ONE BY ONE. DOES IT REMAIN WITH NONE?

Study of the leaves´ fall of trees of Pujato -Argentina-

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SUMMARY

This project was carried out during 2016 with students of the fifth and sixth grades of the Primary School N°1345 "Nuestra Señora.del Carmen" of Pujato, Argentina. We worked with GLOBE[1] protocols of Phenology. Visible changes were investigated about the basic life processes that are produced in a vegetable during a period, which covered the foliation, the autumnal coloring of the foliage and its fall. Each year, while conditions for plant growth increase, a "wave of green" spreads on the surface of the earth and then decreases, when conditions decline. From the activities of the GLOBE (Green Down) Program, three trees were chosen (Ash, Ombú and liquidambar) and a **question for research: What is the relationship between the colour change in the leaves of some trees in the town of Pujato (Santa Fe) during the autumn period with the fall of them?**

Initial assumptions were made, suggesting a possibility: "Leaf fall during autumn is due to the presence of the wind". Investigations followed and it was noted that it was not the only period of the year with the presence of the wind. Information is then sought on the change in the coloring of the foliage and thus the **hypothesis** arises: The leaves of some trees of Pujato (Santa Fe) change their colour during autumn-winter and, every year, these trees lose their foliage during this period due to certain modification of meteorological conditions. Observation, research, inquiry, experimentation and analysis were carried out with the **aim** of testing the hypothesis and establishing relationships with a plant process which occurs during the fall.

Keywords: GLOBE Green Down Protocol. Autumn. Coloring and dropping of leaves.

[1] [1]GLOBE: Theoretical practical program that promotes the learning and teaching of Science for the benefit of the environment (www.globe.gov). School 1345 has been involved in this program since 2002.

INTRODUCTION

The Earth is a dynamic system where environmental changes have been part of its evolution, and two main types of global changes can be identified, those that alter the equilibrium of the Earth's roofs (atmosphere and oceans) and which are experienced all over the planet and those occurring in discrete, localized sites. With the passage of the seasons, in some regions of the Earth, changes are seen not only in both the structure and function of ecosystems but also in the morph physiology of many species. These biological changes constitute a series of responses to environmental changes related to the annual course of the weather. In each region the landscape has its own characteristics, a physiognomy that favors survival and optimizes the exploitation of the resources. The phenological phases are the manifestation of genetic information acquired along the evolution as adaptation to the variations of the climate. Consequently, they are related to the present, past and future time, determined by the climate.

Some of the climatic variations mentioned are seasonal, and phenology is manifested in cycles and changes in nature throughout the year. In the southern hemisphere, autumn begins approximately on March 21st and particularly, in intermediate latitude zones, from that date the nights are longer than the days, which means that the solar radiation is lower as it happens where this study was carried out: Pujato (latitude -33.0192, longitude -61.043) located in the province of Santa Fe, Argentina. Figure 1 shows the location of Pujato in San Lorenzo Department, Province of Santa Fe, Argentina, American Continent.

Figure 1: Pujato in America.

In turn, due to its geographical location, Pujato is in the region of mild Pampeano climate, here the four seasons (autumn, winter, summer and spring) are marked and quite differentiated. In this respect, the fundamental feature of the autumnal landscape is the colour change of the foliage and the subsequent fall of the leaves of the deciduous trees. Year after year, when the autumn season arrives, it is perceived with the naked eye that some trees in Pujato change the colouring of their leaves and after a certain period they begin to fall. Although the phenomenon occurs as a repetitive cycle, the curiosity to explain and understand this fact from school science gives rise to the following questions:

Do all trees of Pujato lose their leaves?

Is the colour change of the leaves related to their fall?

Do leaves always fall on the same station and at the same time for all species?

Do all leaves get the same colours before they fall?

Does the tree get rid of its leaves?

There are many issues that are proposed, all of them are intended to limit the study with the proposal of a problem that will mobilize the school research.

Research question

How is the change of coloration related to the leaves of some local trees of Pujato (Santa Fe) during the autumn period with the fall of the same?

It seeks an answer to the problem presented in order to define the hypothesis that will guide this research:

Hypothesis

The leaves of some trees of Pujato (Santa Fe) change their colour during the autumn-winter and, every year; these trees lose their foliage during this period due to the modification of certain meteorological conditions.

The following objectives are also formulated:

General objective

To observe the retreat of the green (change of colour and fall of the leaves) in some trees of Pujato, to link the change of coloration of the leaves in autumn-winter and its subsequent fall.

Specific objectives

- ✓ To define the study sites where the plants are located to observe the Green in the town of Pujato.
- ✓ To apply the GLOBE Phenology protocols corresponding to the retreat from the green to the established trees as study sites.
- ✓ To analyze the changes of coloration of the leaves of the observed trees.
- ✓ To relate the colour changes of the leaves with their fall.

Importance of school research.

For the community: This study related to Phenology, in particular to the study and analysis of plant phenomena during the period of retreat of the green, can be used to examine the plant response to the environmental changes related to the annual course of the weather, such as mentioned above.

Relationship with curricular content: Researchers and their learning.

Through this study students were able to consolidate the contents developed in the Natural Sciences classes established by the Ministry of Education of Argentina (2005) as priority learning centers:

In relation to living beings: diversity, unity, interrelations and changes:

- ✓ The observation and characterization of the plants under study in comparison with others.
- The differentiation of plants with the climatic characteristics of the autumn season recognizing the effect on the leaves.
- Plant adaptations changing their structure and function in response to weather-related environmental changes in the fall.
- The recognition of plants as open systems, highlighting the main relationships established with the environment, in particular the change in color of their leaves and fall in autumn.

In relation to the Earth, the Universe and its changes:

- The construction of the idea of atmospheric weather as an introduction to the notion of climate. The study of the changes associated with the seasonal cycle, particularly in autumn.
- The relationship between the weather and the fall of the leaves of the trees.

Antecedents

It is important to emphasize that some years ago, other students of the 1345 School of Pujato, have applied the phenology protocols, in particular the Green Down, in different study sites. These practices established in the protocols are known by teachers who develop activities of science in the school, however, students have not studied the relationship between the change in color of the foliage and the fall of the leaves; this is a new contribution to the phenomenological study in the region.

Theoretical framework

These are the main concepts that have been worked with during the school research.

The **orientation** in the site allows determining the relative position of an object in relation to the established reference points. An observer is oriented in a place when he determines the direction of each of the **cardinal points** of the place; those are points of reference through which it is possible to locate any place on the surface of the Earth. They are: North, South, East and West.

Compass: instrument used to indicate orientation through the Earth's magnetic field. It is based on a magnetized iron bar (needle) that tends to be oriented according to the direction of the Earth's magnetic field. To achieve correct operation of the compass it should be placed on a flat surface and wait until the needle stops oscillating and indicates the magnetic north.

GPS: Geographic positioning system that works using satellites.

Plant: Living organism that grows without being able to move, especially the one that grows fixed to the ground and is nourished of the mineral salts and the carbon dioxide that absorbs by the roots or the pores of the leaves. Among the plants may be considered trees or shrubs.

Tree: Perennial plant with woody stem, which branches to a certain height of the ground. The Term usually refers to those plants whose height exceeds a certain limit in its maturity, and can reach up to 30 meters. It is considered medium tree those whose height is between 2 and 3 meters.

Shrub: perennial plant formed by several woody trunks that emerge from the ground; depending on the variety ranging from 0.5m to 6 meters.

Deciduous or deciduous tree or shrub: are those that lose leaves during a time of year. In mild climates, as in the case of Pujato, the loss of leaves in a seasonal way is usually the coldest, autumn-winter.

Evergreen or evergreen tree or shrub: are those that do not lose the leaves at any time of year.

Autochthonous species: Plant that lives in the wild, in interaction with animals, climate, soil, other plants and without human intervention.

Exotic species: Plant originating from another site that is planted and man-cared for.

Leaf: it is the part of the vegetables, smooth and thin, commonly green.

Parts of the leaf: It consists of leaf, petiole and stipe. The **leaf** is the part of the leaf frequently flattened and extended, green due to the presence of chlorophyll; it is where photosynthesis occurs. The **petiole** is a continuation of the stem; it possesses conductive tissues, of raw and processed sap. The **stipulum** is the leaf extension, usually laminar and small that is at the base of the petiole.

Single leaf: it has the foliar lamina constituted by a single unit.

Composite leaf: the leaf is divided into several leaflets; each one is supported by an axis called petiole.

Phenology: Observation of the evolution of organisms in their life cycle, studying the linkages between this biological evolution and the variation of environmental characteristics (climatic, edaphic, biotic). Phenology studies the start and end dates of the different phases of the development of plants by registering them in chronological order and making these observations in many places for several years to obtain reliable data on plant development and its relation with environmental factors.

Phenology Protocols: rules or standards that allow to control and communicate the progress and retreat of the green according to the seasonal changes. In this paper, the Leaf Fall Protocol or Green Down of the GLOBE program is applied, which indicates the procedures to identify signs of the end of the growing season of the plant, to observe seasonal changes of the leaf, report data, classify plant species and study the dominant color of the leaf.

Vegetable color guide: it is a primer with the possible shades of leaves that allows through a comparison to estimate, by means of a pre-established code, the dominant color of each leaf.

Leaf type guide: it is a leaf that contains the classification of the leaves according to their shape, which is just one of the ways to classify them since you could do the same considering the shape of the stem, the durability of the leaf , according to the limbo among other issues.

Photosynthesis: is the process by which plants, algae, and some bacteria use the energy of light, along with carbon dioxide and water, to produce food (sugars).

Chlorophyll: it is a pigment that gives the plants their green colour, it traps the light energy for these organisms to get their food. A pigment is a material that changes the color of light reflecting as a result of selective color absorption. Photosynthetic pigments are the only ones that have the capacity to absorb the energy of sunlight and make it available for the photosynthetic apparatus. In ground plants there are two kinds of photosynthetic pigments: chlorophylls and carotenoids.

Leaf Chromatography: This is a physical method of separation. The objective of chromatography is to separate the different components of a mixture so that it can be identified.

Phototropism: corresponds to a response of the vegetable to the luminous stimulus.

Weather: is the state of the atmosphere in a place and at a certain time.

Climate: is the average state of the atmosphere over a period of longer time, generally recorded for years. Weather is characterized by weather variables such as temperature, atmospheric pressure, cloudiness, wind, rain, among others.

As for the climate, it is possible to detail the characteristics of the **mild Pampeano climate** to which belongs the region where the town of Pujato (Santa Fe) is located in Argentina. It is characterized by annual average temperatures of around 15 ° C. The temperature varies regularly throughout the year, with a mean higher of 10 ° C in the warmer months, and between -3 ° C and 18 ° C in the cold months. It has four well-defined seasons: a relatively warm summer, an autumn with gradually lower temperatures as the days go by, a cold winter, and a spring, with gradually higher temperatures as the days go by. In particular, it is a humid climate with precipitations from 900mm to 950mm per year, with the maximum in the warmer months, with winds from the South Atlantic anticyclone. Local winds: sudestada, pampero and north wind.

MATERIALS AND METHODS

After the research question was raised and with the intention of testing the proposed hypothesis, the different actions were carried out.

A first look at Phenology …

Work teams' organization and observation, inquiry and registration of trees in the vicinity.

- Three groups of students were organized to initiate activities as shown in Figure 2.

Figure 2: Student teams

- A walk was conducted near the school "Nuestra Señora del Carmen" (Perimeter of approximately 400 meters) to corroborate the presence of trees in the vicinity, with the intention of choosing a suitable study site.

Observation: At least 5 different species have been detected with the naked eye in coloration, size, shape and height.

- Species were identified and notes were taken down with the purpose of selecting varied options for the development of the work.

Observation: The species that could be differentiated during the journey, expressed according to their common name, were: privet; ash tree; lapacho; ombú, ilurapitá; liquidambar; crepe and palm.

Study sites selection

Analysis of the selected species

- The species were analyzed and three different species were chosen from the list to apply on them the observation tasks typical of the greenback protocol.

<u>Selection:</u> It was made for its proximity to the school and for different reasons indicated in each case:

- ❖ Ash for being one of the oldest plants that adorned the local sidewalks.
- ❖ Ombú for its meaning to the cultural heritage of the Argentineans, since it represents the pampa, it is the native tree of the gauchos.
- ❖ Clear for its aesthetic appeal.

Study sites location

School and species location.

- It was located on an aerial photograph of the town of Pujato, the 1345 School and the sites of studies chosen *1 Ash, 2 Ombú and 3 Liquidámbar* (Figure 3).

Figure 3: Aerial view of the 1345 School and the three study sites.

- The geographical coordinates of each study site were determined with a GPS and were indicated on a satellite image of the locality obtained from "google maps" (Figure 4).

Ash: 33 ° 01,118 'south latitude; 61 ° 02,587 'west longitude
Ombú: 33 ° 01,143 'south latitude; 61 ° 02.615 'west longitude
Liquidambar: 33 ° 01,139 'south latitude; 61 ° 02.548 'west longitude

Figure 4: Satellite image of Pujato where the study sites are located.

Characterization of each study site

Description of tree species under study

- A name was assigned to each observation site.

The names chosen for the study sites were as follows: *Ash of the Garden, The Ombú of the neighborhood of 1345 and The corner tree.*

- Posters were made in the computer room of the 1345 School, as shown in Figure 5.

Figure 5: Studying to prepare identification posters.

- The species that were located in the three study sites were characterized by the use of magazines, web pages and biology books.

The **ash** is a deciduous tree native to Europe. It is of the genus Fraxinus within the Oleaceae family. It has a medium size since it reaches a height of between 8 to 12 meters and in some specimens they reach more than 30 meters. It belongs to the oleaceous family. It is used as an urban tree because it gives a lot of shade and adapts well to cities, it develops well in mild climates but it is quite resistant to cold and wind, it does not tolerate intense heat and very dry climates. The trunk is straight and hard with cylindrical shape; it gives much shade so it is used in public trees and gardens or parks. The leaves are lanceolate in dark green color and the branches are thin and next to the leaves they form a rounded cup. Its scientific name is FRAXINUS EXCELSIOR and belongs to the group of exotic plants.

The **Ombú** is a tree plant of the genus Phytolacca dioica, belonging to the family Phytolaccaea. It is native of the Pampas Argentina, Uruguay- and South of Brazil, and Paraguay. It is part of Argentina traditions. Despite its thick trunk and large size, it reaches a height of 10 to 15 m, with a large crown and large visible roots. It is an herb that can reach large proportions (especially at the base of the trunk) but the consistency of its wood is very light, almost herbaceous, so erroneously there are those who see it more as a tree than a giant herb. Its stem is quite moist and green with notorious rings of bark, soft and fluffy wood contains large amounts of water, which allows it to survive in the environment of sparse rainfall of the dry pampas. It grows rapidly, and is immune to most insects. Its scientific name is PHYTOLACCA DIOICA and belongs to the group of autochthonous plants.

The **Liquidámbar** is of the genus Liquidambar styraciflua L, belonging to the family Hamamelidácea. Also known as "liquid amber", due to the aromatic resin that is obtained from its bark, it means "rich in gummy substances". It belongs to the Hamamelidaceae family. It is one of the most decorative trees, with maple leaves that offer one of the most colorful autumnal shades of color. Its approximate height is between 10 and 40 meters, reaching its cup a diameter of approximately 10 meters. It is also a deciduous tree, with a pyramidal or conical bearing, narrow and conical in the early years and then widens as it ages. Its trunk is very characteristic, by the deep corky grooves of the bark. Its scientific name is LIQUIDAMBAR STYRACIFLUA and belongs to the group of exotic plants.

- Photographs of the tree species in each site were taken to complete their description. The images were taken from each plant to the different cardinal points: North (N), East (E), West (W) and South (S); which are determined with the help of a compass.

Figure 6 shows the *Ash of the orchard*, in addition another photo is presented upwards where the foliage is observed (Figure 7).

Figure 6: View of the Ash towards the cardinal points.

Figure 7: Ash view up.

It can be seen in Figure 8 *The Ombú of the neighborhood of 1345*, towards the four cardinal directions and in Figure 9 an upward view is shown.

Figure 8: View of the Ombú towards the cardinal points.

Figure 9: View of the Ombú upwards.

In Figure 10 and 11 *The corner tree* is shown according to the cardinal points and upwards respectively.

Figure 10: View of Liquidámbar towards the points.

Figure 11: Liquidambar view up.

Study site definition

Details required by the GLOBE Program.

The required data from the three study sites were completed:

The ash of the garden,

The Ombú of the neighborhood of the 1345, and

The corner tree.

Figures 12, 13 and 14 show the screenshots of the presentation of each site on the GLOBE Program website.

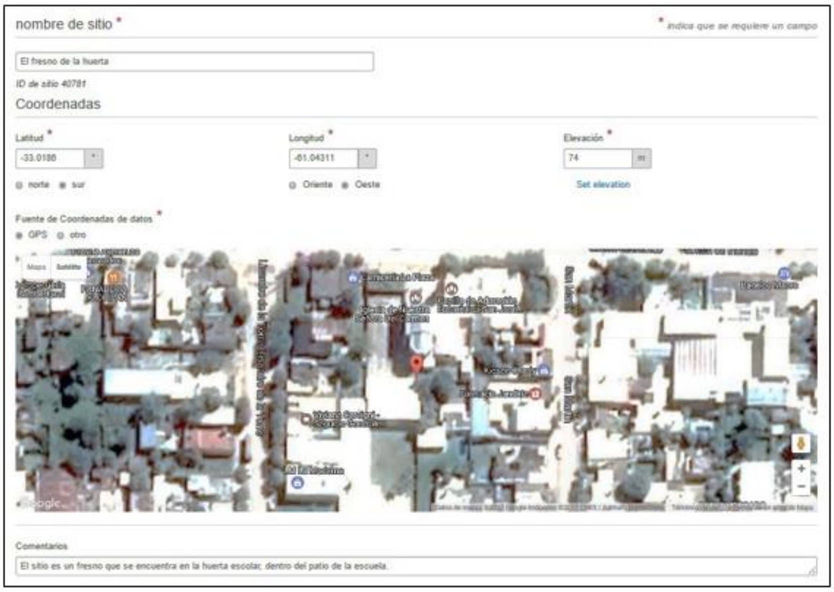

Figure 12: Definition site "*The ash of the garden*"

Figure 13: Definition site "*The Ombú of the neighborhood of the 1345*"

Figure 14: Definition site "*The corner tree*".

Monitoring and Reporting for the GLOBE Green down Protocol

Changes in foliage color and leaf fall.

- For each species, the following monitoring and reporting actions were carried out:

- ✓ Selection of a branch and four of the farthest leaves to the trunk on which the observations will be made. This branch should be directed to the north, for this the compass is used. In turn, a low branch is chosen that is within the reach of the students in order to avoid accidents.
- ✓ Identification of the branch with wool of striking color.
- ✓ Start of observations for a minimum period of two months.
- ✓ Inclusion in each study site of the photographs upwards, showing the foliage of the plant, and towards the four cardinal points, as shown in the previous "Characterization of each study site" in Figures 6, 7, 8 , 9, 10 and 11.
- ✓ Observation of the color change of the leaves of the selected branch until the last leaf has been lost. To do this, it is used the color chart provided by the GLOBE program (Figure 15) to complete the data according to the Green Down for each of the defined study sites.
- ✓ Obtaining photos of the plants, from the tree to the 4 cardinal points and upwards at the end of the application of the Green Down Protocol in order to compare them with the photographs included in the definition of each of the study sites.
- ✓ Comparative analysis of the results obtained in the three tree sites defined in the study. The students work on teams as shown in Figure 16.

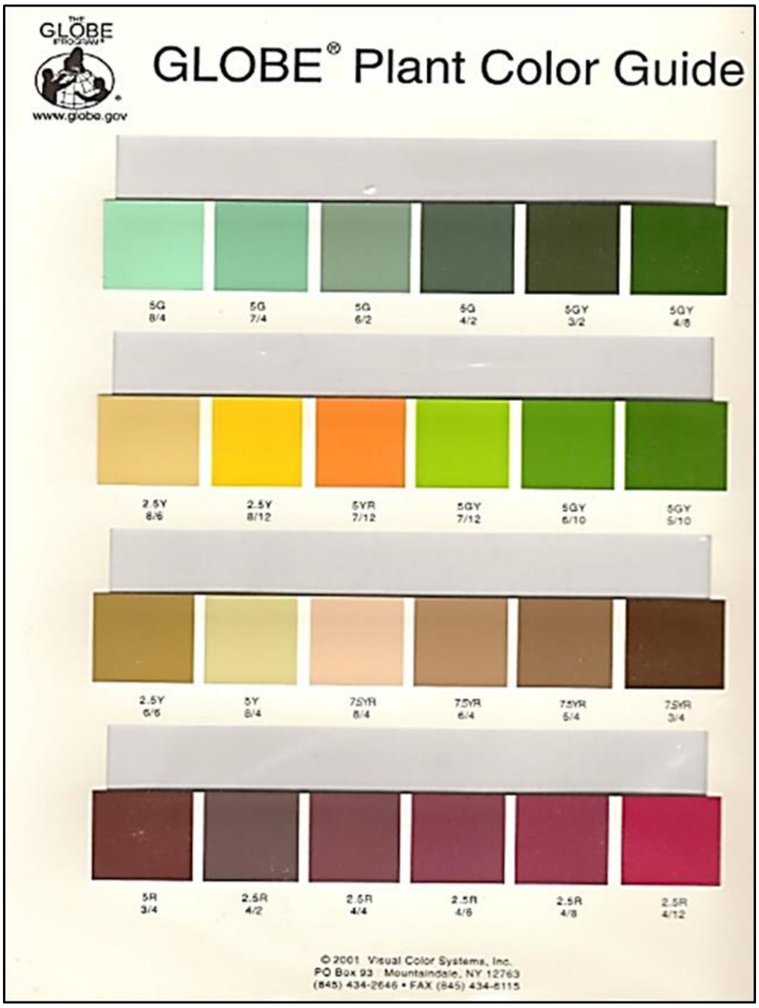

Figure 15: GLOBE Color Chart for Green Down

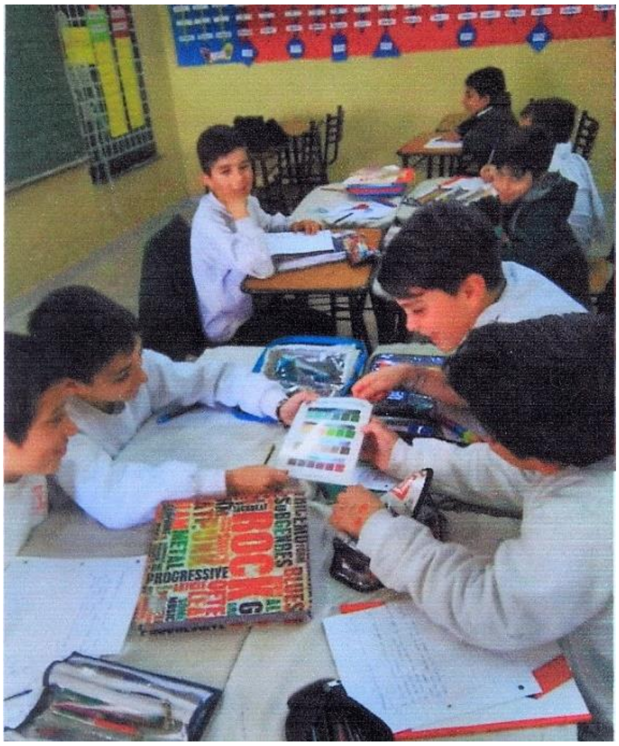

Figure 16: Students comparing results of
the application of the Green Down protocol.

Temperature recording

Maximum and minimum temperatures during the period March-July 2016

Within the meteorological conditions that characterize the climate of Pujato, mild pampeano with four distinct seasons (autumn, winter, summer and spring), extreme temperatures are recorded to relate the fall of the leaves with the environmental conditions.

For this, a record of the maximum and minimum during the autumn - winter period (March, April, May, June and July of 2016) was made. For this purpose, the GLOBE Program database was used in conjunction with the Atmospheric Research study site: ATM-01 of the Private Elementary School Nº 1345 "Nuestra Señora del Carmen", located near the three study sites corresponding to this research work.

Sunrise and Sunset

Search for records and calculate the amount of light hours in the study sites.

- With the help of the internet, from DATEANDTIME.INFO page[2], a detail of the sunrise and sunset times for the area corresponding to the study sites was made, in this case the city of Rosario -Argentina- 40 km De Pujato, during the months included in the different seasons of the year considered in this research:
  - ✓ November 2015 / December 2015 (up to and including 20): Spring
  - ✓ December 2015 / January / February / March 2016 (up to and including 20): Summer
  - ✓ March / April / May / June / July (up to and including 20) 2016: Fall
  - ✓ July 2016: Winter (time the research ends)
- Performing mathematical calculations by students (Figure 17) to establish the average amounts of daily light hours per month and the total amount of light hours per month.

Figure 17: Students performing calculations and interpretations of data.

- Comparison of the amount of light hours in the different seasons in relation to the change in the color of the foliage and the fall of the leaves in the autumn-winter period.

Photosynthesis: a phenomenon related to the growth of plants

Study introduction.

- The following questions were based on the results obtained in the observations made on the leaves of different species:

[2] http://dateandtime.info/es/citysunrisesunset.php?id=3838583&month=7&year=2016

- ✓ What would happen to the growth of the plant if it was placed somewhere without light?
- ✓ Do you think plants can live without light?

From the discussion emerged the importance of light in the growth of plants, and in relation to the answers and conjectures arrived some practices were performed to test what was discussed.

Experiment #1

Students are set up to perform the experimental practice (Figure 18).

Figure 18: Students preparing materials for the experiment.

- Three plants were taken and it was done in each as follows:
  - ✓ The first: it was left in the open air where it received for a week sunlight and water.
  - ✓ The second: it was placed inside a closet, during the same period of time, and received the same irrigation conditions as the first.
  - ✓ In the third: some leaves were covered with a dark EVA (ethylvinylacetate) rubber and left in the open air during the same time and with the same type of irrigation.
- We observed each of the plants and compared the behaviors of each of them.

Experiment # 2

- A green leafy plant was placed inside a closed box that is much larger than the plant dimensions. A small hole was made in one of the upper corners. The box was left in the open air for a week, and was frequently watered.
- Attention was paid to the behavior of the plant and interpreted the observed.

Experiment # 3

- Green, yellow and red leaves of different trees were cut into pieces and crushed with a mortar adding a splash of alcohol, as shown in Figure 19.

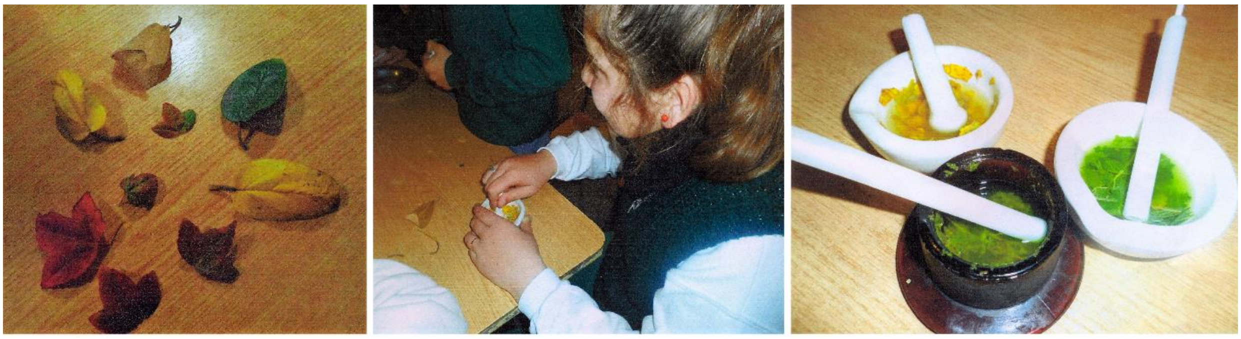

Figure 19: Preparation of Experiment 3.

- A little more alcohol was added and the mixture was placed in three different jars, leaving a rest, as in Figure 20.

Figure 20: Crushed sheets to prepare the chromatography.

- Then the liquids were poured into three clear glasses and a strip of filter paper was placed inside each.
- The result of the practice was observed and interpreted in detail.

RESULTS

Results according to the actions mentioned in the previous section.

As for the **"Monitoring and Reporting for the GLOBE Green Down Protocol"** applied at the three study sites, the data on the GLOBE website corresponding to the observation days for *The ash of the garden, The ombú of the neighborhood of the 1345 and The Corner Tree*, are shown in Figures 21, 22 and 23.

THEGLOBEPROGRAM Entrada de datos CIENCIA

datos Inicio / Escuela Primaria Particular Incorporada N°1345 Nuestra Señora del Carmen / El fresno de la huerta / Green Up/Green Down

Observaciones previas para Green Up/Green Down

From 2016-04-18 To 2016-07-25

	Medido a la hora UTC
1	2016-04-18 00:00 UTC
2	2016-04-21 00:00 UTC
3	2016-04-28 00:00 UTC
4	2016-05-09 00:00 UTC
5	2016-05-12 00:00 UTC
6	2016-05-18 00:00 UTC
7	2016-05-22 00:00 UTC

Figure 21: Dates in which Green Down data were incorporated in the site "*The ash of the garden*"

THEGLOBEPROGRAM Entrada de datos CIENCIA

datos Inicio / Escuela Primaria Particular Incorporada N°1345 Nuestra Señora del Carmen / El ombú del barrio de la 1345 / Green Up/Green Down

Observaciones previas para Green Up/Green Down

From 2016-04-18 To 2017-02-01

	Medido a la hora UTC
1	2016-04-18 00:00 UTC
2	2016-04-21 00:00 UTC
3	2016-04-28 00:00 UTC
4	2016-05-09 00:00 UTC
5	2016-05-12 00:00 UTC
6	2016-05-18 00:00 UTC
7	2016-05-22 00:00 UTC
8	2016-05-26 00:00 UTC

Figure 22: Dates incorporating Green Down data on the site "*The Ombú of the neighborhood of the 1345*"

Figure 23: Dates in which Green Down data was entered on the site "*The Corner Tree*"

Data on foliage coloring and leaf fall according to the Green Down protocol, which were completed at the sites *El ash of the garden, El ombú in the neighborhood of 1345 and The corner tree*, are presented below in Tables 1 , 2 and 3, respectively.

Table 1: Green Down data corresponding to the site: *"The ash of the garden*"

Fecha	Hoja 1		Hoja 2		Hoja 3		Hoja 4	
	Código	Color	Código	Color	Código	Color	Código	Color
18/04/2016	5 GY 3/2		5 GY 3/2		5 GY 5/10		5 GY 3/2	
21/04/2016	5 GY 3/2		5 GY 3/2		5 GY 5/10		5 GY 3/2	
28/04/2016	5 GY 3/2		5 GY 4/8		5 GY 3/2		5 GY 4/8	
09/05/2016	5 YR 7/12		5 YR 7/12		5 GY 3/2		5 YR 7/12	
12/05/2016	HOJA CAÍDA		5 GY 7/12		HOJA CAIDA		5 GY 7/12	
18/05/2016			HOJA CAIDA				5 GY 7/12	
22/05/2016							HOJA CAIDA	

Table 2: Green Data Below corresponds to the site: "*The ombú of the neighborhood of the 1345"*

Fecha	Hoja 1		Hoja 2		Hoja 3		Hoja 4	
	Código	Color	Código	Color	Código	Color	Código	Color
18/04/2016	5 GY 4/8		5 GY 4/8		5 GY 4/8		5 GY 4/8	
21/04/2016	5 GY 4/8		5 GY 4/8		5 GY 4/8		5 GY 4/8	
28/04/2016	5 GY 4/8		5 GY 4/8		5 GY 4/8		5 GY 4/8	
09/05/2016	5 GY 4/8		5 GY 4/8		5 GY 4/8		5 GY 4/8	
12/05/2016	5 GY 4/8		5 GY 4/8		5 GY 4/8		5 GY 4/8	
18/05/2016	5 GY 4/8		5 GY 4/8		5 GY 4/8		5 GY 4/8	
22/05/2016	5 GY 4/8		5 GY 4/8		5 GY 4/8		5 GY 4/8	
26/05/2016	5 GY 4/8		5 GY 4/8		5 GY 4/8		5 GY 4/8	

Table 3: Green Down data corresponding to the site: "*The corner tree*".

Fecha	Hoja 1		Hoja 2		Hoja 3		Hoja 4	
	Código	Color	Código	Color	Código	Color	Código	Color
18/04/2016	5 GY 7/12		5 GY 7/12		5 GY 5/10		5 GY 3/2	
21/04/2016	5 GY 7/12		5 GY 7/12		5 GY 5/10		5 GY 3/2	
28/04/2016	5 R 3/4		5 GY 4/8		5 GY 3/2		5 GY 4/8	
09/05/2016	5 R 3/4		2.5 R 4/4		2.5 R 4/6		5 GY 4/8	
12/05/2016	HOJA CAÍDA		5 R 3/4		5 R 3/4		5 GY 4/2	
18/05/2016			HOJA CAIDA		HOJA CAIDA		2.5 R 4/4	
22/05/2016							5 R 3/4	
26/05/2016							HOJA CAIDA	

Based on detailed recording of the observations in the previous tables, it was stated that:

- ✓ Ash foliage varied within the shades of yellow.
- ✓ The leaves of the Ombú kept the green tone.
- ✓ The foliage of Liquidámbar varied from reddish to brown.

The ash was the first to detach from all its leaves, then the liquidambar, while the Ombú retained the total of the leaves studied. These results could also be verified by observing the photographs corresponding to the last day of application of the protocol. Figure 24 shows three branches corresponding to the species of each site: the *Ash of the orchard, the Tree of the corner* and *the Ombú of the neighborhood of the 1345*, respectively.

Figure 24: Photographs of the branches of the phenological sites completed the study.

Respect to **"Temperature Records".**

The average values of maximum and minimum temperatures obtained during the study period are shown in Table 4 below.

Table 4: Extreme temperatures for the period March / July 2016

Months for 2016	**March**	**April**	**May**	**June**	**July**
Average minimum temperature	15.4ºC	13.5ºC	8.7º C	3.5º C	5.9º C
Average Maximum Temperature	27º C	22.9ºC	17.4ºC	16.2ºC	15.8º

It was observed that during the studied period, from March 2016 to July 2016, both the average minimum temperature and the average maximum temperature decreased markedly.

In the statistical graph shown in Figure 25 it is possible to visualize the recorded data and the trends of the same, in both decreasing cases.

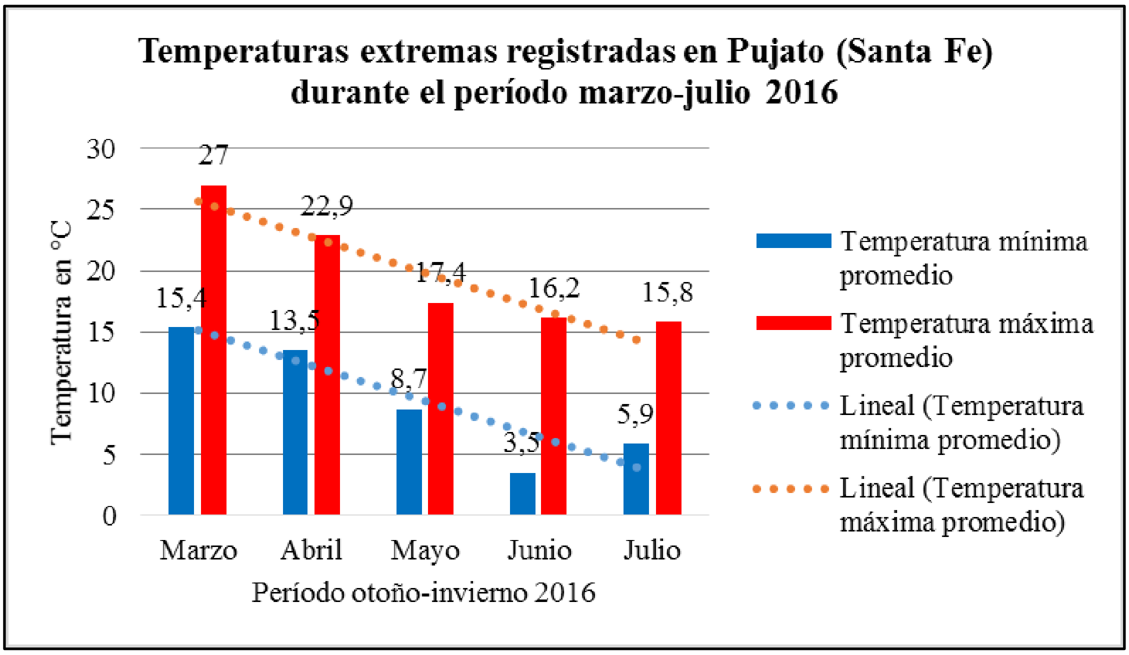

Figure 25: Records of maximum and minimum temperatures in study sites during the autumn-winter period 2016.

After making the registration indicated in **"Sunrise and sunset times**", the time of sunrise and sunset was tabulated as well as the amount of light hours per day for each day of the period from November 2015 to July 2016. Subsequently, the average number of hours of light per day was determined by mathematical calculations and the total amount of light hours per month, as shown in Table 5.

Table 5: Average daily light hours per month and total light hours per month from November 2015 to July 2016.

Months of the year	Average daily light hours per month	Total hours of light per month
November 2015	13.83	414.87
December 2015	14.29	442.89
January 2016	14.03	434.91
February 2016	13.23	383.81
March 2016	12.23	379.27
April 2016	11.23	336.80
May 2016	10.40	322.45
June 2016	10.01	300.29
July 2016	10.24	317.41

Figures 26 and 27 show the table data expressed by statistical graphs where a trend line is included.

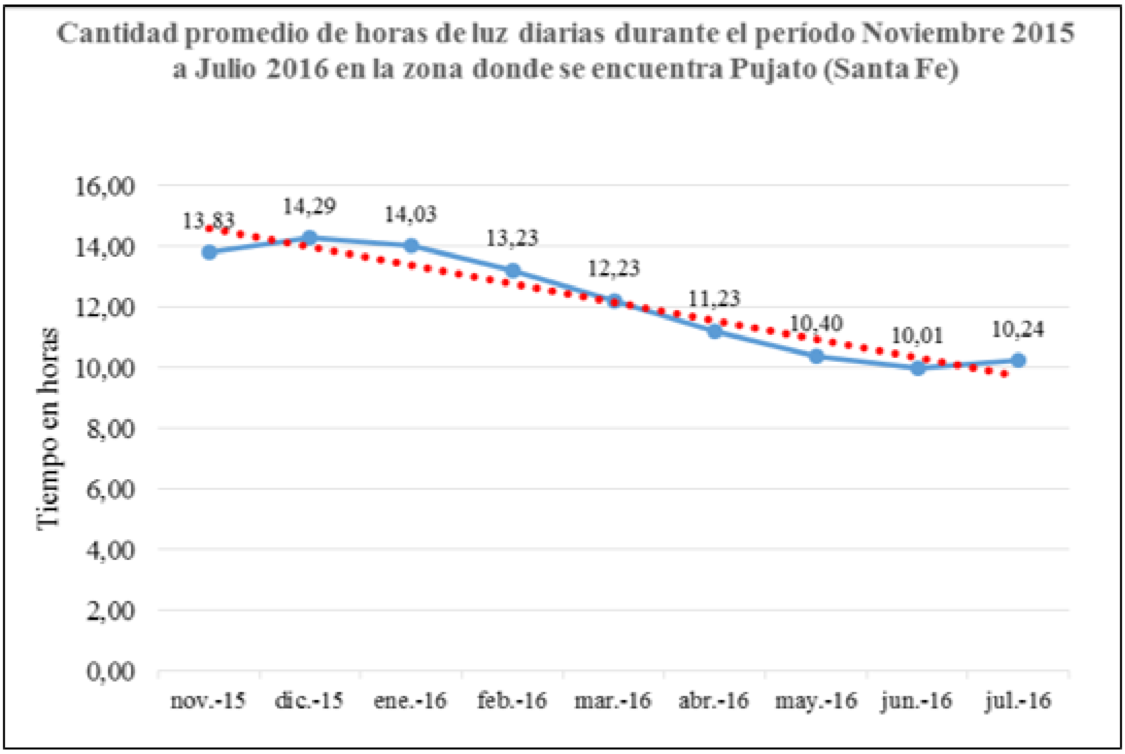

Figure 26: Average hours of daily light in the studied period and corresponding trend.

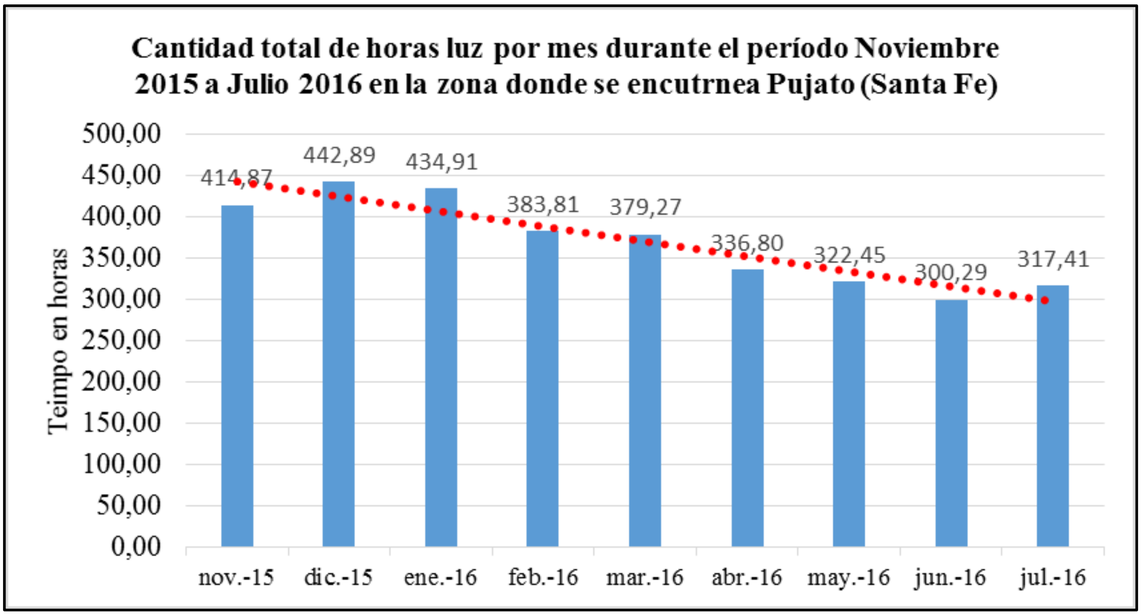

Figure 27: Total hours of light per month in the studied period and corresponding trend.

The data summarized in the table and in the previous statistical graphs show that both the average amount of light hours per day and the total amount of light hours are higher during the summer months (in this study: end of December 2015 - beginning of March 2016). In addition, both variables begin to decrease in the autumn months (in this study: end of March 2016 until the end of June 2016). In spring (in this study: November 2015 and December 2015) the average amounts of light hours per day as total amount of light hours are lower than in summer. Then there is a tendency for both variables to decrease during the winter (in this study: late 2016 and July 2016).

The results of the experiments detailed in the section **"Photosynthesis: A phenomenon related to plant growth"** are shown below.

Experiment 1:

The first plant maintains its vitality. The second plant withers and dies. The third plant undergoes changes of coloration in the covered leaves that did not receive light.

What is observed is that light affects the growth and coloring of plants.

Experiment 2:

The plant grew and oriented in the direction of the hole, where sunlight was entering. This behavior reveals the "positive phototropism" of plants showing how they grow towards the direction where the light is.

Experiment 3:

The technique applied in this practice is called chromatography, that is to say separation of the pigments of different colors that compose the sheet and that are observed in each strip of filter paper; it is due to the fact that green, yellow as reddish leaves contain not only chlorophyll (green pigment) but also other pigments. Chlorophyll is most prominent in spring and summer.

The leaves of the trees are the place where the food of the tree is cooked, a process that is called photosynthesis. In autumn the days are shorter; this tells the tree that there is less for the winter. With the reduction of the hours of light, the trees begin to close the kitchen, and in winter they will live on stored food reserves. The production of chlorophyll stops and the other pigments present in the leaves begin to be seen; which were hidden by the intense green color of chlorophyll.

DISCUSSION

In order to interpret the obtained results, they are analyzed in the light of the contents developed in the theoretical framework.

From the analysis it can be said that the change in coloration of the foliage in autumn-winter is related to the subsequent fall of the leaves. This was detected in two species of study sites, ASH and LIQUIDÁMBAR; while OMBÚ did not change the placement of the leaves and they did not fall.

By linking the results with the theoretical concepts developed it can be stated that the **deciduous trees** change the coloration of their leaves until they fall off the branches during autumn-winter. In this study, according to the records obtained, the species of the sites "The ash of the garden" and "The corner tree" are deciduous. In these plants it was observed that when the light hours were reduced during the autumn-winter period, as detailed above, the leaves were varying in color, in the case of ASH, they passed from green to yellow and in LIQUIDÁMBAR it turned from green to reddish.

In relation to the phenomenon of **photosynthesis**, it can be said that as leaves changed their color they lost the **chlorophyll** that kept them green and that allowed the photosynthesis. The color change of the ASH and LIQUIDÁMBAR leaves showed that the leaves ceased to produce food (chlorophyll) and therefore the appearance of these trees as "dry". This process of color change of the foliage and fall of the leaves coincides with the decrease of hours of light and low in the averages of temperatures, it is something that happens with the arrival of autumn and later winter.

In turn, **evergreen trees** maintain the color of their leaves, not losing them during the autumn-winter period. In this study OMBÚ did not show a change in the color of its leaves that were always green, suggesting that this tree can fit within the evergreen group.

In addition, it has been verified that during the period between March and July 2016 (autumn-winter) in which the color of the foliage changes and the leaves of the deciduous trees studied fall, the average extreme temperatures show a remarkable decrease of the order of 11 ° C for the maximum and 12 ° C for the minimum.

CONCLUSIONS

Finally, it can be concluded that the hypothesis presented has been corroborated through different activities carried out by the students. The leaves of some trees of Pujato (Argentina) change their color during autumn - winter and lose the foliage during this period due to the reduction of the amount of chlorophyll, a tree´s food, which is the modification of certain meteorological variables that directly affect the process of photosynthesis.

One of the detected meteorological conditions has been the reduction of the light hours that decrease from the summer (434 hours) to the winter (277 hours). These hours of light are the ones that allow the plant, through the process of photosynthesis to elaborate the food; as the light period is shortened, the plant also reduces this production, so that the leaf loses its green color, causing other pigments to become more potent, such as yellow, brown and reddish.

Another influential meteorological condition in the decrease of the food production is the decrease of the average minimum temperatures and maximum from the end of the summer towards the winter. This characteristic of mild pampas is the one that marks notorious seasonal differences and which manifests the fall of the leaves of the trees, the changes of coloration of the leaves gives a typical landscape to this region in the autumn-winter period. These changes of coloration that occur from the green to the brown until the leaves finally fall and only the branches remain to simulate dry trees. In this way, the change in the colors of the leaves is related to the fall of the same.

PROJECTION:

It is proposed to observe the leaves of these trees during the spring-summer period, so it will be possible to complete a cycle of study of the foliage throughout the four seasons of the year as it occurs in the region of Santa Fe where Pujato is located.

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