

TOPOGRAPHIC AND TOURIST CARTOGRAPHY OF NATIONAL PARKS AND RESERVES

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ABSTRACT

The main aim of this work is to present the methodology implemented in 'Instituto Geográfico Nacional' (IGN) -National Geographic Institute- to produce Topographic and Tourist Cartography of all National Parks in Argentina. To create a reliable thematic mapping, it was necessary the participation of the 'Administración de Parques Nacionales' (APN) -National Parks Administration- that provided interesting information, symbology, pictures and geo-spatial data. The project is called '*Topographic and Tourist Cartography of National Parks and Reserves*'. The example presented on this occasion as the proposed prototype is a map of '*Los Alerces National Park and Reserve*' at 1:100,000 scale. After a brief description of the project plan, the processes involved in the confection of this map will be presented in the following order: the analysis of available material in the work area, technical characteristics of all input to use, different capture methods, incorporation of data from APN, shadows and illumination model, cartographic edition, additional information, back-side information, and finally, two more stages that have not been finished yet: quality controls and final approval.

Keywords: Protected areas – Tourist – Mapping – Shadow Model – Transparency

1. INTRODUCTION

After a series of surveys among the public in the IGN sales office it was found that map users often demand updated mapping of the places they want to visit in their next holidays. Most of them want to acquire maps of the main tourist circuits in the country which show enough detail to identify all the activities that they can performed in the park. It explains the need for cartographic materials for the process of tourism improvement. Being aware of their needs, we have developed this project hoping to attract the public's attention and promote national tourism. For the first time, IGN and APN -both highly recognized and responsible entities- are working together in order to produce this successful mapping.

Finally, there is an interested audience in acquiring official maps of the most representative tourist circuits of the country. Many of these circuits are in protected areas by the APN who has the most important data that tourists need. In addition, IGN has the cartographic base, skills and resources needed to develop the mapping that society requires. The conditions are set to develop this project.

2. AIMS

- Develop the methodology to implement the production of topographic and tourist cartography at 1:100,000 scale of all protected areas of Argentina.
- Use previous mapping combined with the obtained new captures through several remote sensing systems.
- Make up this cartography with the collaboration of the APN that provides the IGN with general information in different formats.
- Generate, as the proposed prototype, the cartography of a National Park located in the mountain region.
- Add useful back-side information.
- Display the information on the back-side considering the folding.
- Guarantee of an official, accurate and updated cartography of all National Parks of Argentina, for the user to recognize the main characteristics of the area as well as the different activities and services available.

3. PLANIFICATION

In the planning stage the most important details of the overall project were defined such as:

3.1 The scale of representation of the entire project will be 1:100,000 because it is the major cartographic coverage made by IGN. There will be some exceptions: if the park is so extensive that its cartographic representation exceeds 1 meter in length -in any direction-, it will be divided into two maps. But, if its longer dimension is shorter than 40 cm, it will be represented at 1:50,000 scale.

3.2 Using a database of all the parks, generated by the APN, as a starting point, a first classification was performed by region, then by size and after that five columns were added. The 1st and 2nd columns show the distances between the extreme points of each park, expressed in kilometers, the 3rd and 4th columns determine the same distances at the proposed scale but expressed in centimeters, and the last column shows the appropriate scale of representation of each park.

3.3 A deep analysis of previous cartography of all protected areas.

3.4 It will be selected the most appropriate projection in each case.

3.5 The depicted methodology was developed to apply to all protected areas that belong to mountain environment. For the cartographic representation of all parks located out of this environment, the Digital Elevation Model (DEM) will not be used because it is useless in flat areas.

3.6 The most significant element of this cartography is the extra information about all activities and tourist services offered to tourists. This contribution will be made -in different formats- by the APN. This information will consist of geo-spatial data, cartographic signs, general information, and photographs of the most representative sites.

3.7 The final product, will display the map of the site in one side and different information on the back-side. When purchasing the map, the user will be able to choose between two versions: rolled or folded.

3.8 The size of the folded map will be 12.5 cm. wide x 20 cm. high in the whole series. This means that the size of each map will be set in terms of multiples of the above measures in each direction.

4. PARK MODEL SELECTION

After a preliminary analysis of the database and available cartographic material, a park was chosen to be the prototype for the development of the necessary methodology to implement the generation of topographic and tourist cartography of all national parks and reserves.

For its selection, there were four requirements which it had to meet: to be located in mountainous environment, the existence of official maps of the whole park, official cartography at 1:100,000 scale (or greater), and the dimensions of the park had to allow its cartographic representation to be printed on only one sheet.

Of the 41 protected areas in Argentina, only 22 complied with the first requirement. Then, taking into account the official cartography of full parks, the number was narrowed down to three: *Lanin*, *Los Alerces* and *Los Glaciares*. Analyzing the availability of cartography at 1:100,000 scale, there still remained the same three parks. Finally, analyzing their dimensions, both *Lanin* and *Los Glaciares* were too large to be printed on only one sheet. Therefore, *Los Alerces National Park and Reserve* turned out to be the appropriate park for the prototype map.

5. WORK AREA

Los Alerces National Park and Reserve belongs to mountainous environment and covers an area of 2630 km². It was created as National Reserve in 1937 and was declared National Park in April 1945. Located in the Chubut Province (Fig. 1a) at the northwest (Fig. 1b), the park (Fig. 1c) belongs to the Cordillera de los Andes, to the Patagonian Forests Ecoregion and to the corridor of the Northpatagonian Lakes. Some of the peaks exceed 2000 meters, and includes some glaciers and several lakes, framed in a forest habitat that makes the park so particular.

The approximate geographical coordinates of the centre of the park are: 71°50' W and 42°50' S. To the west, the park borders the neighbouring Chile Republic.

Los 'Alerces' is a forest of ancient trees, known in Europe as Larchs. The 'Abuelo' (Grandfather) is the oldest specimen in the park and it is about 2600 years old.

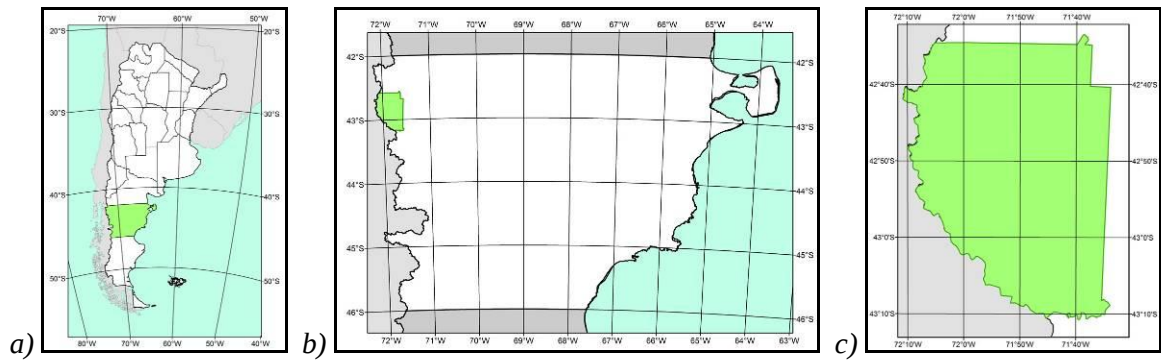


Fig 1: a) Chubut Province in Argentina; b) the park in Chubut Province; c) the park itself.

6. AVAILABLE CARTOGRAPHY

6.1 Cartography of the Whole Park

A topographic and tourist map at 1:150,000 scale (Fig. 2a) was made and printed by 'Institute Geográfico Militar' (IGM -IGN since 2009-) in 1977. It has a contour interval of 150 meters and includes all the information about tourist activities done at the time.

6.2 Cartography at 1:100,000 scale

Five topographic maps at this scale (Fig. 2b), which make up the whole park, were published by IGM during 1981 and 1982. They have a contour interval of 100 meters.

6.3 Boundary Cartography

Six topographic maps (Fig. 2c) at 1:50,000 scale were published in 1995 by 'Comisión Nacional de Límites Internacionales' (CONALI) -Argentinian National Commission of International Boundaries-. It have a contour interval of 50 meters. They don't cover the total area of the park, but only a thin strip on both sides of the international boundary.

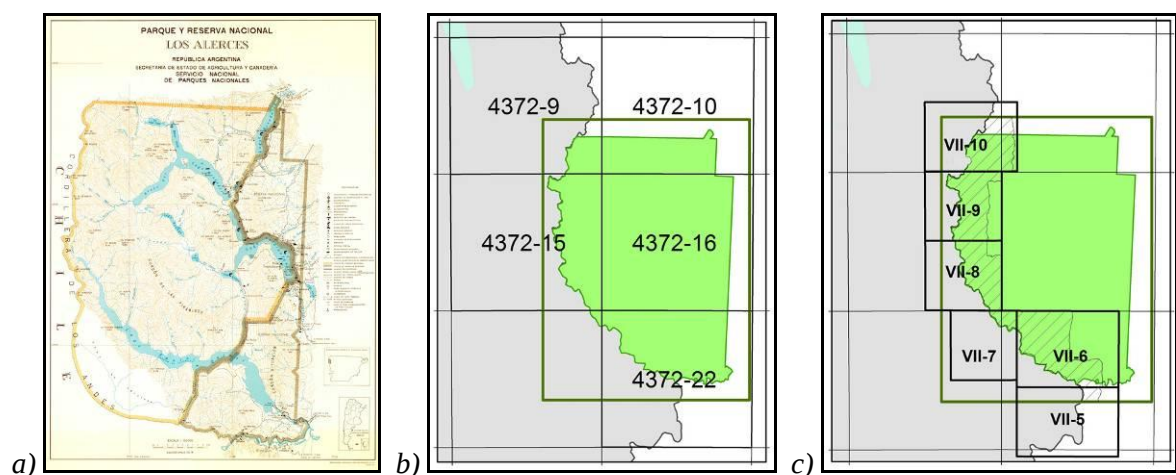


Fig. 2: a) Whole Park, 1:150,000, IGM-1977; b) 5 topographic maps, 1:100,000, IGM-1981/2; c) 6 Boundary maps, 1:50,000, CONALI-1995

7. IMPLEMENTED SYSTEMS

The different systems used to produce the prototype map are next:

7.1 Projection System

Gauss Krüger, Strip 1: a Transversal Mercator Projection whose meridian of tangency is 72° W.

7.2 Coordinate System

Geographic: many users utilise GPS navigators which express the value of coordinates on the same system. The interval between each pair of parallels and meridians represented shall be five minutes.

7.3 Reference System

WGS84.

7.4 Geodetic Reference Frame

POSGAR 07, i.e. Argentinean Geodetic Positioning 2007. It was adopted as National Geodetic Framework in 2009.

8. GEOREFERENCING OF PREVIOUS CARTOGRAPHY

The previous cartography was scanned and then geo-referenced to WGS84. As for the tourist map, it lacks enough information to know which projection was used. The only known fact is that it is not a Gauss Krüger Projection. Therefore, the map was adjusted by similarity of features. Despite of the fact that such a method lacked precision, it is nevertheless considered acceptable because its scale of representation is less than the proposed and because, from this one, we only needed all tourism activities and services represented on it.

The IGM cartography at 1:100,000 scale as well as the CONALI cartography were made on two different local reference systems, both separated from each other by the 43° S parallel. The two systems are: Extremo Sur Base El Bolsón, which is to the north of the 43° S parallel, and Extremo Sur Base Lago General Paz, to the south. The transformation parameters from these local systems to WGS84 are:

- Datum Base “El Bolsón”: X= - 51.00 meters
Y= + 69.70 meters
- Datum Base “Lago General Paz”: X= - 220.30 meters
Y= + 9.75 meters

Knowing the transformation parameters of each system to WGS84, the two re-projections were made without any problems. The result of the adjustment was within the permitted tolerance for the scale chosen.

9. NEW TECHNOLOGIES EMPLOYED

9.1 Digital Elevation Model (DEM)

IGN developed a DEM (Fig 3a) for Argentina. This model was based on information from the SRTM (Shuttle Radar Topography Mission) 30 meter pixel size, from field surveys and photogrammetric restitution. This new obtained DEM has a resolution of 45 meters. Once cut the DEM of the work area, it was adjusted to the Argentine altimetric frame, whose 0-meter height matches mid-sea level, which is set by the Servicio de Hidrografía Naval's tide gauge of Mar del Plata City, in Buenos Aires Province.

9.2 Satellite Imagery

The satellite images used for cartographic capture and updating of information comes from two different sources: on the one hand, a 30m-Landsat 8-multispectral image merged with a 15 m-panchromatic one (Fig. 3b). On the other hand, the Imagery Package is provided by ESRI Company by means of the software ArcGis v.10.

9.3 Geographic Information System (GIS)

IGN doesn't have cartography in GIS format for the required scale about this park, but the capture of some elements by satellite image was made by a geographic information system. The APN, by contrast, has almost all its geo-spatial data in this format (Fig 3c).

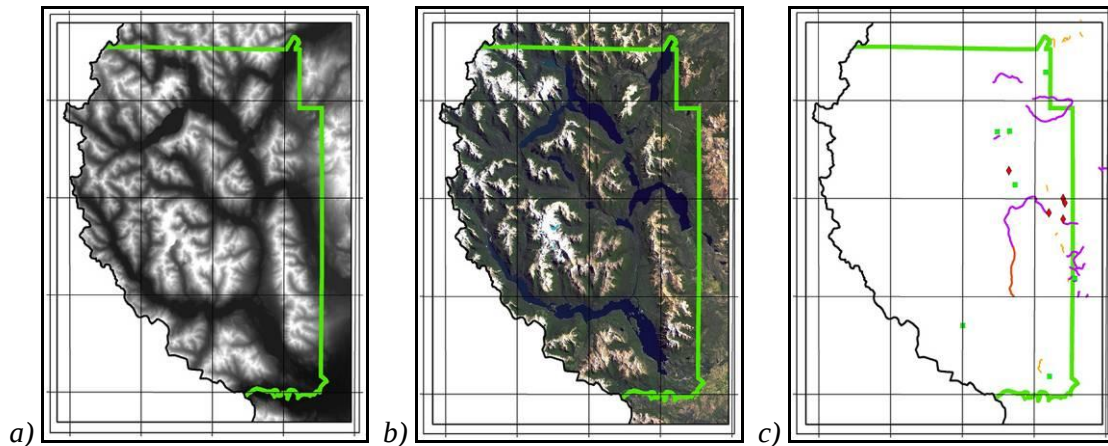


Fig. 3: a) DEM-45m IGN; b) Landsat 8 Satellite Image; c) GIS from APN

10. CAPTURE METHODS

The origin of the different captures and the geographical objects captured from each are:

10.1 Satellite Image

This process was divided in three stages:

- Water Bodies and Hydrography (Fig. 5a)
- Roads and Buildings (Fig. 5b)
- Vegetation Areas and Snow Areas (Fig. 5c)

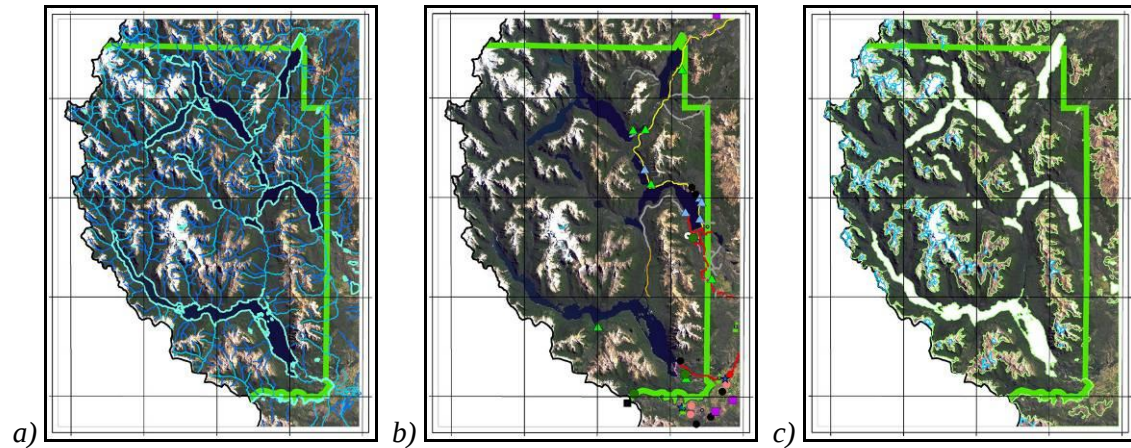


Fig. 5: Capture of: a) Lakes and Rivers; b) Roads and Buildings; c) Vegetation and Snow Areas

The capture was taken ensuring the incorporation of all cartographic elements represented in old cartography.

The features that could not be identified in the Landsat 8 image were captured from Imagery Package. The scale of capture was 1:50,000 for the first case and 1:20,000 for the second.

10.2 DEM

- Contour lines. Contour interval: 100 meters (Fig. 4a)
- Shadow model (Fig. 4b)
- Hypsometry where there are areas covered by vegetation (Fig.4c)

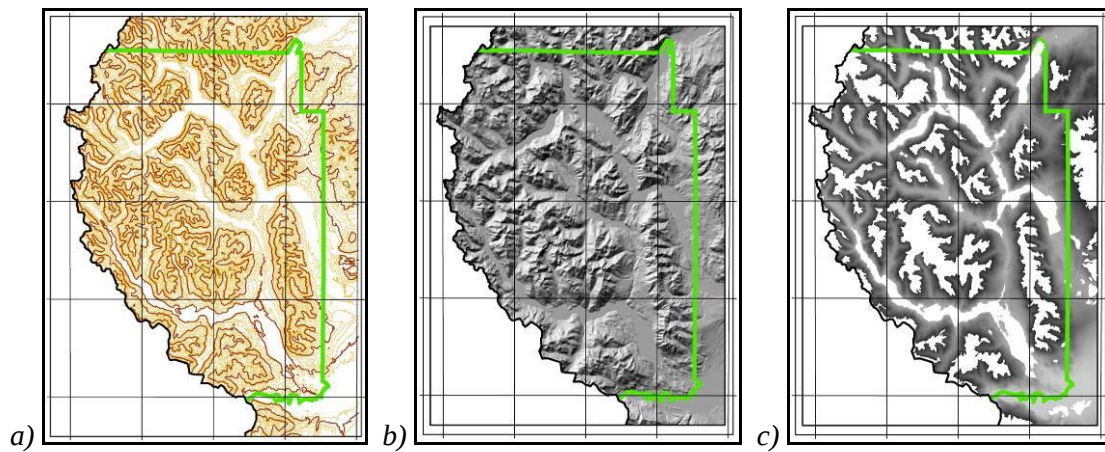


Fig. 4: a) Contour lines; b) Shadow Model; c) Hypsometry in Vegetation Areas

10.3 Previous Cartography

- Geographical Names
- Spot Heights
- International Boundary

10.4 APN GIS

- Park Ranger
- Points of interest
- Trekking Paths
- Updated Geographical Names

11. COMPARISON OF CONTOUR LINES AND EDITION OF THE ALTIMETRY

A comparison between the contour lines -obtained from DEM- and the hydrography -captured from the satellite image- was made. The outcome was more than satisfactory. The only feature that had to be modified was a contour line of 500 meters in some parts of the coast of a lake and in a stretch of one of its tributary rivers (Fig. 6).

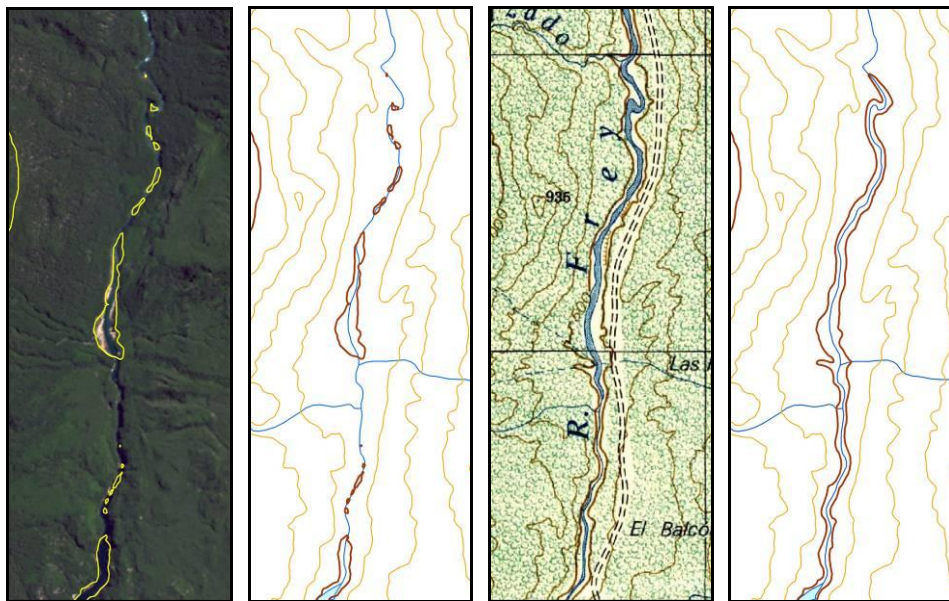


Fig. 6: A contour line, located along a river, had to be vectorized

Comparing the altimetry with previous cartography, two kinds of mistakes were detected: one of them in big slopes (1) and the other, on small flat areas (2):

- 1) On the side of a peak, a group of eleven contour lines developed in a perfectly stepped fashion (Fig. 7).

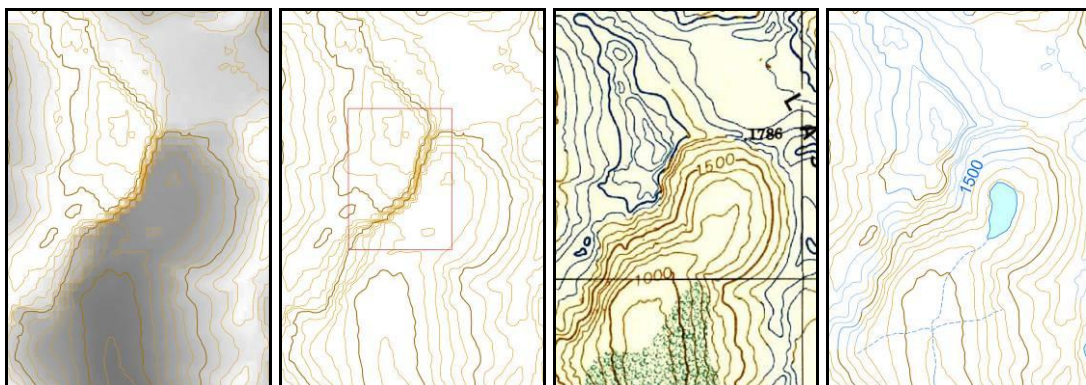


Fig. 7: eleven contour lines had to be corrected

- 2) In front of both coasts of the arm of a lake, there were contour lines suggesting cliffs where there are none (Fig. 8). The case of greater magnitude expressed total length of 9 km and a maximum height of about 400 meters.



Fig. 8: contour lines located in the coast of a lake were corrected

In both cases, the solution was the capture of contour lines from the previous mapping.

Regarding the “Spot Heights – Contour lines” control made according to the heights in previous cartography, some inconsistencies were detected. With a total of 245 spot heights represented in IGM and CONALI cartography (at 1:100,000 and 1:50,000 respectively) only 81 coincided and 95 of them were able to adapt. These 176 spot heights (nearly 72%) uniformly distributed throughout the work area were incorporated.

Solution: the points contained within a ratio of 100 meters from the place where they should be (generally mountain peaks) were moved to the true spatial position.

12. SHADOWS AND ILLUMINATION MODEL

Overall, the model used as raster image underneath the rest of the geographic information, graphically represents the lighting and shadow of the sun applied on a portion of the earth's surface at any given time, which is based on the position of the Sun with respect to the work area. This position is defined by two angular values: azimuth and altitude of the Sun. In the proposed map these parameters are 315° and 45° respectively. This model comes from the processing of the Argentinean DEM of 45 m.

To begin with, the DEM was processed by ERDAS software, to obtain the shadows model. Then, the model was processed by ArcGis software; the color ramp applied starts in black colour on the left and finishes in white colour on the right. Subsequently, the lighting model was generated from a copy of the shadow model. This stage required changing the color ramp by another which was divided in two parts; the first starts on the left in a white colour and finishes in a light yellow (1% cyan, 1% magenta and 13% yellow), and the second part starts on the left in the same last colour, and gradually increases its percentages to reach in medium yellow on the opposite end (4% cyan, 4% magenta and 52% yellow).

After that, the percentage of contrast, brightness and transparency in each (Fig.9) were modified to highlight the intended effect. The adjusting made in each model was next:

Shadow model: contrast: 25%; brightness: 33% and transparency: 65%.

Illumination model: contrast: 50%; brightness: 10% and transparency: 80%

Applying transparency to the illumination model and overlaying it on the shadow model, both effects can be appreciated. The combination and contrast between them makes it easy for users to interpret the relief of the mapped area.

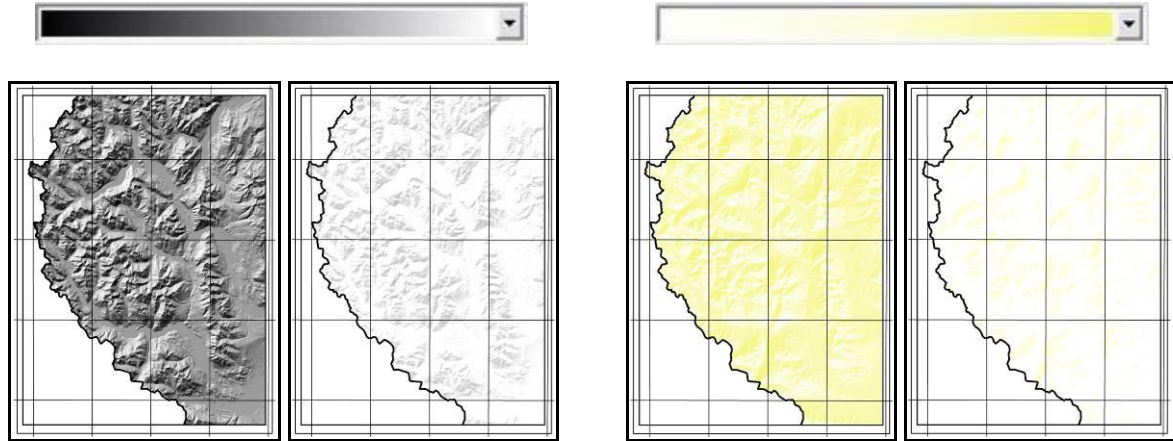


Fig. 9: The color ramps (grey and yellow) before and after adjusting of the contrast, brightness and transparency.

13. AREAS: VEGETATION, STEPPE AND SNOW

13.1 Vegetation areas

Polygons representing perimeter vegetation areas were used to cut the original DEM. This new file, in an img format and with a green color ramp, represents the area covered by vegetation. Then, a 65% of transparency was applied (Fig. 10a) and this raster file was put on top of the shadow and illumination model. The ramp achieves a hypsometric effect in these areas. In this case, the lowest areas were represented in light green colour and the highest ones in dark green.

13.2 Steppe areas

A light brown polygon (Fig. 10b) was placed over the areas without vegetation, usually located in the zone comprehended between forests and snow areas. Then, a 50% transparency was applied, which allows the display of the shadow and illumination model.

13.3 Snow areas

For the representation of water in its solid state (snowfields, icefields and glaciers), it was necessary to cover the shadow model of these zones with white masks. After that, another raster file was generated by cutting the shadow model with the perimeters of these areas, and then, a cyan color ramp was applied to it. The ramp begins in a darker grayish cyan tone on the left and it ends in a low percentage of cyan on the right. This was possible by decreasing the percentage of cyan, magenta and yellow. Then, after being applied a 15% contrast, 15% brightness and 50 % transparency, the new image (Fig. 10c) was put on top of the white shapes.

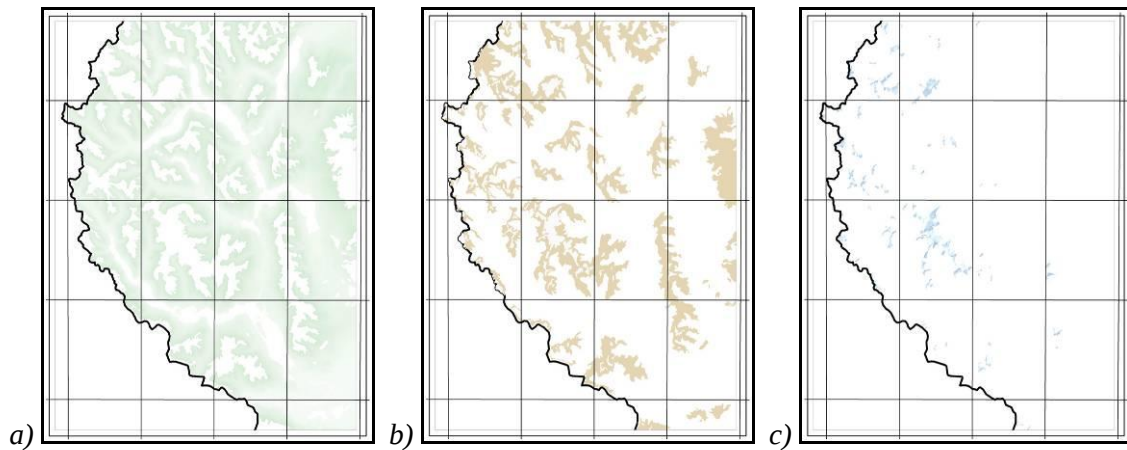


Fig. 10: The three kinds of areas represented: vegetation, steppe and snow

After the representation of these three areas, a new image was made, showing the merger of shadow, lighting, vegetation, steppe and snow areas. Then, the file was saved as geo-referenced raster file and, after that, some design adjustments, using Photoshop software were made (Fig. 11). The file was then used as reference for cartographic editing, by opening it underneath the vector file.



Fig. 11: Merge of the five raster files

14. CARTOGRAPHIC EDITING

In general, most of the symbols used in this map are the same that IGN uses for making official maps, based on its Cartographic Signs Handbook.

An important change is the sign which is used to represent the administrative boundary of the park; its size was increased to twice the size of those in accordance with regulations. Also, below this sign, we added a 7.5-millimeter-thick mask (5 mm going into the park and 2.5 out) in dark green colour to highlight its location at a glance.

On the raster image that represents the shadow model and the areas, a 40% transparent white mask was applied over all territory that doesn't belong to the park. Then the green mask that goes along the park boundary with 55% transparency was incorporated, and finally the new image was saved as a GeoTIFF raster file.

The signs used to represent all points of tourist attraction are the same that APN uses in all its publications.

In order to facilitate its reading, the size of all geographical names of all the mountains and their heights was increased by a point with respect to the established by the IGN cartographic rules for its topographic maps at 1:100,000 scale.

15. ADDITIONAL INFORMATION

To ensure a good reading and interpreting of the mapping proposed, the incorporation of useful additional information to the user was necessary. Since on this occasion, the map includes, to the west, an area of the Chile Republic territory, and it is not our purpose to represent the neighboring country, this sector was taken advantage of for the incorporation of all this additional information. This includes data such as map title (coinciding with the name of the park), scale, contour interval, cartographic references, magnetic declination, meaning of acronyms and abbreviations, four graphics containing political or administrative boundaries, etc. In addition, outside of the work area there is some more information, such as: contour values, road directions and geographical coordinates.

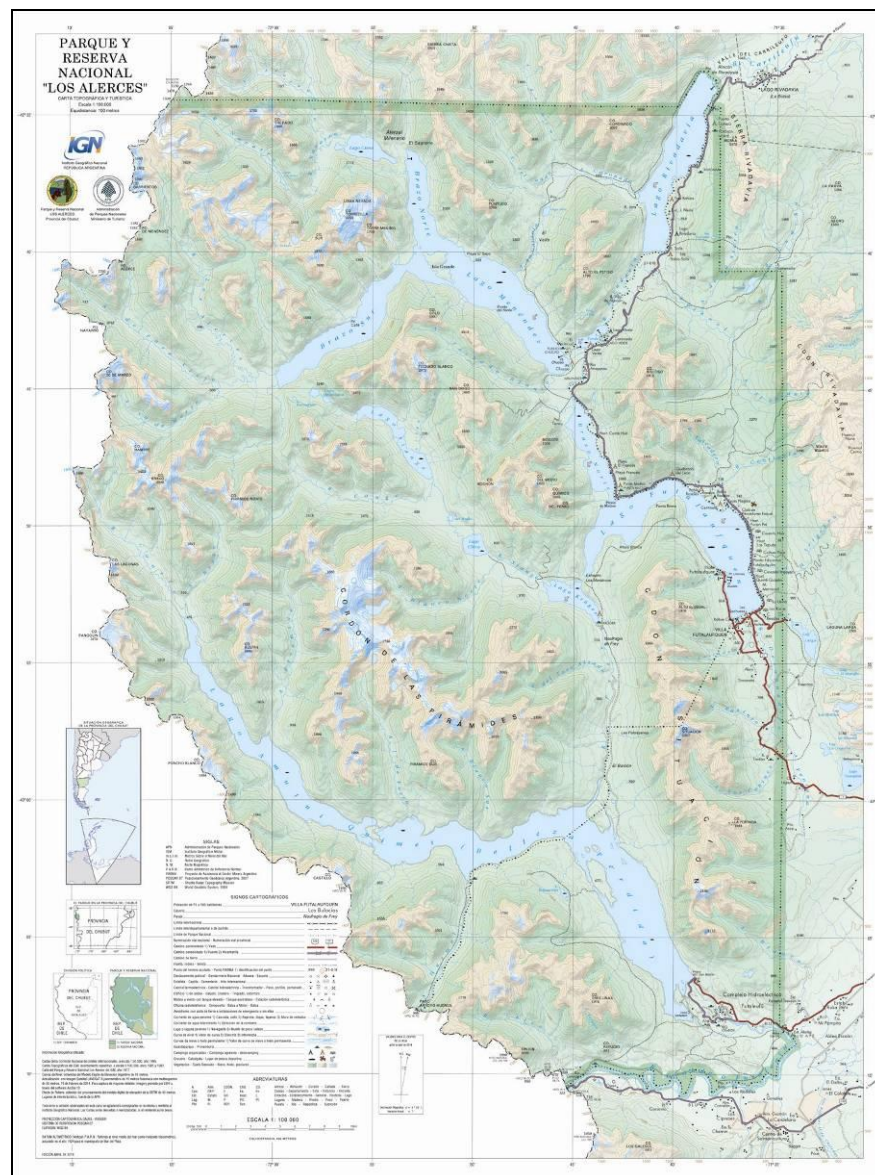


Fig. 12: The prototype map of 'Los Alerces National Park and Reserve' at 1:100.000 scale.

16. BACK-SIDE INFORMATION

At the back of the map (Fig. 13), the project incorporates a satellite image at 1:200,000 scale, general information and some photographs of the most representative places of the park. Except for the satellite image, the main geographic characteristics and IGN institutional information, the rest of the information at the back, was provided by APN: History of the park, geographical characteristics, useful data, lodging, camping sites, hiking, curiosities, native species and an interesting guide to safety regulations. The design and distribution of information on the back-side were made by personnel from IGN's Institutional Relations Design Department.



Fig. 13: the back-side information

17. QUALITY CONTROLS

Currently, the map is in the control stages

There were four controls performed on plots: one at APN and three at IGN:

17.1 Checking (APN)

One printed map was given to APN to incorporate all the observations that ensure a better product quality.

17.2 Geographic Update (IGN)

IGN's Geographic Services General Office is controlling the categories of communication routes and the applied toponymy.

17.3 Quality Control (IGN)

IGN's Quality Control Department have to sure that the map included all the information placed in the previous mapping, the correct application of the signs, the spot height-contour line relationship, geographic coordinates and the overall aesthetics of the map.

17.4 Text Revision (IGN)

All the texts included on both sides are being reviewed by the IGN's Revision Area, detecting some mistakes both of grammatical and spelling origin.

18. CORRECTIONS, FINAL APPROVAL AND FINISHED FILE

Each control stage will generate a detailed report containing all detected errors and suggestions to make the appropriate correction in each case. Then the reports will be attached to the corresponding plots and delivered to IGN's Cartography Office to perform the required corrections.

Before the printing stage, two more plots will be printed for final approval from the authorities of both agencies. Any disagreement about aspects of the product will be discussed with the consultant team and the areas involved. If necessary, the map and the new generated report will return to IGN's Cartography Office to make the necessary corrections. Then, once the plots are signed, IGN's Director will order the printing of 2500 copies of the map on waterproof paper.

For the printing, IGN's Cartography Office will export the map file in dgn format to pdf format. Finally, this file, together with the back-side information file, will be sent to IGN's Graphic Department for printing.

19. CONCLUSIONS

Finally, it was possible to develop a methodology to generate topographic and tourist maps of all protected areas that belong to Administración de Parques Nacionales. It was used previous mapping, as well as new inputs obtained from the capture of modern remote sensing systems to generate this proposed cartography. The APN has cast the most important contribution to achieving the objective. We relied on shape format files from GIS APN in order to include them in the GIS IGN, indications related to tourist activities, long texts with different pieces of general information, photographs and overall, the advice and support from all the technical and controlling staff. As first prototype of this authorized thematic mapping, this topographic and tourist Mapping of 'Los Alerces National Park and Reserve' located in a mountain environment was produced at 1:100.000 scale which will soon be available for the public. We made sure to include all the information that both agencies had available, good accuracy, updated data and new techniques of mountain cartographic representation, to produce a different aesthetic design ever seen in our previous cartographic products. The user, with the help of this map, will be able to recognize each place, guide itself, plan their stay according to the activities offered, stroll along the paths and learn about the main characteristics of the park and its habitat.

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