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.

www.fieldstudies.org

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.

In a shared goal with the Earth Systems and Climate course, students will be able 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.

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 (%)
Participation	10
Field Quizzes	15
Field Exercises	20
Field Notebook	20
In-class Presentations	10
Field Exam	25
TOTAL	**100**

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 during classes, discussions, and assignments is expected, both in the classroom and in the field. NOTE: most class sessions at the Center are block-day classes, and many of these may have an activity associated with them.

Field Quizzes (15%)

Field quizzes will be used to evaluate your ability to synthesize and apply knowledge from one context to another. For example, during our trip to Pingo Salvaje, you may be asked questions about how topics discussed in class and/or during prior field outings can be contextualized in their new setting. Field Quizzes will take no more than fifteen (15) minutes. You will have seven (7) quizzes during the semester.

Field Exercise (FEX) 1: Aquatic Macroinvertebrates (7.5%)

Subject: Evaluating stream processes and water quality using aquatic macroinvertebrates as indicators
Methods: In the freshwater systems of Laguna Sofía, 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 species richness.

Field Exercise (FEX) 2: Contrasting Notro Growth Patterns (12.5%)

Subject: Observational skills, hypothesis testing, linear regression, and plant phenology techniques
Methods: We will be evaluating climatic effects on the growth forms of notro (*Embotrium coccineum*) in Magallanes (Southern Patagonia) and Los Lagos (Northern Patagonia). You will be provided with theory on plant growth responses to climatic factors and guidance in the process of taking simple measurements. You will use simple linear regression modeling to evaluate how plant growth differs across climatic conditions, and you will also learn how to collect field data that will be used by others.

Field Notebook (20%)

Each location we travel to 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 make personal observations in every field outing – apart from any formal academic activities (e.g., FEX, field lectures) that take place there. These personal observations can form the basis of entries written up in a designated field notebook. You can choose how you wish to develop your field notebook entries to best match your own observational and writing style. NOTE: the field notebook is a shared assignment across the core courses. It will be handed in twice during the semester: before the Midsemester Break and after the Final Exam. Keep in mind the following grading rubric:

- **Completeness (2%):** Your field notebook must have at least one entry per day in the field, and you must have at least one entry for each class at each hand-in. In addition, each individual entry must include the location, the date and time, the course to which the entry is directed, and – of course – the observation you made at the indicated date and time.
- **Coherence (5%):** Each entry should be coherent in the way it presents information. This includes legibility, clear argumentation, a 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 (or stand independent from) any accompanying writing.
- **Correctness (8%):** Each entry should connect with topics covered during lectures, discussions, readings, etc. In addition, the specifics contained in the entry must be factually correct. There is no requirement for formal citations.
- **Connection (5%):** Each entry should connect the field observation with something external to the location – ideally connecting to **themes** being built and discussed across your field notebook entries. Examples of themes: history of fire, the effects of wind, the impacts of conservation initiatives, and even comparisons with familiar landscapes back home. The key is to expand your entries beyond just the lectures or activities of the associated field trip and write your entries with the idea of using them to explore concepts and ideas throughout the semester, instead of having a set of disconnected entries.

In-class Presentations (10%)

You will work in small groups to prepare presentations on ecological topics, based on selected scientific papers related to the topic. 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, the adherence to the time limit, and the degree of engagement of the presentation. There will be three (3) in-class presentations during the semester. Note that PowerPoint (or similar) is *not* required.

Field Exam (25%)

The final exam for the course will take us to a field location where you will have one hour for making field observations related with the exam content. You will receive the exam 24 hours before leaving for the field. You may use the 24 hours before leaving for the field location to prepare answers and field observation strategies. Given this, all field observations, exam preparations, and exam writing must be done individually. Additionally, you will be placed in one of three exam groups, and you will complete the core course exams in a particular order.

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

Plagiarism – using the ideas or material of others without giving due credit – is cheating and will not be tolerated. A grade of zero will be assigned for anyone caught cheating or aiding another person to cheat either actively or passively.

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 two days past the deadline assignments will not be accepted anymore. Assignments will be handed back to students after a one-week grading period.

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.

Use of Computers - Personal screens (e.g., smartphones, tablets, and computers) are not allowed in the classroom, except for specific activities. Revising lecture notes manually has been shown in various studies to help with information retention and integration of concepts. In addition, working directly with written notebooks diminishes the distraction of those around you, which has been shown to increase with the general use of screens in a classroom setting. Finally, we actively discourage everyone from bringing tablets and computers on all day trips and nearly all multi-day trips out of the Center, due to concerns about weather, breakage, and security. Students with learning accommodations granted through the Office of Academic Affairs must talk with the Lead Faculty.

Assignment Delivery - All assignments must be handed in by their deadline. Written assignments may be typed or hand-written and must indicate your name and the assignment name. Hand-written submissions must be legible; illegible submissions will be returned and will be deemed late if a legible copy is not submitted by the hand-in deadline. Typed responses must be submitted using MS Word. Submissions sent after the hand-in deadline will be considered late.

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

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

*Not all readings are required. See above note on class readings.

No	*Title and Outline*	*Type*	*Hours*	*Readings*
PE01	**Course Introduction**	O	1.0	
PE02	**Introduction to ecology** Introduction to ecology as a discipline, and to high-latitude Patagonian ecology. **Ecological niche models** Operationalizing the ecological niche. **Reading ecology papers** Reviewing strategies to reading ecology papers to develop presentations and participate in class discussion. **Urban Ecology** Exploring the ecology found around the city of Puerto Natales, and how urban planning shapes urban ecologies.	L; CA	4.0	Antonelli, 2017 Gonázlez, 2013 Premoli, 2010 Pérez, 2018 Rozzi, 2003
PE03	**Wind-shaped forests of Patagonia** Effects of constant high winds on the forests of Patagonia.	FL	1.0	Korner, 2007
PE04	**Plant and animal adaptations to Patagonia** Physiological peculiarities that suit organisms to Patagonia **Natural history of Patagonia** How phylogeny and topography explain Patagonian diversity. **Past climatic change and shifts in ecology** Climatic change leading into the Holocene **Defining "Anthropocene"** Trying to define an evolving concept, and place it in a non-Earth Systems framework.	L; CA	4.0	Rozzi, 2008 Metcalf. 2016 Villavicencio, 2016 Pino, 2019
PE05	**Using ecological lenses to view the landscape** Connecting observation with deductive and inductive reasoning while in the field	FL	1.0	
PE06	**FEX 1: Aquatic macroinvertebrates** Collecting, identifying, and evaluating species richness across different freshwater habitat types	FEX	2.0	
PE07	**Freshwater ecosystems and ecology** Examining the functioning of freshwater systems from an ecological perspective and introducing aquatic macroinvertebrates and fish	FL	4.0	Lacy, 2020 Cussac, 2016
PE08	**PN Pali Aike and the early Patagonians** Prehistoric humans in Southern Patagonia	FL	1.0	Nakatsuka, 2020 Morales, 2009 Motti, 2009
PE09	**King Penguins** Conservation at the northern edge of an ecological niche	FL	2.0	Le Bohec, 2005

PE10	**FEX 2, Part 1: Contrasting notro growth patterns** Collecting leaf dimension data in Parque del Estrecho to compare against data collected in Senda Darwin (PE19)	FEX	2.0	Souto, 2009
PE11	**Ecosystems services in the urban and peri-urban** Understanding the context of ecosystem services in human-dominated landscapes.	CA	1.0	
PE12	**Wetland ecology** Explore the coastal wetlands along the shore of Lago Toro, in the heart of the Río Serrano watershed.	FL	1.5	
PE13	**Fire ecology** What ecological role has fire played in historical and ecological timescales in Patagonia? **Recent Fires** Ecological impacts of the 2015 fires in PN Torres del Paine **GIS, Remote Sensing, and Ecology** Utilizing geographic data to evaluate ecology across landscapes.	L; CA	4.0	Huber, 2003 Cifuentes, 2017 Mataix-Solera, 2021
PE14	***Nothofagus* distributions** Visualizing how climatic factors affect Southern Patagonian forest structure.	FL	1.5	Promis, 2008
PE15	**Glacial ecology** What lives on and below glaciers? **Paleolake Tehuelche** The ecological implications of a post-glacial landscape **Glacial retreat, changing hydrological ecology** Glacier retreat and lakes in PN Torres del Paine **Shifting-baseline Syndrome** The pitfalls of personal experience and evaluating ecosystem trends.	L; CA	4.0	Miserendino, 2018 Stibal, 2020 Birrell, 2020 Elser, 2020 Pauly, 1995 Soga, 2018
PE16	**Synthesizing the major interdisciplinary themes** Mid-semester review and discussion of the many ways in which the lecture themes tie together.	D	1.5	
PE17	**Northern Patagonia contrasts with Southern Patagonia**	L; D	1.0	Sérsic, 2011
PE18	**Shorebirds of MN Islas de Puñihuil**	FL	2.0	Rey, 2013
PE19	**FEX 2, Part 2: Contrasting notro growth patterns** Collecting leaf dimension data in Senda Darwin to compare againAst data collected in Parque del Estrecho (PE10).	FEX	2.0	Souto, 2009
PE20	**Post-eruption Ecology** How do volcanic eruptions create immediate and long-term ecological impacts.	L	2.0	Hintz, 2021
PE21	**River-forest ecological interactions** On our walk through the Romahue private protected area, we will examine the ways in which the Maullin River interacts with the ecology of riparian old growth forests.	FL	1.0	

PE22	**Salmon farming** What impacts do salmon farms have – how well do they prepare for such impacts beforehand?	D	1.0	Sepúlveda, 2013 Lacy, 2017
PE23	**FEX 2 review** Reviewing the results and examining the implications for the write-up. **Ecological conservation** Understanding the implications of conservation from an ecological context. How well does the Chilean protected area network conserve Chilean (and regional) ecology?	CA	2.0	
PE24	**Invasive species** Examining the impact of invasive species in the PN Torres del Paine.	GL	1.0	
PE25	**Field Observations** On each day of the trip, write a field notebook entry that integrates field observations related with Patagonian Ecology with at least one other core course.	CA	4.0	
PE26	**Human hands on the landscape** The perceptions of nature, and the implications of human definitions of landscapes.	CA	1.0	Vining, 2008
PE27	**Climate change effects on ecology** The implications of climate change on ecosystems and ecology **Climate change and ecological niche shifts in Patagonia** Examining how climate change is expected to affect iconic species in Patagonia. **Climate grief and ecological grief** Emotional and mental health impacts, awareness, coping strategies	L; CA; D	4.0	Hampe, 2005 Cunsolo, 2018 Westoby, 2019
PE28	**Synthesizing the major interdisciplinary themes** Semester review and discussion of the many ways in which the lecture themes tie together.	D	1.5	
28	**Final Field Exam**		3.0	
		Total Hours	60	

Reading List

*Not all readings are required. See above note on class readings.

1. Antonelli A. Drivers of bioregionalization. Nature Ecology and Evolution. 2017;1(February 2018):1–2.
2. Birrell JH, Shah AA, Hotaling S, Giersch JJ, Williamson CE, Jacobsen D, et al. Insects in high-elevation streams: Life in extreme environments imperiled by climate change. Glob Change Biol. 2020 Dec;26(12):6667–84.
3. Cifuentes AN, Viveros RB, Poblete CM. 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;2017-Janua (August 2018): 1–7.
4. Cunsolo A, Ellis NR. Ecological grief as a mental health response to climate change-related loss. Nature Climate Change. 2018;8(4):275–81.
5. Cussac VE, Habit E, Ciancio J, Battini MA, Riva Rossi C, Barriga JP, et al. Freshwater fishes of Patagonia: conservation and fisheries. Journal of Fish Biology. 2016;89(1):1068–97.
6. Elser JJ, Wu C, González AL, Shain DH, Smith HJ, Sommaruga R, et al. Key rules of life and the fading cryosphere: Impacts in alpine lakes and streams. Glob Change Biol. 2020 Dec;26(12):6644–56.
7. González BA, Samaniego H, Marín JC, Estades CF. Unveiling current guanaco distribution in Chile based upon niche structure of phylogeographic lineages: Andean puna to subpolar forests. PLoS ONE. 2013;8(11):12–4.
8. Hampe A, Petit RJ. Conserving biodiversity under climate change: The rear edge matters. Ecology Letters. 2005;8(5):461–7.
9. Hintz L, Fischer D, Ferrari N, Crisafulli CM. Vegetation dynamics under residual large trees following a volcanic eruption in a Valdivian temperate rainforest. Plant Ecol. 2021 Aug;222(8):915–31.
10. Huber UM, Markgraf V. European impact on fire regimes and vegetation dynamics at the steppe-forest ecotone of southern Patagonia. The Holocene. 2003 May;13(4):567–79.
11. Körner C. The use of 'altitude' in ecological research. Trends in Ecology & Evolution. 2007 Nov;22(11):569–74.
12. Lacy SN, Di Giminiani P, Mao L. What defines a river? Modelling the interplay between physical and social driving factors in characterising the waterways in Chile. The Geographical Journal. 2018 Dec;184(4):342–56.
13. Lacy SN, Meza FJ, Marquet PA. Can environmental impact assessments alone conserve freshwater fish biota? Review of the Chilean experience. Environmental Impact Assessment Review. 2017 Mar;63:87–94.
14. Lacy SN. Freshwater Ecosystems: A Foundation for Life on Land. In: Leal Filho W, Azul AM, Brandli L, Özuyar PG, Wall T, editors. Life on Land [Internet]. Cham: Springer International Publishing; 2020 [cited 2020 May 14]. p. 1–10. (Encyclopedia of the UN Sustainable Development Goals). Available from: http://link.springer.com/10.1007/978-3-319-71065-5_75-1
15. Le Bohec C, Gauthier-Clerc M, Le Maho Y. The adaptive significance of crèches in the king penguin. Animal Behaviour. 2005;70(3):527–38.

16. Mataix-Solera J, Arellano EC, Jaña JE, Olivares L, Guardiola J, Arcenegui V, et al. Soil Vulnerability Indicators to Degradation by Wildfires in Torres del Paine National Park (Patagonia, Chile). Span J Soil Sci. 2021 Jul 2;11:10008.

17. Metcalf JL, Turney C, Barnett R, Martin F, Bray SC, Vilstrup JT, et al. Synergistic roles of climate warming and human occupation in Patagonian megafaunal extinctions during the Last Deglaciation. Science Advances. 2016;2(6):1–9.

18. Miserendino ML, Brand C, Epele LB, Di Prinzio CY, Omad GH, Archangelsky M, et al. Biotic diversity of benthic macroinvertebrates at contrasting glacier-fed systems in Patagonia Mountains: The role of environmental heterogeneity facing global warming. Science of The Total Environment. 2018 May;622–623:152–63.

19. Morales M, Barberena R, Belardi JB, Borrero L, Cortegoso V, Durán V, et al. Reviewing human–environment interactions in arid regions of southern South America during the past 3000 years. Palaeogeography, Palaeoclimatology, Palaeoecology. 2009 Oct;281(3–4):283–95.

20. Motti JMB, Luisi P, Salemme M, Santiago F. El estudio de genomas antiguos contribuye a reconstruir la historia de las poblacio- nes humanas de Patagonia Austral. Se identificaron movimientos migratorios aso- ciados a cambios tecnológicos y se observó mestizaje entre poblaciones vecinas. 2020;17:9.

21. Nakatsuka N, Luisi P, Motti JMB, Salemme M, Santiago F, D'Angelo del Campo MD, et al. Ancient genomes in South Patagonia reveal population movements associated with technological shifts and geography. Nat Commun. 2020 Dec;11(1):3868.

22. Pauly D. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology & Evolution. 1995 Oct;10(10):430.

23. Pérez GE, Conte A, Garde EJ, Messori S, Vanderstichel R, Serpell J. Movement and home range of owned free-roaming male dogs in Puerto Natales, Chile. Applied Animal Behaviour Science. 2018 Aug;205:74–82.

24. Pino M, Abarzúa AM, Astorga G, Martel-Cea A, Cossio-Montecinos N, Navarro RX, et al. Sedimentary record from Patagonia, southern Chile supports cosmic-impact triggering of biomass burning, climate change, and megafaunal extinctions at 12.8 ka. Scientific Reports. 2019 Dec 13;9(1):4413.

25. Premoli AC, Mathiasen P, Kitzberger T. Southern-most Nothofagus trees enduring ice ages: Genetic evidence and ecological niche retrodiction reveal high latitude (54°S) glacial refugia. Palaeogeography, Palaeoclimatology, Palaeoecology. 2010;298(3–4):247–56.

26. 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). 2008;36(1):53–67.

27. Rey AR, Pütz K, Simeone A, Hiriart-Bertrand L, Reyes-Arriagada R, Riquelme V, et al. Comparative foraging behaviour of sympatric Humboldt and Magellanic Penguins reveals species-specific and sex-specific strategies. Emu. 2013;113(2):145.

28. Rozzi R, Armesto JJ, Goffinet B, Buck W, Massardo F, Silander J, et al. Changing lenses to assess biodiversity: Patterns of species richness in sub-Antarctic plants and implications for global conservation. Frontiers in Ecology and the Environment. 2008;6(3):131–7.

29. Rozzi R, Massardo F, Jr JS, Dollenz O, Connolly B, Turner N. Árboles nativos y exóticos en las plazas de magallanes. 2003;27–42.

30. Sepúlveda M, Arismendi II, Soto D, Jara F, Farias F. Escaped farmed salmon and trout in Chile: Incidence, impacts, and the need for an ecosystem view. Aquaculture Environment Interactions. 2013;4(3):273–83.

31. Sérsic AN, Cosacov A, Cocucci AA, Johnson LA, Pozner R, Avila LJ, et al. Emerging phylogeographical patterns of plants and terrestrial vertebrates from Patagonia. Biological Journal of the Linnean Society. 2011 Jun;103(2):475–94.

32. Soga M, Gaston KJ. Shifting baseline syndrome: causes, consequences, and implications. Frontiers in Ecology and the Environment. 2018;16(4):222–30.

33. Souto CP, Premoli AC, Reich PB. Complex bioclimatic and soil gradients shape leaf trait variation in Embothrium coccineum (Proteaceae) among austral forests in Patagonia. Revista Chilena de Historia Natural. 2009;82(2):209–22.

34. Stibal M, Bradley JA, Edwards A, Hotaling S, Zawierucha K, Rosvold J, et al. Glacial ecosystems are essential to understanding biodiversity responses to glacier retreat. Nat Ecol Evol. 2020 May;4(5):686–7.

35. Villavicencio NA, Lindsey EL, Martin FM, Borrero LA, Moreno PI, Marshall CR, et al. Combination of humans, climate, and vegetation change triggered Late Quaternary megafauna extinction in the Última Esperanza region, southern Patagonia, Chile. Ecography. 2016;39(2):125–40.

36. Vining J, Merrick MS, Price EA. The distinction between humans and nature: Human perceptions of connectedness to nature and elements of the natural and unnatural. Human Ecology Review. 2008;15(1):1–11.

37. Westoby R, McNamara KE. Fear, grief, hope and action. Nature Climate Change. 2019;9(7):500–

38. Zangrando AFJ, Tivoli AM. Human use of birds and fish in marine settings of southern Patagonia and Tierra del Fuego in the Holocene: A first macro-regional approach. Quaternary International. 2015 Jul;373:82–95.