THE SCHOOL FOR FIELD STUDIES

Patagonian Ecology
SFS 3781

Syllabus
4 credits

The School for Field Studies (SFS)
Center for Climate Studies (CCS)
Puerto Natales, Chile

This syllabus may develop or change over time based on local conditions, learning opportunities, and faculty expertise. Course content may vary from semester to semester.

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COURSE CONTENT SUBJECT TO CHANGE

Please note that this is a copy of a recent syllabus. A final syllabus will be provided to students on the first day of academic programming.

SFS programs are different from other travel or study abroad programs. Each iteration of a program is unique and often cannot be implemented exactly as planned for a variety of reasons. There are factors which, although monitored closely, are beyond our control. For example:

- Changes in access to or expiration or change in terms of permits to the highly regulated and sensitive environments in which we work;
- Changes in social/political conditions or tenuous weather situations/natural disasters may require changes to sites or plans, often with little notice;
- Some aspects of programs depend on the current faculty team as well as the goodwill and generosity of individuals, communities, and institutions which lend support.

Please be advised that these or other variables may require changes before or during the program. Part of the SFS experience is adapting to changing conditions and overcoming the obstacles that they may present. In other words, this is a field program, and the field can change.

Course Overview

This course focuses on ecology as a discipline, biodiversity, and the Patagonian ecoregions and habitats that have evolved with short growing seasons, tenacious southwesterly winds, and fierce winters. We will examine the ecology and evolution of faunal species such as guanaco (related to the llama), Magellanic and king penguins, and the flightless ñandúes, most of them endemic to the region. We will explore ecological succession, including primary succession, which is how life recruits into new environments, such as bare rock after glacial retreat or after volcanic eruptions. We will explore a remarkable climatological gradient from Magellanic rainforests to semi-arid pampa. We will also travel to the temperate rainforests of Northern Patagonia.

Thematically, we will traverse alpine ecology, exposed terrestrial ecology, coastal ecology, marine ecology, and fire ecology. From the central focus on the theory and practice of ecology, we will expand to investigate relationships between people and nature in conservation, resilience, and environmental challenges. We will explore the role of protected areas in conservation, invasive species, human-landscape interactions, and current and predicted changes due to climate change. The course is constructed so that the role of climate in shaping ecosystems and ecological relations are central to discussions and observations.

Learning Objectives

A fundamental skill in applying ecological contexts is to understand how large-scale processes (climate, evolution, etc.) derive a location's ecological context. This will help understand and begin to predict the likely impacts of local and regional perturbations. Field practica will connect organismal ecology with ecosystem ecology to view the behaviors and patterns of animals within the larger contexts that they shape and – in turn – shape them.

This course has three major objectives for student learning:

1. Understand and articulate the mechanisms of global warming and utilize this to begin to understand how ecosystems and associated ecological interactions are likely to be affected.
2. Use spatial data to interpret how past and current climate shape the ecological distributions of native and exotic species across Patagonia.
3. Develop scientific questions to analyze ecological data. By defining the question for analysis, it is possible to evaluate what aspects of ecological relevance can be evaluated from data.

Thematic Components and Research Direction

The large-scale question we address in this course is:

How can Patagonia respond to local and global challenges while securing the functionality of its natural and human systems?

Subtheme 1

Understand how local ecologies throughout Patagonia are affected by medium and large-scale processes that are under change. By understanding how factors like climate and management intersect with local topography and evolutionary lineages, it is possible to examine the directionality and degree of changes affecting the region.

Subtheme 2
Understand how local management strategies (conservation, ranching, etc.) create ecological effects within and beyond the physical boundaries of managed areas. This will help evaluate the implications of the presence and management of protected areas on private, neighboring properties, and vice-versa. Understanding the permeability – let alone visibility – of these boundaries will help in evaluating the implications of the addition of salmon farming, agricultural practice, and sheep and cattle grazing on the wider environment, as well as the implications of the designation and management of protected areas in that same environment.

Assessment

The evaluation breakdown for the course is as follows:

Assessment Item	Value (%)
FEXs (x2)	25
Species Report	20
Field Notebook	15
Field Activities	10
In-class Activities	10
Integrated Discussion	10
Participation	10
TOTAL	**100**

FEXs (25%)

FEX 1 (10%) Aquatic macroinvertebrates
Subject: Evaluating stream processes and water quality using aquatic macroinvertebrates as indicators
Methods*:* In the freshwater systems near Puerto Natales, we will collect aquatic macroinvertebrates. Given their physiological requirements, these organisms can provide a good evaluation of ecosystem functioning and the implications of natural and human influences on water quality. We will use fundamental statistical approaches to evaluate different questions about environmental conditions and collected abundances.
General Skills: Students will develop a basic research question, evaluate the collected data based on their research question, and practice their editing skills.

FEX 2 (15%) Monitoring reforestation in Torres del Paine National Park
Subject*:* Collecting simple field measurements to evaluate patterns of tree growth
Methods*:* We will be measuring the growth of *Nothofagus* saplings that were planted in Parque Nacional Torres del Paine as part of a larger restoration effort. You will be provided with theory about conservation, reforestation, and measuring techniques prior to going to the field. In the field, you will work in groups to measure *Nothofagus* in a reforestation zone, and then use these measurements to conduct simple statistics and write up a report.
General Skills: Students will develop a basic research question, utilize statistical methods (ANOVA), and practice their editing skills.

Species Report (20%)

Patagonia is a region with a particular ecology, shaped by ice, isolation, and biological invasions. In order

to develop a deeper understanding of some of the more visible species found in the region, you will work in groups of four throughout the semester to compile and comprehensive report on one species. This report will be developed through direct field observations, online data, scientific reports, and basic ecological modeling. Each group must schedule *at least* two meetings with me (one on each side of the mid-semester break) to develop a plan for developing the report, understand what to anticipate for species sightings in field expeditions, and work through questions and challenges they are having.

Field Notebook (15%)

Each field expedition provides a context for observation and learning. As we progress through the semester, the class themes will become easier to see in the landscape, and the things we see in a new location deepen the understandings we made in prior spaces. A field notebook is a physical means of capturing the observations and insights that you gain in the field over the course of the semester.

You should become in the habit of making observations of your surroundings and contextualizing them to the processes that surround them. Especially when we go out of town, every day on a field excursion is an opportunity to develop your field observation skills. During a field outing, these personal observations will form the basis of entries you write up in your field notebook. You can develop your field notebook observations in many forms, including a written description, a drawing with its short description, a conceptual diagram, etc. However, your field observations should **not** be a simple recapitulation of the academic field activities (i.e., lectures, FEXs, professor-guided activities). Rather, they should be based on **your own** observations, insights, and musings.

During every field expedition, you will have assigned time to develop your field notebook. This programming promotes efficient time use and considers that faculty members will be present to clarify any observation you make on that day.

Your field notebook must have at least one (1) entry per field day, and it must include at least two (2) entries for each class at each hand-in, namely following the PE18 and PE34 classes.

Keep in mind the following grading rubric:

- **Completeness (1%):** Each individual entry must include the *location*, the *date*, the *course* to which the entry is directed, and the *observation* you made.
- **Coherence (4%):** Each entry should be **coherent** in the way it presents information. This includes legibility, connection of ideas, and concept development. If figures and drawings are included, coherence would mean placing them in their observed context and indicating how they connect with the short writing description of it.
- **Correctness (6%):** Each entry should contain factually **correct information**. If you need clarifications, faculty members are geared to help you.
- **Connection (4%):** Each entry should try to connect the field observation with something beyond the location. This can be to other observations you made within your field notebook, course content, and even familiar landscapes back home. The key is to use the field notebook as a tool to connect with understandings that are being developed in the classes, knowledge that you bring with you, and observations and insights you have made in various locations.

Field Activities (10%)

The field offers many opportunities to learn, both with the contexts that we find in the location we visit, as well as in comparison to other locations. Field activities include data collection, quizzes, and field site analysis. Data collection using the iNaturalist app will help develop a local database of species

observations and will be evaluated on collected data quality. Quizzes will evaluate your ability to connect field observations with course materials. Field site analysis will evaluate the ability of the students to find information from the field location that draws on various lines of knowledge and observation to tell us about the expected conditions we find in a location.

Classroom Activities (10%)

You will work in small groups to pursue in-class activities throughout the semester. These include exercises in GIS, working through statistics, and making presentations on ecological topics. GIS and statistics exercises will be based on ecological and ecosystemic datasets that are relevant to topics of Patagonian Ecology. Presentations will have a time limit and will be graded on the connectivity of the paper with the selected ecological topic, the correctness of the information presented, adherence to time limits, and the quality of the presentation. PowerPoint-style presentations are not required.

Integrated Discussion (10%)

To review and develop our understandings of the topics explored in the field, we will have **two** integrated discussions. Since all field locations provide context for observation and learning, this activity will take advantage of your Field Notebook entries and class notes to integrate knowledge. For each integrated discussion, the class will be broken into four (4) groups, with each group being in charge of connecting specific themes with specific field locations. Each group will use an online platform to make a presentation and guide a discussion of their peers.

Keep in mind the following grading rubric:

- **Digital platform use (3%):** Each group must select an online platform to create their presentation and discussion guide. Your use of this platform should best display the knowledge gained in field locations. This platform should display content in an interactive way and must be capable of offline sharing.
- **Connecting field locations to course contents (3%):** Each group will be evaluated on how they connect their assigned field locations with course content on the platform. This includes coherency of the written content.
- **Presentation and discussion (4%):** Each group member will be evaluated on the presentation of their materials to their peers, their ability to lead and moderate a discussion that covers the topics they were assigned, and their level of engagement with the discussions of other groups.

Participation (10%)

Everybody should be prepared for each academic session. This implies reading materials for each session with enough detail to be able to ask relevant questions; participating in analytical discussions about the key issues. Throughout the semester, you will also be asked to lead assignments on assigned topics. Active participation is expected, both in the SFS Center and in the field**.**

Grading Scheme

Grade corrections in any of the above items should be requested in writing at least 24 hours after assignments are returned. No corrections will be considered afterwards.

A	95.00 - 100.00%	B+	86.00 - 89.99%	C+	76.00 - 79.99%	D	60.00 - 69.99%
A-	90.00 - 94.99%	B	83.00 - 85.99%	C	73.00 - 75.99%	F	0.00 - 59.99%
		B-	80.00 - 82.99%	C-	70.00 - 72.99%		

General Reminders

Honor Code/Plagiarism – SFS places high expectations on their students and we hold students accountable for their behaviors. SFS students are held to the honor code below. SFS has a zero-tolerance policy towards student cheating, plagiarism, data falsification, and any other form of dishonest academic and/or research practice or behavior. Using the ideas or material of others without giving due credit is cheating and will not be tolerated. Any SFS student found to have engaged in or facilitated academic and/or research dishonesty will receive no credit (0%) for that activity.

> "SFS does not tolerate cheating or plagiarism in any form. While participating in an SFS program, students are expected to refrain from cheating, plagiarism and any other behavior which would result in a student receiving credit for work which they did not accomplish on their own. Students are expected to report any instance of cheating or plagiarism by others."

Deadlines – Deadlines for written and oral assignments are instated to promote equity among students and to allow faculty ample time to review and return assignments before others are due. As such, deadlines are firm; extensions will only be considered under extreme circumstances. Late assignments will incur a penalty of 10% of your grade for each day you are late. After 48 hours past the deadline, assignments will not be accepted anymore. Assignments will be handed back to students after a one-week grading period. Grade corrections for any assessment item should be requested in writing at least 24 hours after assignments are returned. No corrections will be considered afterwards.

Content Statement – Every student comes to SFS with unique life experiences, which contribute to the way various information is processed. Some of the content in this course may be intellectually or emotionally challenging but has been intentionally selected to achieve certain learning goals and/or showcase the complexity of many modern issues. If you anticipate a challenge engaging with a certain topic or find that you are struggling with certain discussions, we encourage you to talk about it with faculty, friends, family, the HWM, or access available mental health resources.

Participation – Since we offer a program that is likely more intensive than you might be used to at your home institution, missing even one lecture can have a proportionally greater effect on your final grade simply because there is little room to make up for lost time. Participation in all components of the course is mandatory, it is important that you are prompt for all activities, bring the necessary equipment for field exercises and class activities, and simply get involved.

A Note About Class Readings - Many of the classes have two or more papers associated with them. In these cases, different readings will be assigned to different reading groups. The members for each group will be expected to have read the key portions of their article for the upcoming class, so as to help lead the discussion on the topics covered in their paper. Many research articles use data collection and analysis methodologies that are unfamiliar, and each reading group will be advised about the sections they will be responsible for reading in their papers.

Course Content

CA: Class activity; D: Discussion; FEX: Field Exercise; FL: Field Lecture; L: Lectures; O: Orientation

Readings in bold are required; "Sess": Class session, where 1 class session ≈ 50 minutes

Code	Title and outline	Type	Sess	Readings
PE01	**Academic orientation:** Introducing the courses	O	0.5	
ONE-DAY FIELD EXPEDITION: EXPLORE TORRES DEL PAINE				
PE02	**Using ecological lenses to view the landscape:** Connecting observation with deductive and inductive reasoning while in the field.	FL	1	
TOPIC 1: PATAGONIAN ECOLOGY				
PE03	A. **Introduction to Ecology:** Introduction to ecology as a discipline, and to high-latitude Patagonian ecology. B. **How to read academic papers:** Strategies to reading papers to develop presentations and participate in class discussion. C. **The ecological niche & ecological models:** Operationalizing the ecological niche. D. **What is "natural history"?** Connecting phylogeny and climate to explain species distributions across Southern Patagonia using publicly available species occurrence data within QGIS. Sign up for *Species Report*	L CA L CA	1 1 1 1	**Antonelli, A. (2017)** **Lacy, S. N., et al. (2018)** **Zamorano, et al. (2019)** **González, et al. (2013)**
ONE-DAY FIELD EXPEDITION TO MONUMENTO NATURAL CUEVA DEL MILODÓN				
PE04	**Biological adaptations to Patagonia:** Physiological peculiarities that suit organisms to Patagonia	FL	1.5	
Skill Day				
PE05	**Skills workshop:** improving skills for Field Exercises and class activities related to Patagonian Ecology.	CA	4	
MULTI-DAY EXPEDITION TO PUNTA ARENAS				
PE06	**Urban Wetlands:** Humedal Tres Puentes is a critical habitat for many bird species. During our visit to this urban wetland, we will make observations of birds in the area.	FL	1.5	
PE07	**Wind-shaped forests of Patagonia:** Effects of constant high winds on the forests of Patagonia.	FL	1.5	
PE08	**On the edge of the Magellanic Rainforests:** Exploring the sub-Antarctic rainforests on the coast south of Punta Arenas.	FL	1.5	**Promis, et al. (2008)**
PE09	**Magellanic penguins:** On Isla Magdalena, we will observe and make notes about the behaviors of the penguins that reside on that island.	FL	1.5	
TOPIC 2: FRESHWATER				
PE10	A. **Freshwater ecology:** Introducing macroinvertebrates and fish, examining the contexts of Patagonian freshwater systems B. **Finding academic papers:** Utilizing the framework of questions driving the *Species Report*, each group will work to find scientific papers relevant to their organism. Each group will submit summaries of relevant articles by 18:00.	L CA	1 1	**Cussac, et al. (2009)**

Code	Title and outline	Type	Sess	Readings
PE11	**PE FEX1:** Aquatic macroinvertebrates. Collecting and evaluating species richness across different freshwater habitat types in the Río Natales watershed	FEX	2	
MULTI-DAY EXPEDITION TO PINGO SALVAJE				
PE12	**Early Humans at Cerro Benítez:** Understanding the ecological contexts the Cerro Benítez area for early humans, and the importance of this area in regional expansion	FL	1.5	Martin & Borrero (2017)
PE13	**The ecological implications of Paleolake Tehuelche:** Examining some of the unseen ways that Pleistocene lake systems continue to affect Patagonian ecosystems.	FL	1	Zemlak, T. S. et al. (2008)
PE14	**Freshwater ecosystems:** Examining the functioning of freshwater systems from an ecological perspective	FL	1.5	**Lacy, S. N. (2020)**
PE15	**Integrated Discussion:** Mid-semester review and discussion of the ways that course themes interconnect.	D	2	
MULTI-DAY EXPEDITION TO EL CALAFATE				
PE16	***Nothofagus* distributions:** Visualizing how climatic factors affect Southern Patagonian forest structure.	FL	1	Amigo, J. & Rodríguez-Guitián (2011)
PE17	**Ecologies of past and future climates:** Using the field observation skills developed during the past month to read the current landscapes and anticipate how different climate conditions define different ecosystems.	FL	1	
PE18	**Bird observation:** Evaluating bird behaviors and habitat use in Humedal Nímez.	FL	1	
TOPIC 3: ICE				
PE19	A. **Postglacial ecosystems:** The ecological implications of a post-glacial landscape. B. **Glacial retreat, changing hydrological ecology:** Glacier retreat and lakes in PN Torres del Paine C. **Reforestation in PN Torres del Paine:** Understanding the scope of reforestation efforts and methods of monitoring. *Guest Lecturer: Pablo Sanhueza (CONAF)* D. **GIS, Remote Sensing, and Ecology:** Utilizing geographic data to evaluate the ecological implications of glaciers in Southern Patagonian landscapes, focusing on the organisms chosen for the *Species Report* (PE03D activity).	L CA GL CA	1 1 1 1	**Garibotti, et al. (2011)** **Birrell, J. H. *et al. (2020).*** **Elser, J. J. *et al. (2020)***
MULTI-DAY EXPEDITION TO TORRES DEL PAINE				
PE20	**Topography, microclimates, and wildfire:** Our walk will take us through areas where we can see how changes in topography alter the hyperlocal climate and the spread of the 2011 fire to present us with the ecological mosaic we find.	FL	1	
PE21	**Trimlines and Ecological Succession:** Using our trip to Lago Grey, we will visually examine the processes of ecological succession following the retreat of Glacier Grey.	FL	1	

Code	Title and outline	Type	Sess	Readings
PE22	**Invasive species:** Characteristics of invasive species, and the challenges of biological conservation in PN Torres del Paine. *Guest Lecturer: Dr. Jorge González*	FL	1	
PE23	**PE FEX2:** *Nothofagus* reforestation monitoring. Assistance from Pablo Sanhueza (CONAF).	FL	2	
ONE-DAY FIELD EXPEDITION: VEGA CASTILLO				
PE24	**Wetland ecology:** Explore the coastal wetlands along the shore of Lago Toro, in the heart of the Río Serrano watershed.	FL	1.5	Garay & Johnson (1991)
TOPIC 4: FIRE				
PE25	A. **Fire ecology:** What ecological role has fire played in historical and ecological timescales in Patagonia? B. **Recent Fires:** Ecological impacts of the 2015 fires in PN Torres del Paine C. **Ecological responses to fire:** Students will use research articles to develop short presentations on the effects of wildfire in Patagonian ecosystems and the implications for conservation and reforestation. **D. Applying an Ecological Niche Perspective:** Utilizing the organism of study for their *Species Report*, groups will work in QGIS, evaluating how ecologically relevant climatic and bioclimatic datasets (evaluated during the PE10B activity) correlate with their organism's geographic distribution (shapefile from PE03D activity).	L CA L CA	1 1 1 1	**Huber & Markgraf (2003)** **Cifuentes, et al. (2017)** **Mataix-Solera, et al. (2021)**
MULTI-DAY EXPEDITION TO TIERRA DEL FUEGO				
PE26	**Post-eruption Ecology:** How do volcanic eruptions create immediate and long-term ecological impacts?	FL	1	
PE27	**River-forest ecological interactions:** On our walk through Parque Karukinka, we examine how the forest interacts with the river.	FL	2	**Huertas Herrera, et al. (2020)**
PE28	**King Penguins:** Conservation at the northern edge of an ecological niche. We will visit a king penguin colony at the eastern end of Bahía Inútil, on the island of Tierra del Fuego.	FL	2	
PE29	**Urban Ecology:** Using iNaturalist to examine the plantings in the Plaza de Armas of Porvenir.	FL	1	**Rozzi, et al. (2003)**
PE30	**Shorebirds and thrombolites of MN Laguna los Cisnes:** We will observe the avian fauna and colonial microbes found within this natural monument.	FL	1	
SKILL DAY				
PE31	**Skills workshop:** improving skills for Field Exercises and class activities related to Patagonian Ecology.	CA	2	
Topic 5: Climate Change				
PE32	A. **Climate change effects on ecology:** The implications of climate change on ecosystems and ecology B. **Expected effects of climate change on Patagonian species:** Students will make a short presentation on the available	L CA	1 1	**Hampe & Petit (2005)**

Code	Title and outline	Type	Sess	Readings
	research regarding the expected effects of climate change on their *Species Report* species. C. **Climate grief and ecological grief:** emotional and mental health impacts, awareness, coping strategies D. **Exploring climate change effects at national scales:** Using QGIS, we will use the most recent ecological niche modelling to explore the ways that climate change is expected to alter freshwater fish species distributions across Chile.	D CA	1 1	Pihkala, P. (2022)
PE33	**Finalizing the Species Report:** Students will work in their Species Report groups to finalize technical content of their final reports. This includes any GIS, statistics, modeling, or other technical contexts.	CA	1	
PE34	**Integrated Discussion:** Mid-semester review and discussion of the ways that course themes interconnect.	D	2	
	Total number of class sessions		60	

Reading List

Readings in bold are required

1. Amigo, J. & Rodríguez-Guitián, M. A. Bioclimatic and phytosociological diagnosis of the species of the Nothofagus genus (Nothofagaceae) in South America. 2011.

2. **Antonelli, A.** Drivers of bioregionalization. Nature Ecology and Evolution 1, 1–2 (2017).

3. **Birrell, J. H. et al.** Insects in high-elevation streams: Life in extreme environments imperiled by climate change. Glob. Change Biol. 26, 6667–6684 (2020).

4. **Cifuentes, A. N., Viveros, R. B. & Poblete, C. M.** Forest fire monitoring system, with visible spectrum cameras, in Torres del Paine National Park; Chilean Patagonia. 2017 CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies, CHILECON 2017 - Proceedings 2017-Janua, 1–7 (2017).

5. **Cussac, V. E., Fernández, D. A., Gómez, S. E. & López, H. L.** Fishes of southern South America: A story driven by temperature. Fish Physiology and Biochemistry 35, 29–42 (2009).

6. **Elser, J. J. et al.** Key rules of life and the fading cryosphere: Impacts in alpine lakes and streams. Glob. Change Biol. 26, 6644–6656 (2020).

7. Garay, G. & Johnson, W. E. Relative abundance of aquatic birds and their use of wetlands in the Patagonia of southern Chile. Revista Chilena de Historia Natural 64, 127–137 (1991).

8. **Garibotti, I., Pissolito, C. & Villalba, R.** Spatiotemporal pattern of primary succession in relation to meso-topographic gradients on recently deglaciated terrains in the patagonian andes. Arctic, Antarctic, and Alpine Research 43, 555–567 (2011).

9. **González, B. A., Samaniego, H., Marín, J. C. & Estades, C. F.** Unveiling current guanaco distribution in Chile based upon niche structure of phylogeographic lineages: Andean puna to

subpolar forests. PLoS ONE 8, 12–14 (2013).

10. **Hampe, A. & Petit, R. J.** Conserving biodiversity under climate change: The rear edge matters. Ecology Letters 8, 461–467 (2005).

11. **Huber, U. M. & Markgraf, V.** European impact on fire regimes and vegetation dynamics at the steppe-forest ecotone of southern Patagonia. The Holocene 13, 567–579 (2003).

12. **Huertas Herrera, A., Lencinas, M. V., Toro Manríquez, M., Miller, J. A. & Martínez Pastur, G.** Mapping the status of the North American beaver invasion in the Tierra del Fuego archipelago. PLoS ONE 15, e0232057 (2020).

13. **Lacy, S. N.** Freshwater Ecosystems: A Foundation for Life on Land. in Life on Land (eds. Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G. & Wall, T.) 1–10 (Springer International Publishing, 2020). doi:10.1007/978-3-319-71065-5_75-1.

14. **Lacy, S. N., Ugalde, F. & Mao, L.** Invasive Rainbow Trout (Oncorhynchus mykiss) Are Not Affected by Different Land Uses in a Multi-Use, Mediterranean Climate Landscape. Fishes 3, 37 (2018).

15. Martin, F. M. & Borrero, L. A. Climate change, availability of territory, and Late Pleistocene human exploration of Ultima Esperanza, South Chile. Quaternary International 428, 86–95 (2017).

16. **Mataix-Solera, J. et al.** Soil Vulnerability Indicators to Degradation by Wildfires in Torres del Paine National Park (Patagonia, Chile). Span. J. Soil Sci. 11, 10008 (2021).

17. Pihkala, P. Toward a Taxonomy of Climate Emotions. Front. Clim. 3, 738154 (2022).

18. **Promis, A., Cruz, G., Reif, A. & Gärtner, S.** Nothofagus betuloides (Mirb.) Oerst. 1871 (Fagales: Nothofagaceae) Forests in Southern Patagonia and Tierra Del Fuego. Anales Instituto Patagonia (Chile) 36, 53–67 (2008).

19. **Rozzi, R. et al.** Árboles nativos y exóticos en las plazas de magallanes. 27–42 (2003).

20. **Zamorano, D. et al.** Assessing the effect of fish size on species distribution model performance in southern Chilean rivers. PeerJ 7, e7771 (2019).

21. Zemlak, T. S. et al. Across the southern Andes on fin: Glacial refugia, drainage reversals and a secondary contact zone revealed by the phylogeographical signal of Galaxias platei in Patagonia. Molecular Ecology 17, 5049–5061 (2008).