph N°3)**
- ***Plants species in the biological corridor*** **(Image 21)**

Table N°1 : Richness of plant species

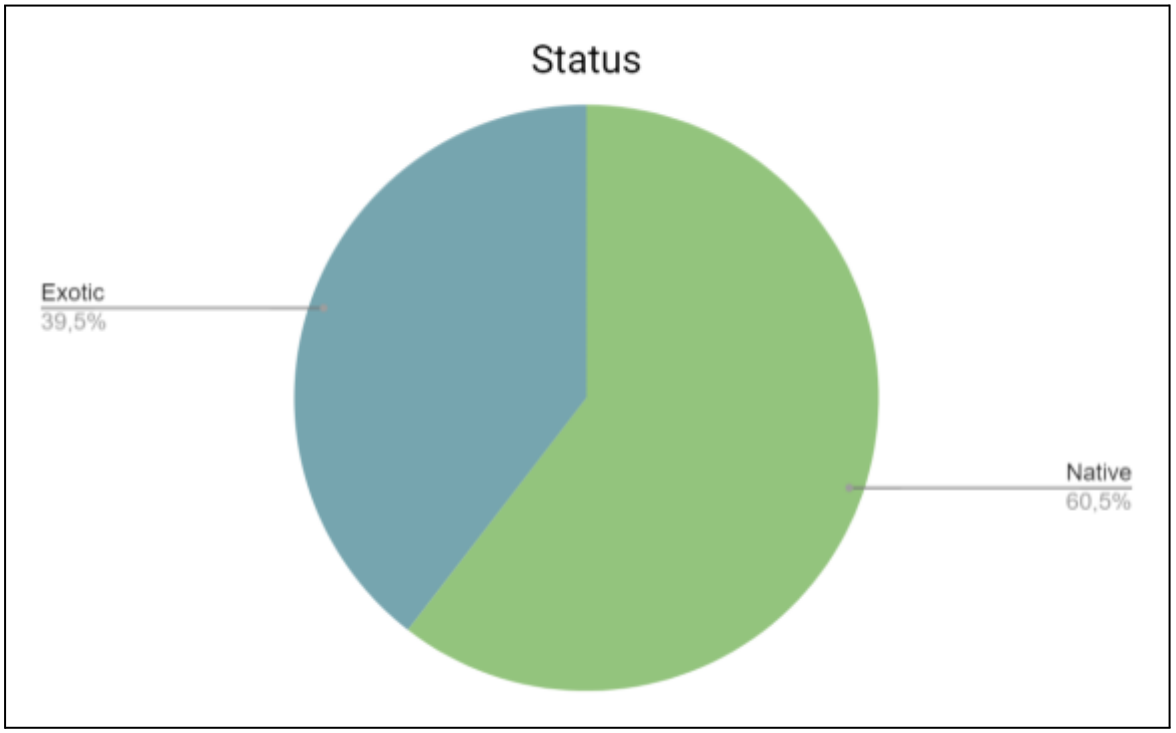
(Press this link to access a database that contains more data)

Family	Scientific name	Status	Habit	Present in Biological Corridor	Present in control
Amaryllidaceae	Nothoscordum nudicaule (Lehm.) Guagl.	Native	Herb	Yes	No
Apiaceae	Bowlesia incana Ruiz & Pav.	Native	Herb	Yes	Yes
Apiaceae	Conium maculatum L.	Exotic	Herb	Yes	No
Apiaceae	Eryngium serra Cham. & Schltdl.	Exotic	Herb	Yes	No
Apocynaceae	Araujia sericifera Brot.	Native	Climber	Yes	No
Apocynaceae	Oxypetalum solanoides Hook. et Arn.	Native	Herb	Yes	No
Asteraceae	Arctium minus (Hill) Bernh.	Exotic	Herb	Yes	No
Asteraceae	Austroeupatorium inulifolium (Kunth) R.M. King & H. Rob.	Native	Shrub	Yes	No
Asteraceae	Baccharis salicifolia (Ruiz et Pav.) Pers.	Native	Shrub	Yes	No
Asteraceae	Carduus acanthoides L.	Exotic	Herb	Yes	No
Asteraceae	Chaptalia nutans (L.) Pol	Native	Herb	Yes	No
Asteraceae	Conyza bonariensis (L.) Cronquist var. angustifolia (Cabrera) Cabrera	Native	Herb	Yes	No

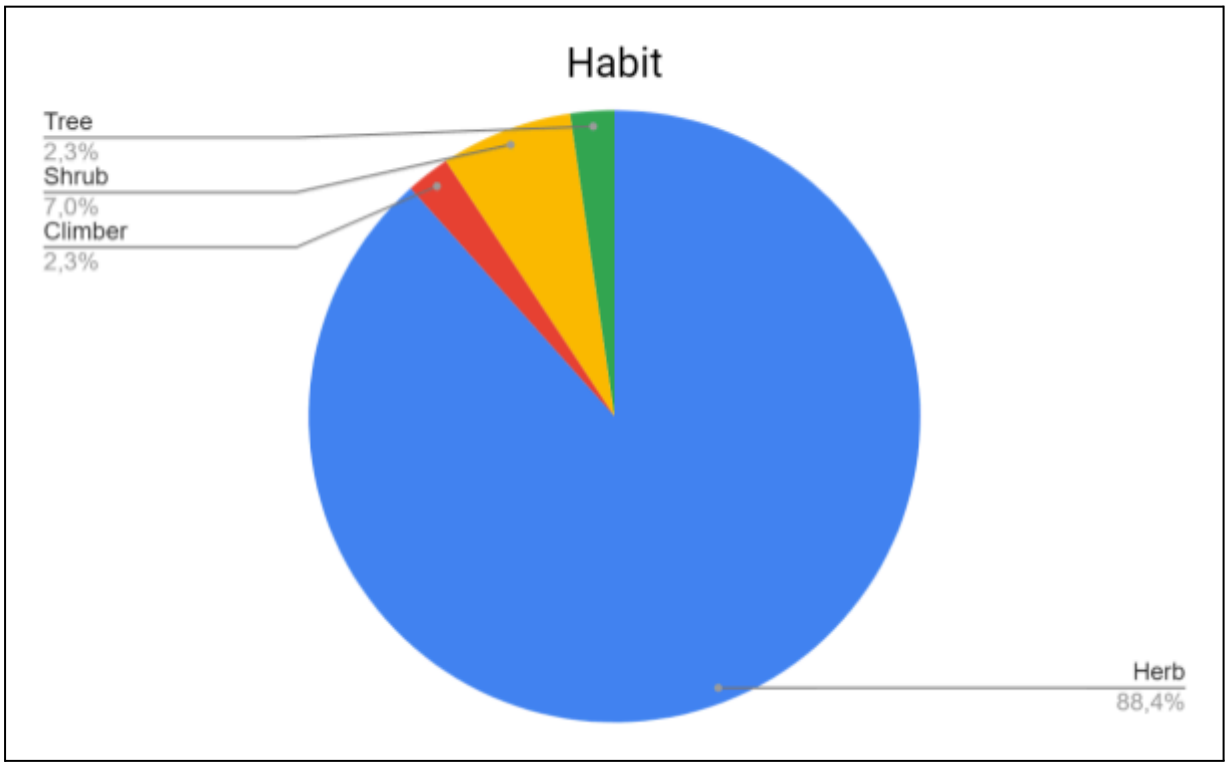
Asteraceae	Gamochaeta americana(Mill.) Wedd.	Native	Herb	Yes	No
Asteraceae	Medicago falcata L.	Exotic	Herb	Yes	Yes
Asteraceae	Onopordum acanthium L.	Exotic	Herb	Yes	No
Asteraceae	Picrosia longifolia D. Don	Native	Herb	Yes	No
Asteraceae	Senecio brasiliensis (Spreng.) Less.	Native	Herb	Yes	No
Asteraceae	Senecio pterophorus DC	Native	Herb	Yes	No
Asteraceae	Sonchus oleraceus L.	Exotic	Herb	Yes	No
Boraginaceae	Echium vulgare L.	Exotic	Herb	No	Yes
Boraginaceae	Heliotropium amplexicaule Vahl.	Native	Herb	Yes	No
Brassicaceae	Rapistrum rugosum L. (All.)	Exotic	Herb	Yes	No
Cyperaceae	Cyperus aggregatus (Willd.) Endl.	Native	Herb	Yes	No
Euphorbiaceae	Euphorbia peplus L.	Exotic	Herb	Yes	No
Fabaceae	Trifolium pratense L.	Exotic	Herb	Yes	Yes
Fabaceae	Medicago lupulina L.	Exotic	Herb	Yes	Yes
Fabaceae	Vicia sativa L.	Exotic	Herb	Yes	No
Malvaceae	Sida rhombifolia L.	Native	Herb	Yes	No
Plantaginaceae	Plantago tomentosa Lam.	Native	Herb	Yes	No
Poaceae	Bothriochloa laguroides (DC .) Herter	Native	Herb	Yes	Yes
Poaceae	Brisa minor L.	Exotic	Herb	Yes	No
Poaceae	Bromus catharticus Vahl	Native	Herb	Yes	Yes
Poaceae	Cynodon dactylon (L.) Pers.	Exotic	Herb	Yes	Yes
Poaceae	Echinochloa Helodes (Hack.) Parodi	Native	Herb	Yes	No
Poaceae	Eleusine tristachya (Lam.) Lam.	Native	Herb	Yes	No
Poaceae	Muhlenbergia schreberi J.F.Gmel.	Native	Herb	Yes	No
Poaceae	Nassella neesiana (Trin. & Rupr.) Barkworth	Native	Herb	Yes	No

Poaceae	Paspalum dilatatum Poi.	Native	Herb	Yes	Yes
Poaceae	Setaria parviflora (Poir.) Kerguélen	Native	Herb	Yes	No
Primulaceae	Lysimachia arvensis (L.) U.Manns & Anderb.	Exotic	Herb	Yes	Yes
Salicaceae	Populus deltoides W. Bartram ex Marshall	Exotic	Tree	Yes	No
Solanaceae	Nicotiana longiflora Cav.	Native	Herb	Yes	No
Verbenaceae	Verbena bonariensis L.	Native	Shrub	Yes	No

Graph N°1: Plant status



Graph N° 2: Plant habit



Graph N°3: Frequency of plant families

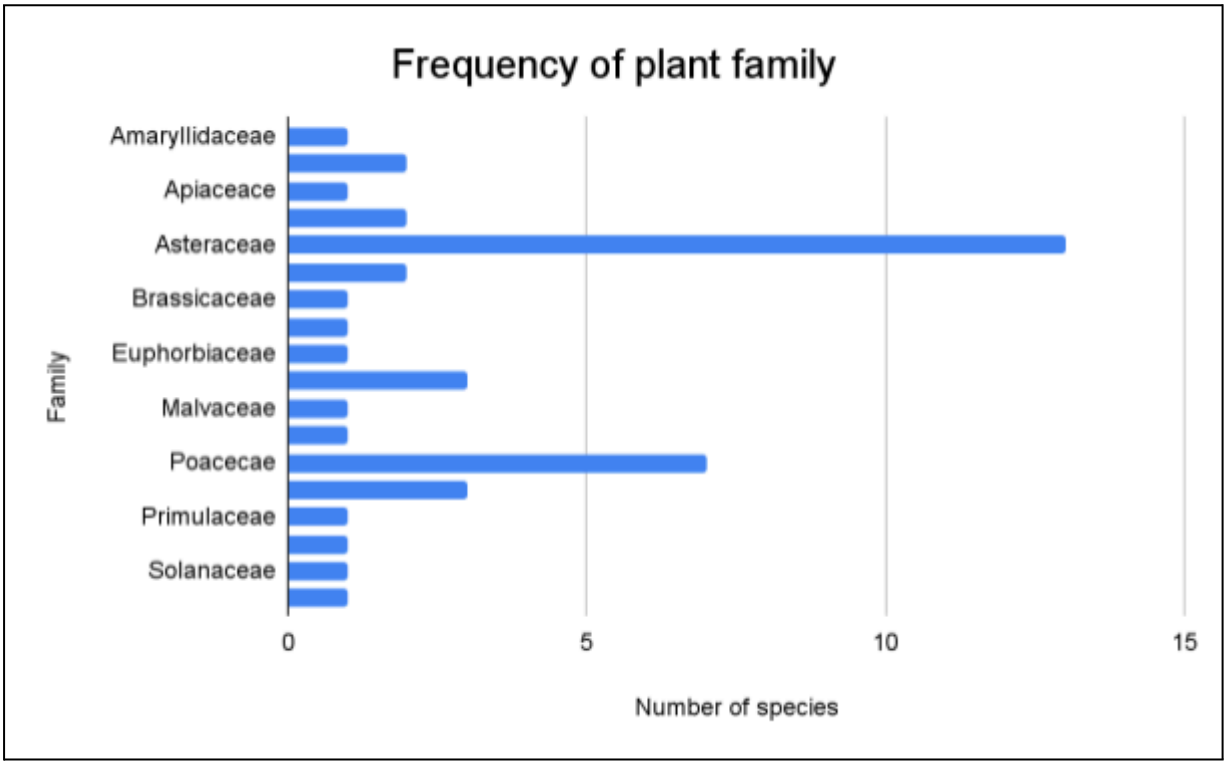


Image N°21 | Plant species in the biological corridor

Butterflies

- ***Daily sightings*** **(Table N°2)**
- ***Richness of species:*** 11 **(Table N°3)**
- ***Total number of sightings:*** 100 **(Table N°3)**
- ***Frequency of occurrence of each species:*** *Agraulis vainillae* was the most frequent species **(Graph N°4)**
- ***Comparison*** of frequency of occurrence between 2022 and 2023 **(Graph N°5)**
- ***Butterflies and related plants*** identified in the biological corridor: 27 plant species were found to be related to 11 butterfly species located within and near the biological corridor. **(Table N°4)**
- ***Butterfly species*** collage **(Image 22)**
- ***Correlation*** between number of sightings and surface/air temperature **(Graph N°6)**

Table N°2 : Daily sightings

(Press the first row of the table or press this link to access a database that contains more data)

Date	Total Day Sightings	Sightings	Common Name	Species	Location
2022					
09/09/22	**1**	1	Not Identified	Not Identified	Near the ditch from the first investigation site
14/09/22	**0**	0			
16/09/22	**0**	0			
28/09/22	**1**	1	Espejitos	Agraulis vanillae	Near the ditch from the first investigation site
14/10/22	**7**	4	Espejitos	Agraulis vanillae	Field
		2	Lechera Común	Tatochila autodice	
		1	Monarca Sudamericana	Danaus erippus	
21/10/22	**1**	1	Monarca Sudamericana	Danaus erippus	Field
28/10/22	**2**	2	Bataraza	Ortilia ithra	Field
4/11/22	**1**	1	Espejitos	Agraulis vanillae	Field
9/11/22	**1**	1	Espejitos	Agraulis vanillae	Field
19/11/22	**0**	0			
25/11/22	**0**	0			
2023					
17/03/23	**5**	1	Cuatro ojos	Junonia genoveva hilaris	Field
		4	Espejitos	Agraulis vanillae	Field

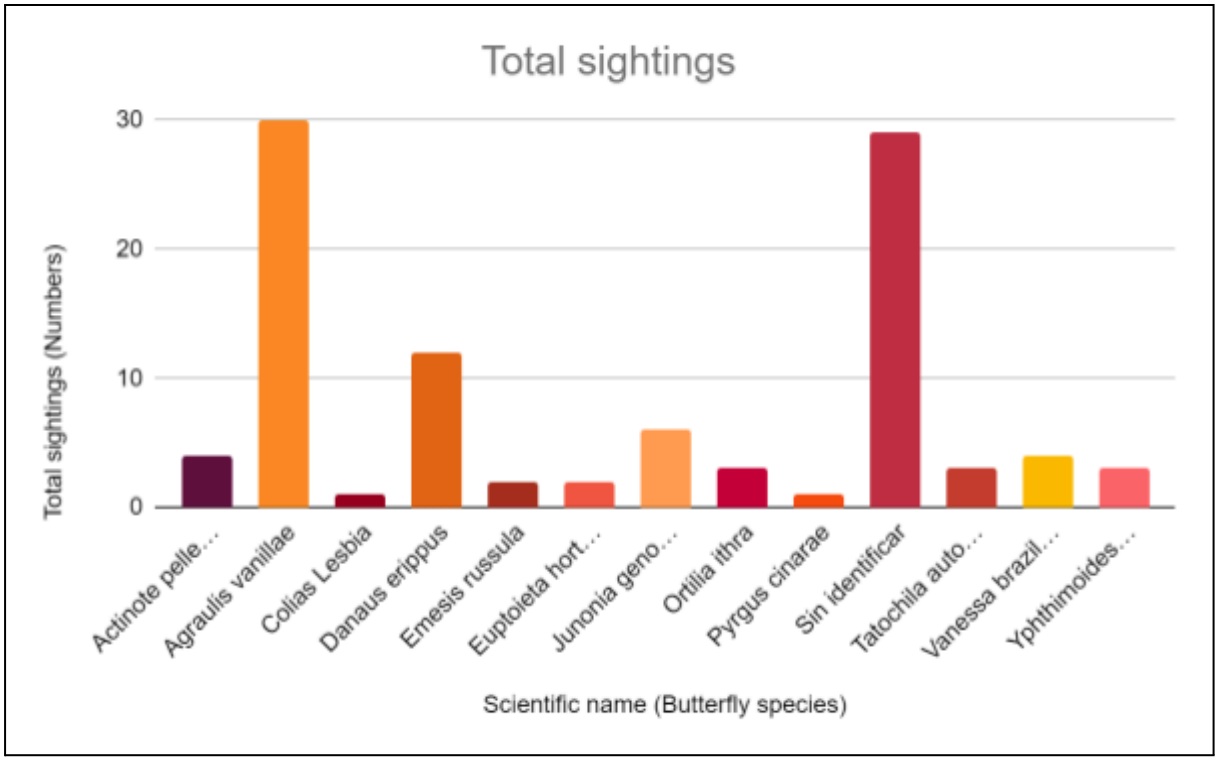
14/04/23	**2**	1	Monarca Sudamericana	Danaus erippus	Field
		1	Cuatro ojos	Junonia genoveva hilaris	
21/04/23	**1**	1	Bataraza	Ortilia ithra	Field
28/04/23	**1**	1	Isoca de la Alfalfa	Colias Lesbia	
05/05/23	**2**	1	Cuatro ojos	Junonia genoveva hilaris	
		1	Hortensia	Euptoieta hortensia	
15/05/23	**2**	1	Cuatro ojos	Junonia genoveva hilaris	Field
		1	Hortensia	Euptoieta hortensia	
02/06/23	**3**	1	Ajedrezada rusa	Pyrgus cinarae	Field
		1	Espejitos	Agraulis vanillae	
		1	Cuatro ojos	Junonia genoveva hilaris	
01/09/23	**2**	1	Dama Pintada	Vanessa braziliensis	
		1	Monarca Sudamericana	Danaus erippus	
13/10/23	**21**	21	Not Identified	Not Identified	Field
20/10/23	**7**	7	Not Identified	Not Identified	Field
27/10/23	**16**	3	Espejitos	Agraulis vanillae	
		2	Acróbata rojiza	Emesis russula	

		9	Monarca Sudamericana	Danaus erippus	
		1	Perezosa común	Actinote pellenea	
		1	Cuatro ojos	Junonia genoveva hilaris	
24/11/23	**22**	3	Marrón del Pastizal	Yphthimoides celmis	Field
		11	Espejitos	Agraulis vanillae	Field
		1	Lechera Común	Tatochila autodice	Field
		4	Dama Pintada	Vanessa braziliensis	Field
		3	Perezosa común	Actinote pellenea	Field
27/11/23	**4**	4	Espejitos	Agraulis vanillae	Field

Table N° 3: Butterflies species sightings

Scientific name	Total sightings
Actinote pellenea	4
Agraulis vanillae	30
Colias Lesbia	1
Danaus erippus	12
Emesis russula	2
Euptoieta hortensia	2
Junonia genoveva hilaris	6
Ortilia ithra	3
Pyrgus cinarae	1
Sin identificar	29
Tatochila autodice	3
Vanessa braziliensis	4
Yphthimoides celmis	3
Suma total	**100**

Graph N°4: Frequency of occurrence of species



Graph N°5: Comparison of frequency of occurrence between 2022 and 2023

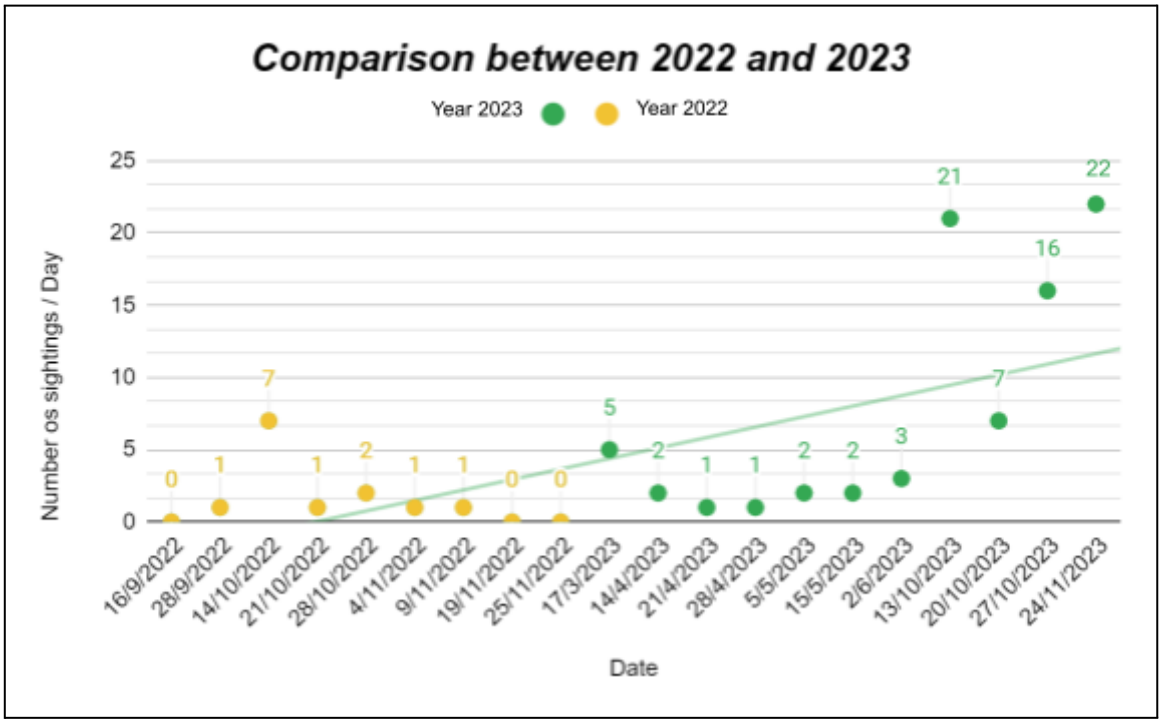


Table N°4 | Butterflies and related plants identified in the biological corridor

(Except * Passiflora coerulea which was within 10 metres from the biological corridor)

Butterflies		***Related plants***	
Scientific name	***Vulgar name***	***Scientific name***	***Family***
Actinote pellenea	Perezosa común	Austroeupatorium inulifolium (Kunth) R.M.King & H.Rob	Asteraceae
		Carduus acanthoides L.	Asteraceae
		Baccharis salicifolia (Ruiz et Pav.) Pers.	Asteraceae
		Senecio pterophorus DC	Asteraceae
Pyrgus orcynoides	Ajedrezada menor	Sida rhombifolia L.	Malvaceae
Danaus erippus	Monarca Sudamericana	Araujia sericifera Brot.	Apocynaceae
		Oxypetalum solanoides Hook. et Arn.	Apocynaceae
		Onopordum acanthium L.	Asteraceae
Tatochila autodice	Lechera común	Baccharis salicifolia (Ruiz et Pav.) Pers.	Asteraceae
		Rapistrum rugosum L. (All.)	Brassicaceae
Euptoieta hortensia	Hortensia	Passiflora caerulea L.*	Passifloraceae
		Austroeupatorium inulifolium (Kunth) R.M.King & H.Rob	Asteraceae
		Onopordum acanthium L.	Asteraceae
Agraulis vanillae	Espejito	Passiflora caerulea L.*	Passifloraceae
		Onopordum acanthium L.	Asteraceae
Yphthimoides celmis	Marrón del Pastizal	Paspalum dilatatum Poi.	Poaceae
		Cynodon dactylon (L.) Pers.	Poaceae
Emesis russula	Acrobata rojiza	Austroeupatorium inulifolium (Kunth) R.M.King & H.Rob	Asteraceae
Junonia genoveva hilaris	Cuatro ojos	Gamochaeta americana(Mill.) Wedd.	Asteraceae
		Austroeupatorium inulifolium (Kunth) R.M.King & H.Rob	Asteraceae
Vanessa braziliensis	Dama pintada	Gamochaeta americana(Mill.) Wedd.	Asteraceae
		Austroeupatorium inulifolium (Kunth) R.M.King & H.Rob	Asteraceae
		Sonchus oleraceus L.	Asteraceae

		Rapistrum rugosum L. (All.)	Brassicaceae
Colias Lesbia	Isoca de la alfalfa	Austroeupatorium inulifolium (Kunth) R.M.King & H.Rob	Asteraceae
		Sonchus oleraceus L.	Asteraceae
		Trifolium pratense L.	Fabaceae

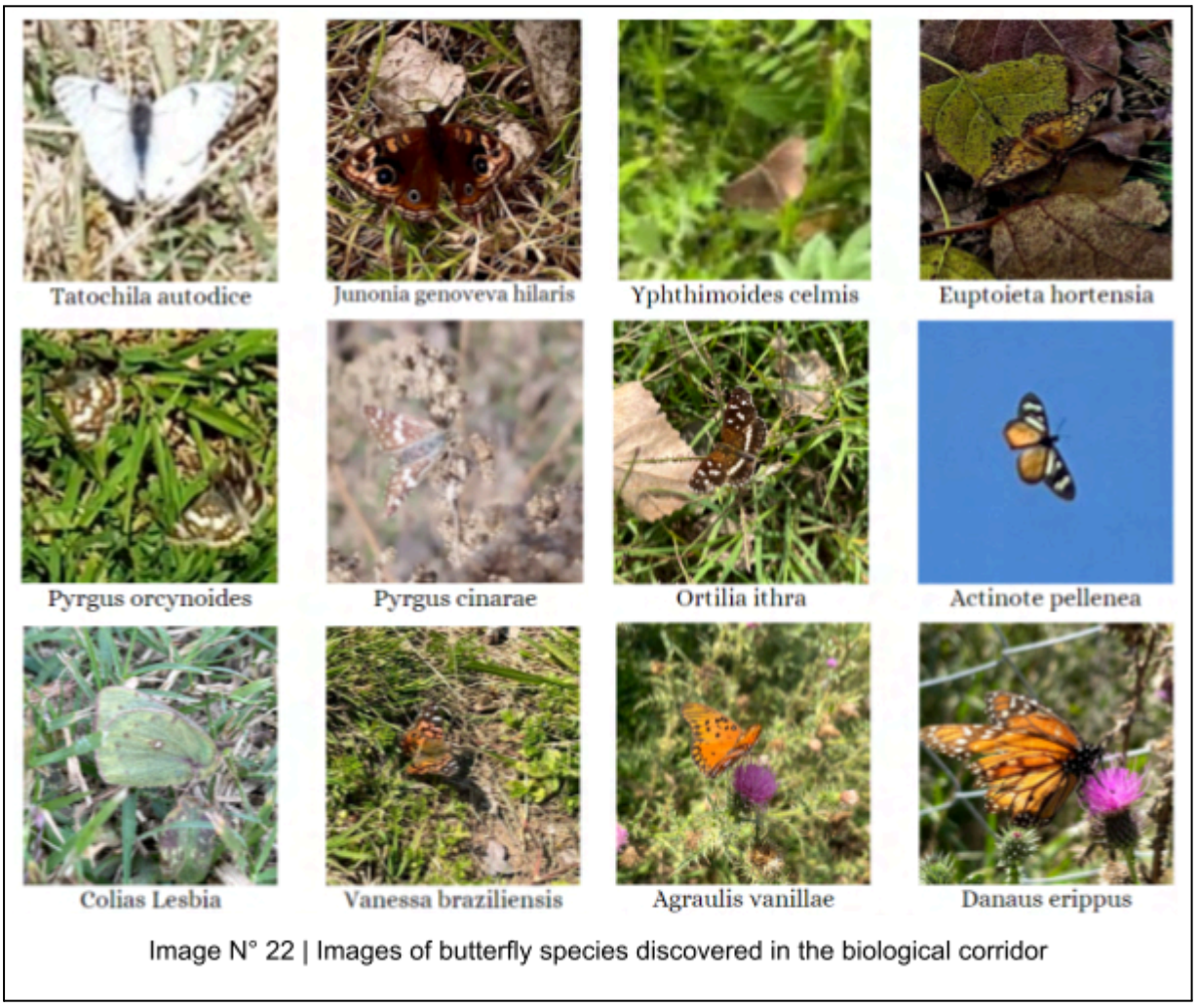
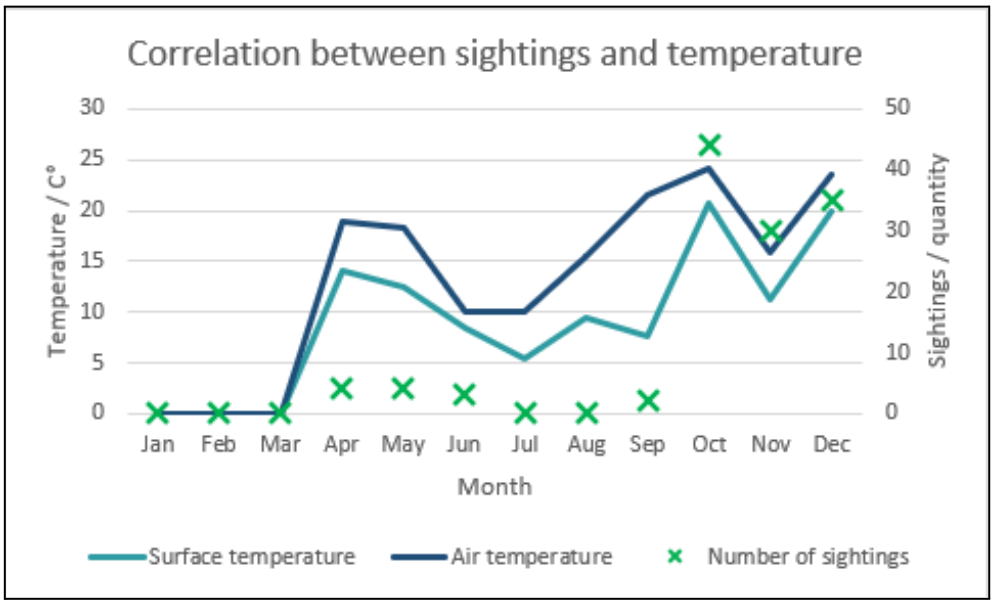


Image N° 22 | Images of butterfly species discovered in the biological corridor

(Click here to view our drive with all of the photos)

Graph N° 6: Correlation between number of sightings and surface/air temperature



Other organisms (Apart from plants and butterflies) **(Table N°5)**

A total of 15 species were observed, corresponding to the following taxonomic groups:

- 7 Insecta
- 2 Arachnida
- 3 Aves
- 1 Gastropoda
- 1 Mammalia
- 1 Fungi

Table N°5 | Other organisms sampled in the biological corridor

(Press this link to access database)

Kingdom	Class	Order	Family	Species	Common name	Location	Date
Animalia	Insecta	Orthoptera	Tettigoniidae	Tettigonia viridissima	Saltamontes verde común	Quadrant 20	5/5
Animalia	Insecta	Coleoptera	Melyridae	Astylus atromaculatus	Escarabajo 7 de oro	Quadrant 5	21/4
Animalia	Aves	Pelecaniformes	Threskiornithidae	Phimosus infoscatus	Ibis	Quadrant 1	5/5
Animalia	Insecta	Coleoptera	Sub familia: Cryptocephalinae (larvae)	-	-	5 meters from quadrant 1	2/6
Animalia	Insecta	Coleoptera	Cantharidae	Chauliognathus lugubris	Soldier beetle	Quadrant 27	21/4

Animalia	Arachnida	Araneae	Araneidae	Argiope argentata	Araña plateada de jardín	Quadrant 6	2/6
Animalia	Insecta	Hymenoptera	Apidae	Bombus pauloensis	Mangangá Negro	Close to the fence in the corridor that doesn't have any quadrants assigned.	14/4
Fungi	-	Agaricales	Basidiomycete	Agaricus SP	-	Grass	2/6
Animalia	Arachnida	Araneae	Lycosidae	Lycosa erythrognatha	Araña Lobo De Quelíceros Rojos	Quadrant 15	2/6
Animalia	Aves	Charadriiformes	Charadriidae.	Vanellus chilensis lampronotus	Tero común	Outside of the quadrant	9/6
Animalia	Aves	Falconiformes	Falconidae.	Caracara plancus	Carancho.	Outside of quadrant 30 & 31	5/5
Animalia	Gastropoda	Stylommatophora	Helicidae	Helix pomatia	Caracol romano	Out of quadrant 30 and 31	5/5
Animalia	Insecta	Lepidoptera	Hesperiidae	Polites vibex	Saltarina Parda	Athletic field	14/4
Animalia	Insecta	Hymenoptera	Apidae	Apis mellifera	Abeja Melífera Europea	Quadrant 11	28/4
Animalia	Mammalia	Lagomorpha	Lepóridos	Lepus europaeus	Liebre Europea	Out of quadrant	5/5

Temperatures

- Air temperature in the biological corridor and in the control quadrant **(Table N°6)**.
- Surface temperature in the biological corridors and in the control quadrant **(Table N°7)**.
- Surface temperature in the biological corridors and in the control quadrant **(Graph N°7).**
- Air temperature in the biological corridor and in the control quadrant **(Graph N°8).**

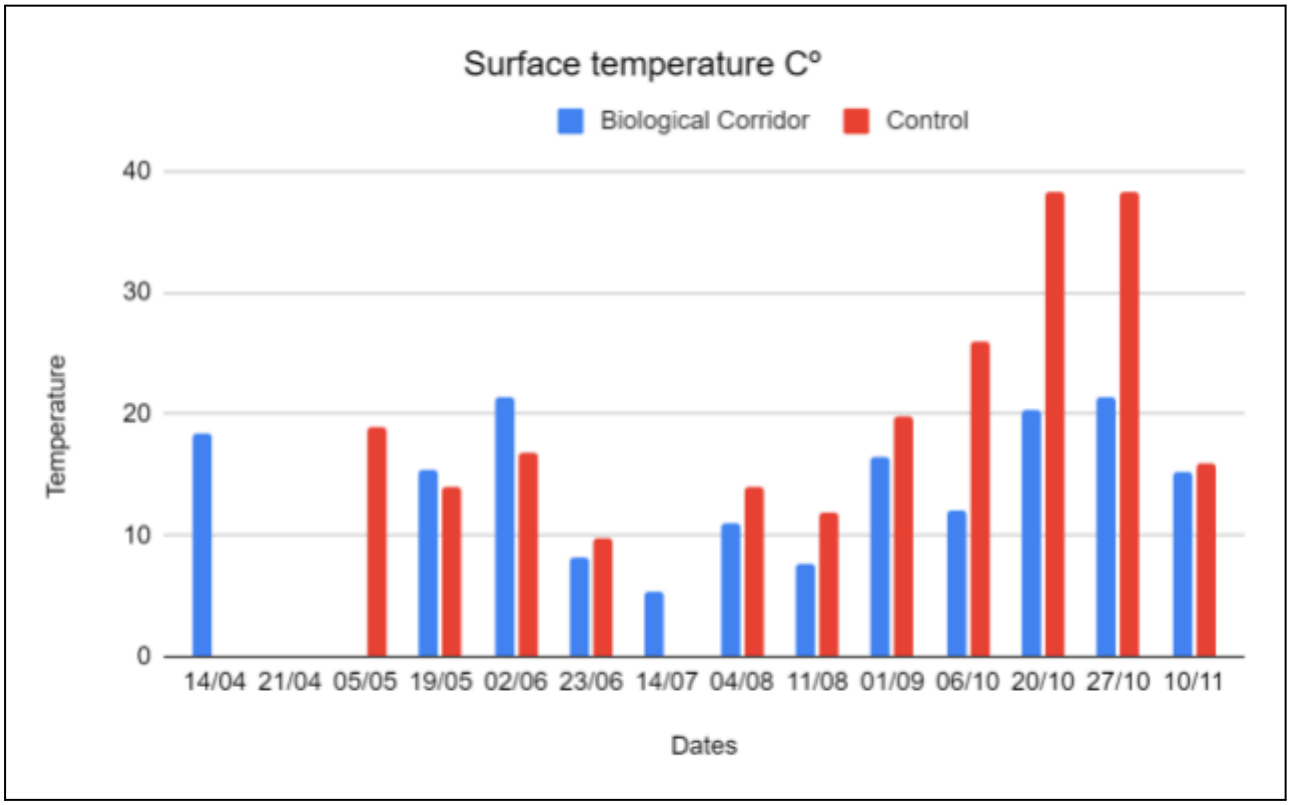
Table N° 6: Air temperature in the Biological corridor and the control (°C)

Air temperature C° in the Biological corridor and the control		
Date	Air temperature C° BC	Air temperature C° Control
14/04	18,7	18,3
21/04	20	-
05/05	19,3	19,8
19/05	13,6	15,3
02/06	20,3	21,3
23/06	10	10
14/07	10	-
04/08	16	-
11/08	15	15
01/09	21,4	22
06/10	23,6	23,5
20/10	24	-
27/10	24	25,5
10/11	17,4	19,8

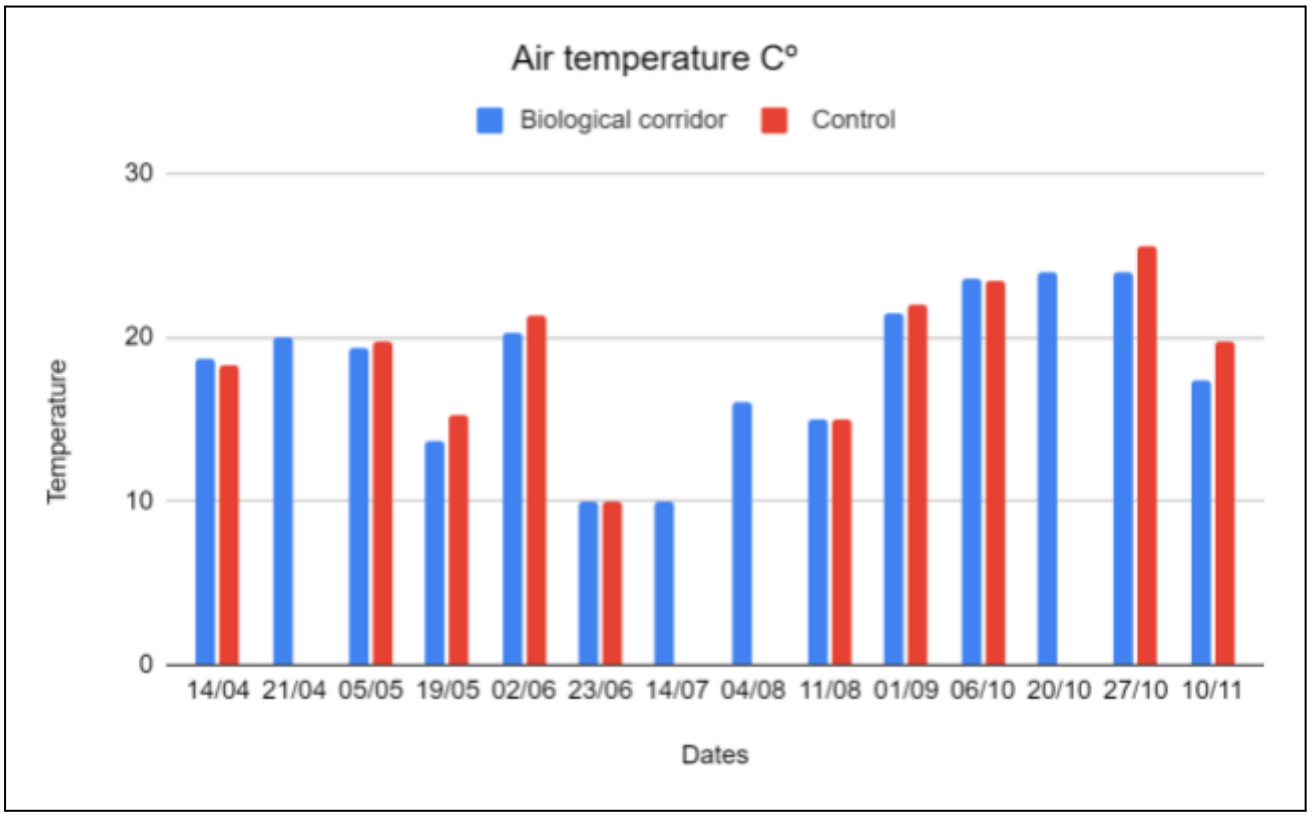
Table N°7:Surface temperature in the Biological corridor and the control (°C)

Surface temperature C° in the Biological corridor and the control		
Date	Surface temperature C° BC	Surface temperature C° Control
14/04	18,3	-
21/04	-	-
05/05	-	19
19/05	15,3	14,0
02/06	21,3	16,8
23/06	8,2	9,8
14/07	5,3	-
04/08	11	14
11/08	7,7	11,9
01/09	16,4	19,8
06/10	12	26
20/10	20,4	38,3
27/10	21,3	38,3
10/11	15,3	16

Graph N° 7: Surface temperature in the Biological corridor and in control (°C)



Graph N° 8: Air temperature in the Biological Corridor and in control(°C)



Land Cover

Since March 2023 plant cover was registered (Image 23). It has evolved constantly due to plant development within the biological corridor.

Image N°23 | Comparison of plant coverage inside and outside the biological corridor

The following photographs show the progress during 2023 (Image 24 - 27):

Image N°24 | Plant coverage March 17 2023: Little growth, almost no noticeable difference

ImageN° 25 | September 1st 2023 - Significant growth, notable difference between BC and control area.

Image N°26 | November 7th 2023

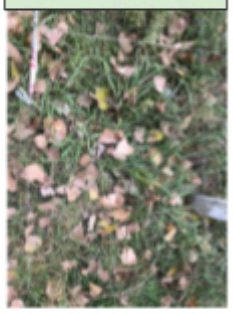
Image N° 27 | December 1st 2023

Analysing our databases it was found that land cover has changed in percentage of plants habit, in height of plants and frequency of species.

Changes in the proportion between different types of herbs (grasses and non-grass) were noticed and also changes in plant height range (maximum/minimum) were measured.

As an example we include here our data analysis corresponding to quadrant N°1. Press here to access the database that includes other quadrants (Note that the information regarding the quadrants starts in the sheet named "Quadrant 1" and ends in "Quadrant 120").

Quadrant 1: *(Image 28)*

	Plant	Present?	How many?	Are there different species?	Species names:	Image
05/05	Non Grass herbs	Yes	7%	1	Names: - Maximum Height: 79cm Minimum Height: 40cm	
	Trees	No	0%	-	-	
	Grasses	Yes	93%	3	Names: Tall grass, normal grass, dry grass. Maximum Height: 81cm Minimum Height: 3cm	
	Shrubs	No	0%	-	-	
	Bare soil	No	0%	-	-	

	Plant	Present?	How many?	Are there different species?	Species names:
02/06	Non Grass herbs	Yes	10%	1	Maximum Height: 98cm Minimum Height: 38cm
	Trees	No	0%	-	-
	Grasses	Yes	90%	3	Tall grass, normal grass, dry grass. Maximum Height: 54 cm Minimum Height: 3cm
	Shrubs	No	0%	-	-
	Bare soil	No	0%	-	-

Image N° 28 | Quadrant N°1 - Land cover

Trees

Also, a group of trees was monitored and measured using the GLOBE Observer App because they were close to the biological corridor and in fact we found that they have reproduced there. Two renewals were found in October 2023 into the biological corridor (Image N°29).

Image N°29- Trees near the biological corridor (Left) | Tree sprout *inside* the biological corridor (Right)

DISCUSSION

We started this investigation in order to increase knowledge about pollinators and their host plants due to their importance in maintaining sustainable ecosystems. Through our research, we emphasise the potential of grassroot interventions in the form of biological corridors by using butterflies as the important bioindicator they are. *"Butterflies depend on resources and habitats that we can easily characterise. They are relatively easy to census. They show variations in abundance from place to place, which may suggest the geography of their evolution. And changes in their numbers over time are powerful indicators of changes in their, and our, environment" (Horn, H. S. 2003).*

The number of pollinators is suffering a decline due to the application of herbicides, extreme weather conditions and habitat destruction. Pollinators are key in every ecosystem, so it is very important to ensure their preservation.

"The threat from climate change gives a sense of urgency to Butterfly Conservation's strategy of conserving species at a landscape scale, making existing habitats bigger, better managed and more well connected. We need to make landscapes more diverse to help conserve many of our butterfly species" (Manpreet, Aulakh. 2022).

Our findings align with the insights of previous research, such as the work by Keeping It Wild Trainee Manpreet (2022), which highlighted the cooling and shading effects of specific environmental features on butterfly species. Notably, the project extends this understanding by incorporating the importance of native plants within biological corridors. *"...within a garden lawn, patches of grass can be left to grow longer - these areas will provide cooler, shady places for many species of butterflies." (Manpreet, Aulakh. 2022).* The biological corridor is essentially this; an area that will provide a suitable habitat for Lepidoptera.

Climate change does affect the butterflies' frequency of occurrence. So we can conclude that environmental variables, such as the corridor we implemented, drastically increase butterfly sightings. Although we did not yet investigate the CO_2 intake of plants in the biological corridor, we suspect that this method is much faster and more efficient than tree growth, which takes years to have a significant carbon capture.

During our 2023 investigation, in September, no results were recorded. This occured due to the lack of field work, which caused a lack of data and lack of field coverage. This happened because during that time we had spring holidays and field trips to other locations.

In spite of the fact that this investigation had a great development, there is some room for improvement. Time was not well managed in 2022, because the project was held outside the school timetable. During 2023, we couldn't go out in the field in winter due to climate conditions and we couldn't stay for long periods of time outside. It would've surely added value to our investigation and we hope to avoid these limitations in further research. Analysing our methods we found that standardising field notes is important in order to retain as many details as possible. Although we have created a specific file for land cover and butterflies sightings (Image 10), it would be much better to include in the same "field file" the atmospheric variables (air temperature, surface temperature and clouds) that need to be measured. It would have been much easier to upload records in our database.

We decided that recording our findings through social media would enrich the investigation and serve as a record available to anyone that was interested. The findings were documented through an account on the platform Instagram. The posts consisted of pictures of butterfly sightings, pictures of the changes in the biological corridor, and other details about the investigation. All posts were kept light-hearted and not extremely scientific as a way to engage people and educate more on the importance of grassland restoration and preservation. We used this platform as an opportunity to interact with users and answer any questions that came up. We think this creates a bigger capacity for engagement and increases awareness. You can find this account by searching for The Butterfly Project HSM or clicking here.

Although this biological corridor is next to the ditch, no aquatic or semi aquatic larvae or caterpillars were found because neither aquatic plants nor marsh plants have grown within it. We have revised bibliography to check if any Lepidoptera genus there could be considered

aquatic or semi aquatic (Bentancur-Viglione et al. 2020). All the species sighted were terrestrial and daytime butterflies.

The vegetation that has been developed in the biological corridor corresponds to a grassland MUC 4323, in spite of the fact that the rest of the School Campus could be considered MUC 821.

In October 2023 another group of students (Mia Turale, Zoe Santana, Camila Festa, Lola Figueroa, Lucas Odriozola, Benicio Vera and Felipe Marmolejo) created a signalling system in order to protect the area and only use it for biological studies (Image 30). This arose because in July 2023 the original restoration site (Image 2 - Marked in red) was lost because the grass was mowed due to a miscommunication. This study site was established in June 2022 by Senior 5. Losing the initial part of the study area (10x1m) made us realize that it was necessary to signal the biological corridor using proper methods and materials, to ensure that no other study sites were lost.

Image N° 30 - Signaling system | Posters made by Mia Turale, Zoe Santana, Camila Festa, Lola Figueroa, Lucas Odriozola, Benicio Vera and Felipe Marmolejo

This research project has a lot of potential follow-up investigations. One of them is to investigate the amount of CO_2 intake in the biological corridor by weighing dry mass in order to know how much we are contributing to reducing climate change. Another one is the possibility to implement biological corridors as another way to tackle climate change, alongside reforestation. We are going to continue our data collection because *"More monitoring is also vital, to ensure early warning of populations at risk, buying us time to implement effective conservation management and gain better understanding of how butterfly changes have knock-on effects more widely for food webs and ecological communities". (Hill, Jane K., 2022)*

It has been also observed that butterflies' behaviour seemed to change "flight direction" after the creation of the corridor. From flying perpendicular (ditch to centre of campus) to flying parallel to the ditch. As we did not measure this variable, we could not include it in results, but we are going to include it in future research.

In conclusion, our research fosters the significance of biological corridors when it refers to climate change and its effects on butterfly species and native plants. Through this project it was demonstrated that atmospheric variables are influenced by the biological corridors and butterflies are benefited by it.

CONCLUSIONS

The creation of our biological corridor has helped increase plant species richness (42 species in biological corridor vs 10 species in control area), which benefits the environment and generates adequate conditions for pollinators.

Using the "not mowing" method, some plants were allowed to spread from the ditch and to regrow towards the biological corridor and butterfly sightings increased by 340% from 5 (17/3/2023) to 22 (24/11/2023) (see Graph N°5).

Due to the biological corridor 26 native plant species have been identified and added to our catalogue. Some of them are host plants for butterflies (Table N°4).

From 100 butterfly sightings, 11 species have been identified (Table N°3).

15 other organisms, belonging to 6 different taxonomic groups (Table N° 5), were sighted; we can assume that this has a direct relation with the increase in plant richness. Based on this data we can conclude that not only are pollinators benefited but the ecosystem health improves, leading to an increase in biodiversity.

This study shows that the differences between the biological corridor and control in air and surface temperature (Table N°6 and N°7) are due to the increase of plant transpiration and land cover. The increment on biomass would also make an impact on carbon intake and therefore decreasing temperatures.

In Graph N°6, the correlation between temperature and butterfly sightings is shown. We can see that in winter (June-September) sightings are scarce/almost none showing that when temperature is low, butterflies are not prone to show up. Therefore it is clear that when temperature rises, butterflies will appear. However, the most important detail this graph gives us is the comparison between sightings in the early part of 2023 vs the last months of the year. The graph shows that in the last three months the number of sightings has drastically increased. Even though the variable is not included in the graph we can conclude that this occurs because the biological corridor has experienced growth, and therefore has a lot more variety of plant species for butterflies to feed off. The graph explains that even though changes in temperature are little, vegetation is key to pollinators.

We hope that this project will trigger the creation of biological corridors that could help tackle climate change. It is important to acknowledge that letting native plants thrive, free of intervention, is necessary and will benefit the environment, by allowing pollinators to flourish.

ACKNOWLEDGMENTS

We would like to acknowledge Mariana Savino (GLOBE Regional Coordinator) and Ana Prieto (Master trainer) for their visit to our school in March 2023.

We also want to thank Andrea Ventoso (GLOBE Uruguay Coordinator) for her suggestions on this report.

BIBLIOGRAPHY

(1) ArgentiNat. https://www.argentinat.org/ ***(revised 15/12/2023)***

(2)Bentancur-Viglione,G.; Castro M.; Morelli, E. 2020. Lista preliminar de las mariposas acuáticas y semiacuáticas (Insecta : Lepidoptera) presentes en el Uruguay. Boletín de la Sociedad Zoológica del Uruguay 29(2) :141-149 https://doi.org./10.26462/29.2.11 ***(revised 19/12/2023)***

(3) Burkart R., Bárbaro N., Sánchez R., and Gómez D. (1999). Eco-regiones de la Argentina. Administración de Parques Nacionales. Secretaria de Recursos Naturales y Desarrollo Sustentable. Presidencia de la Nación. https://sib.gob.ar/ecorregiones ***(revised 15/12/2023)***

(4) Caldas, A. 2014. Species Traits of Relevance for Climate Vulnerability and the Prediction of Phenological Responses to Climate Change.The J. of the Lepidopterists Society .68 (3) :197–202 . https://doi.org/10.18473/lepi.v68i3.a7 ***(revised 15/12/2023)***

(5) Flora del Conosur. http://www.darwin.edu.ar/Proyectos/FloraArgentina/Generos.asp ***(revised 15/12/2023)***

(6) https://www.globe.gov/ ***(revised 15/12/2023)***

(7) Hill, Jane K. 2022, Climate Change and British Butterflies. https://butterfly-conservation.org/news-and-blog/climate-change-and-british-butterflies ***(revised 15/12/2023)***

(8) Hill, et.al, 2021. Climate change effects on animal ecology: butterflies and moths as a case study. (https://onlinelibrary.wiley.com/doi/full/10.1111/brv.12746) ***(revised 15/12/2023)***

(9) Horn, Henry S. 2003. Butterflies as bioindicators. American Scientist 91 (6) American Scientist ***(revised 15/12/2023)***

(10) Manpreet, Aulakh. 2022. How climate change is affecting butterflies in the UK, https://www.wildlondon.org.uk/blog/keeping-it-wild-project/how-climate-change-affecting-butterflies-uk-keeping-it-wild-trainee ***(revised 15/12/2023)***

(11) Mariposas y polillas de Argentina . https://www.facebook.com/groups/706827712732501/ ***(revised 15/12/2023)***

(12) Nuñez Bustos, E.O. 2020. Aspectos de historia natural de las especies de Actinote Hübner (Lepidoptera: Nymphalidae: Heliconiinae: Acraeini) en la Provincia de Buenos Aires, Argentina. Trop. Lepi.Res. 30(2): 103-114. DOI: 10.5281/zenodo.4317587 ***(revised 15/12/2023)***

(13) Nuñez Bustos, E. 2021. Mariposas y polillas en Reserva ecológica costanera Sur. https://www.reservacostanera.com.ar/la-fauna/invertebrados/mariposas-y-polillas (***revised 31/01/2024)***

(14) Purdue Online Writing Lab. (n.d.). General Writing FAQs. Purdue Online Writing Lab. https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_style_introduction.html ***(revised 15/12/2023)***

(15) Rosende , Luciana.2023.Plantas nativas y «hoteles de abejas»: una opción ideal a tener en cuenta ante el inicio de la primavera. Tiempo Argentino 17/09/2023. https://www.tiempoar.com.ar/informacion-general/plantas-nativas-hoteles-abejas-primavera-fauba/ ***(revised 15/12/2023)***

BADGE SPECIFICATION

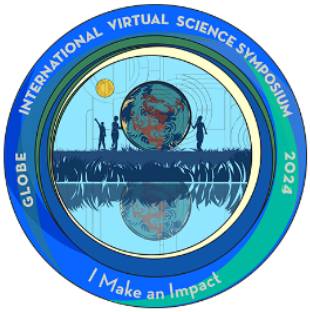
I AM A PROBLEM SOLVER

Why do we deserve it?: This investigation proposes a simple, cheap and easily available way to tackle climate change, by magnifying plant biomass and increasing carbon capture. Creating biological corridors increases richness of species and decreases air and surface temperatures.

During our investigation, we learned how to use previous knowledge to help tackle global warming by creating our own biological corridor. We learnt how to take measurements of it and keep track of how it benefits the environment.

I AM A STEM STORYTELLER

Why do we deserve it?: Since the beginning of 2023 we decided to share our project throughout the social media platform Instagram. We tried to post everytime we went outside. Even before we found out about the "I am a stem storyteller" badge we wanted our project to reach more people, and hopefully inspire them to have their own biological corridors at home (The Butterfly Project HSM).



I MAKE AN IMPACT

Why do we deserve it?: Our investigation aims to propose a simple and affordable solution to tackle some effects of climate change and the decline in pollinator populations, by creating biological corridors. These types of actions contribute to climate education. Sharing this idea with our community could make a big difference, if multiple people join this restoration effort with individual little actions.