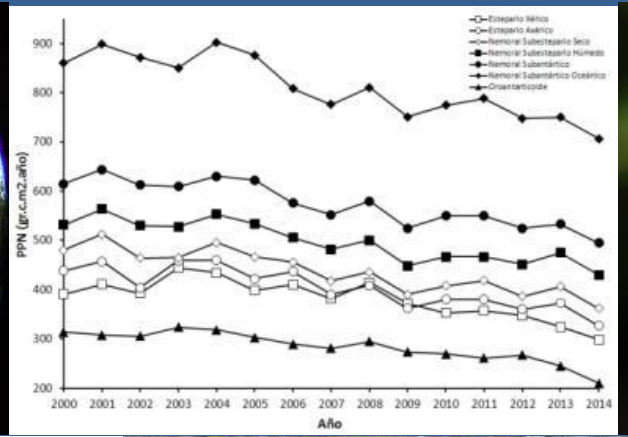
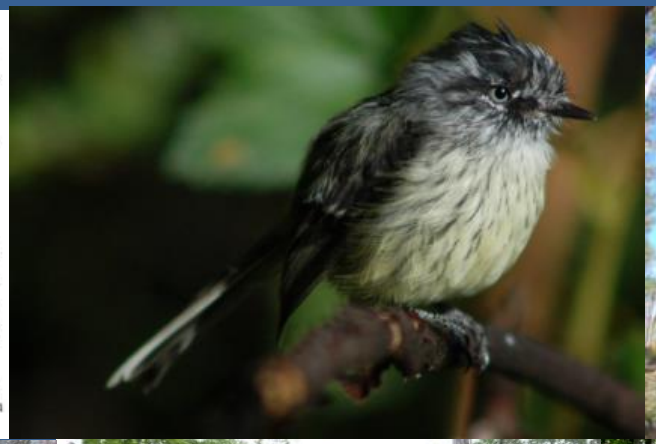
Patagonian forests vulnerability to climate change: Consequences for management and conservation

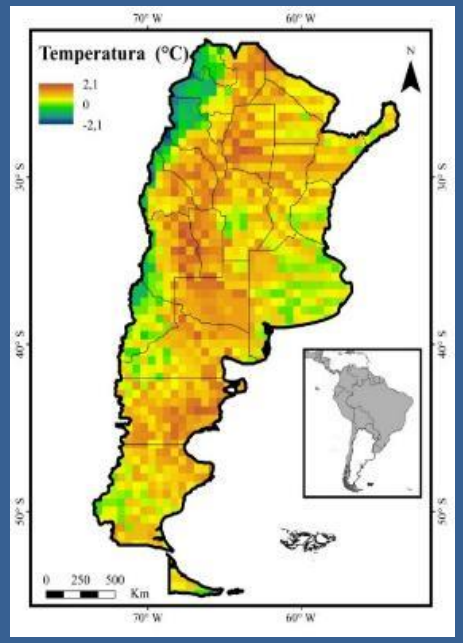


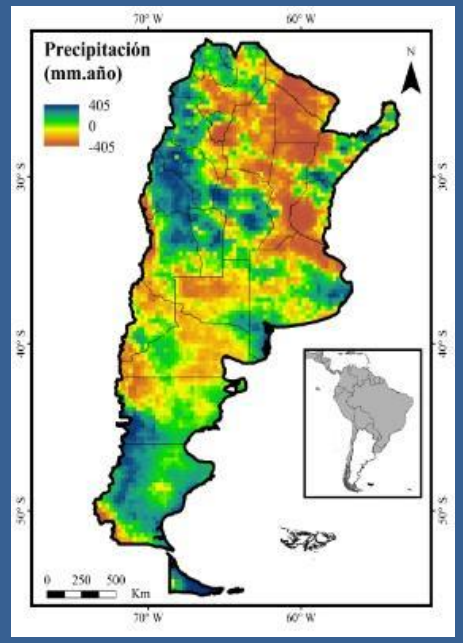


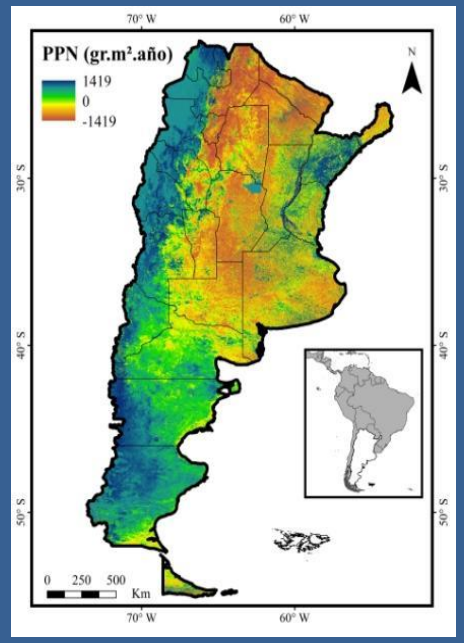
Guillermo Martínez Pastur, Yamina M. Rosas, Mónica Toro Manríquez, Alejandro Huertas Herrera, Julieta Benitez, Paula Blazina, María V. Lencinas, Ricardo Díaz-Delgado, Pablo L. Peri, Marco Ferretti

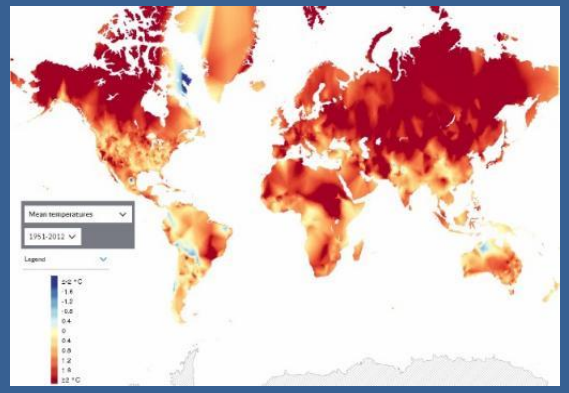
CONICET CADIC

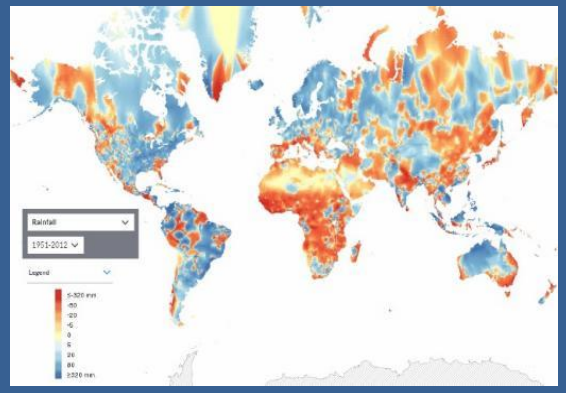
Climate change influence worldwide, but presents different patterns according to specific regions.



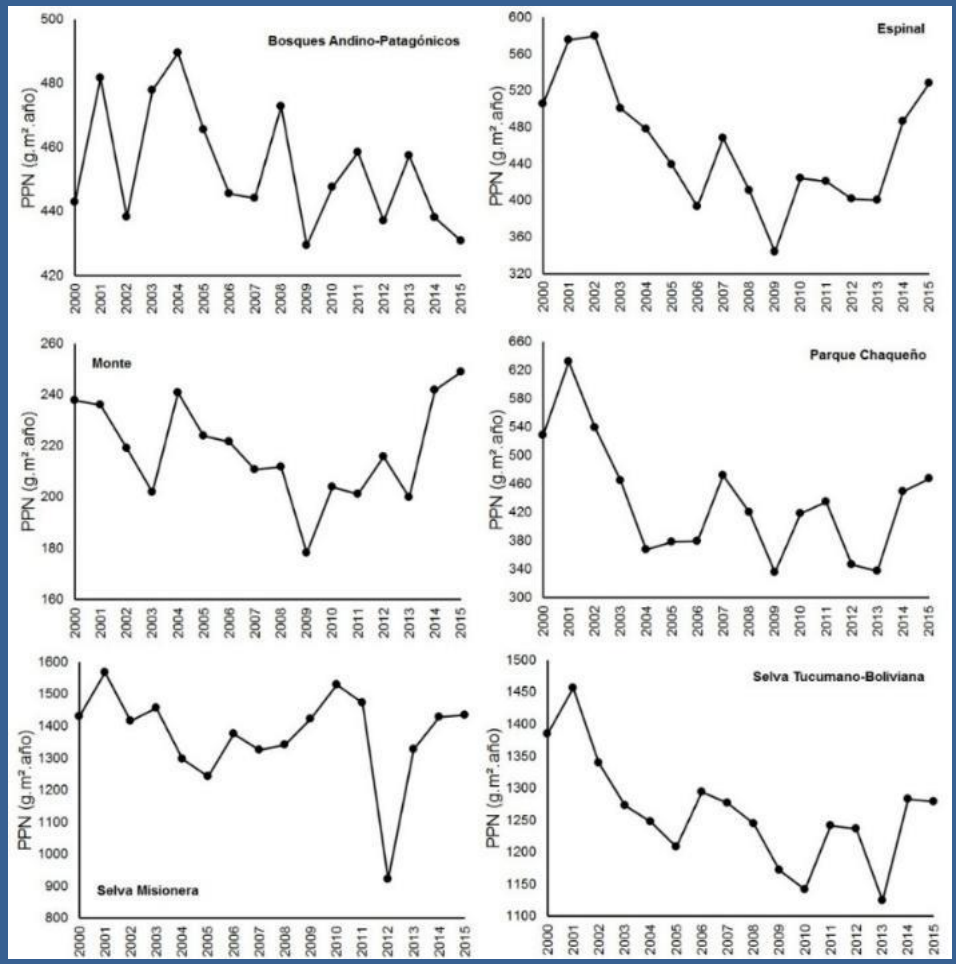






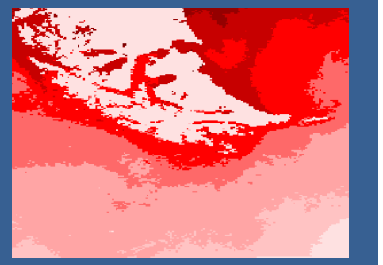


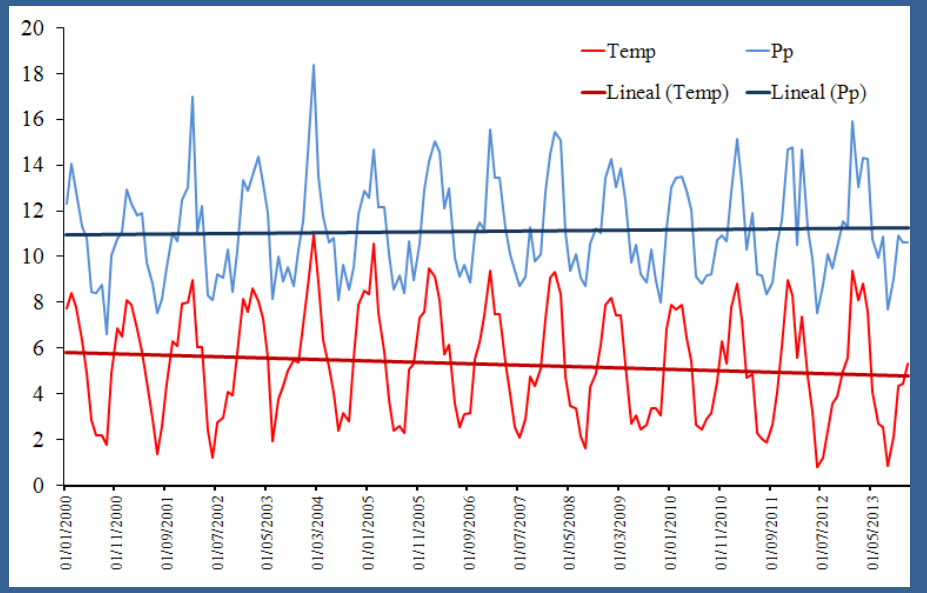
Forest regions in Argentina



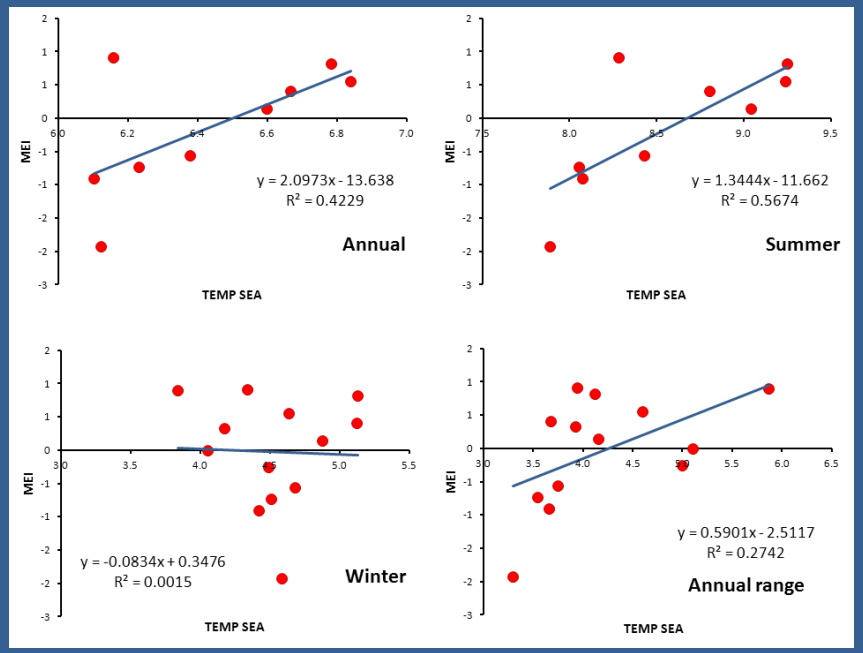
CONICET CADIC

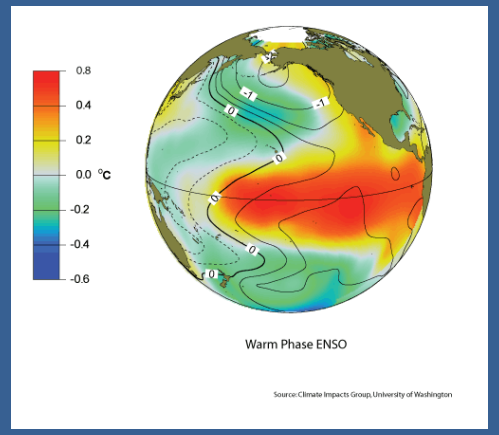
Antarctica and oceans (Pacific and Atlantic) influence over Tierra del Fuego, where temperature and rainfall patterns were highly correlated with climate phenomena (e.g. ENSO).

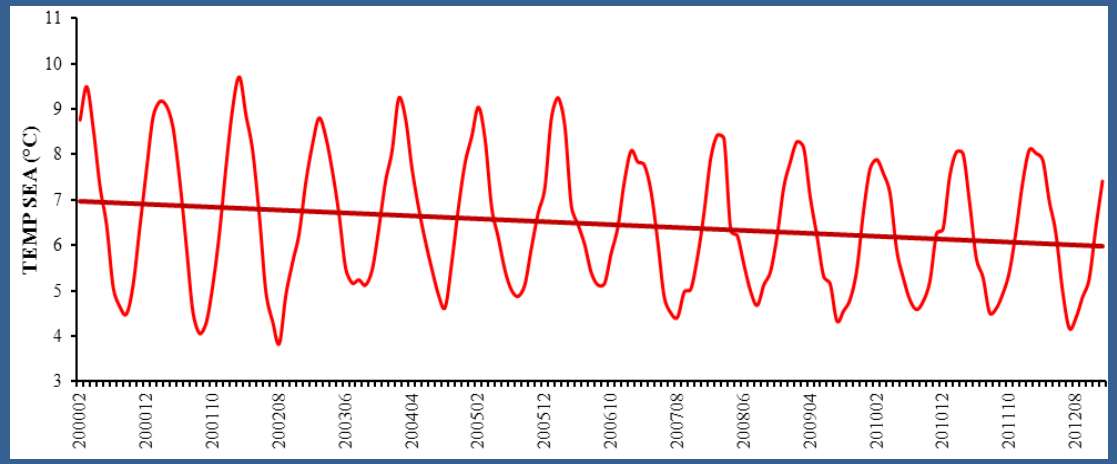




ENSO in summer is correlated with sea temperature.

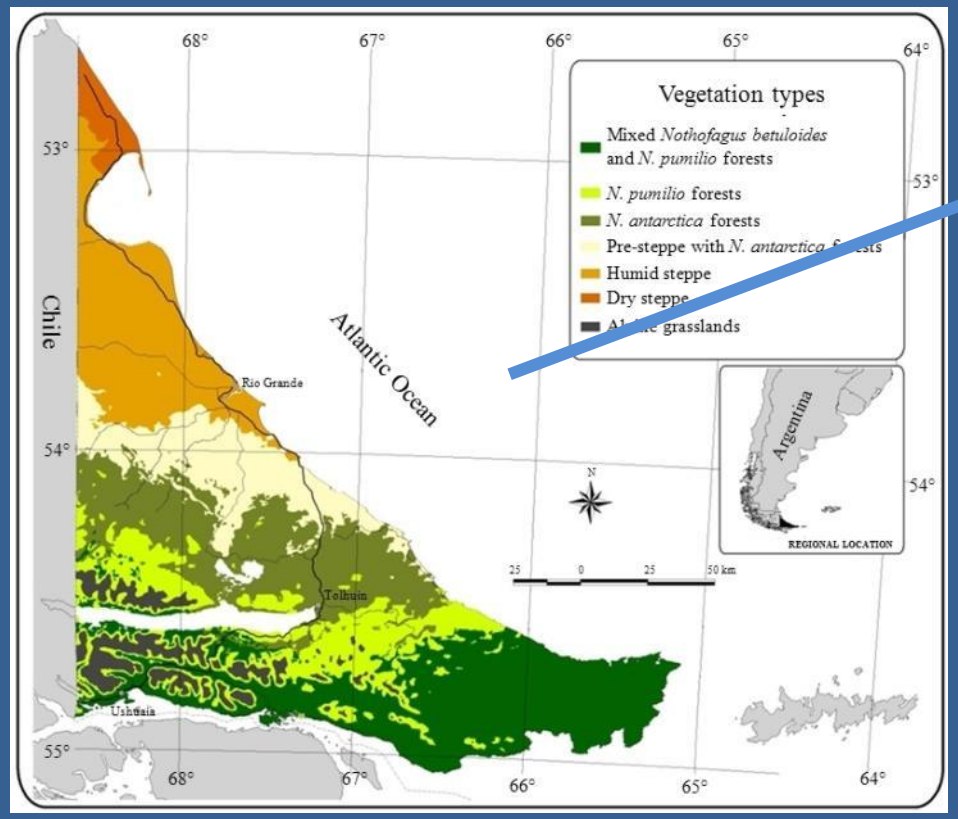


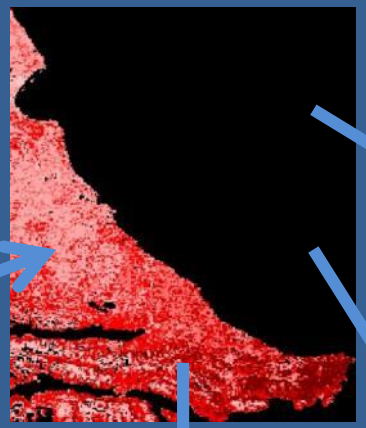


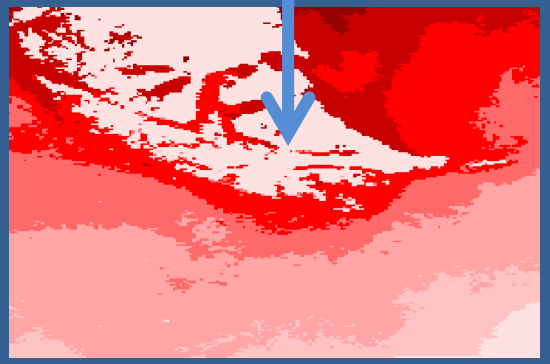


Satellite data estimations of rainfall showed an slightly increase, and a decrease in average temperature of land and sea surface.

The objective was to determine changes in diversity, forest structure and ecosystem processes and relate them with climate variables and indexes (e.g. El Nino Southern Oscillation, ENSO; Southern Annular Mode, SAM) in the short-medium-term (last 5-20 years).



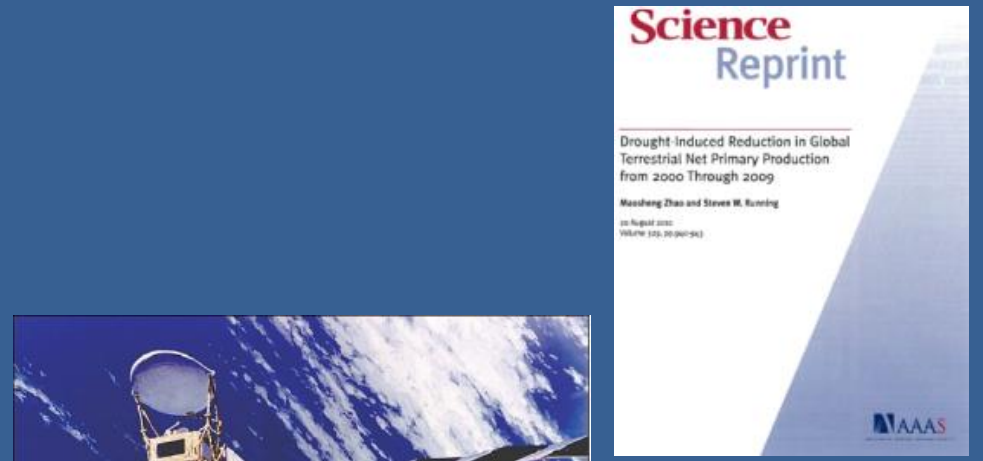


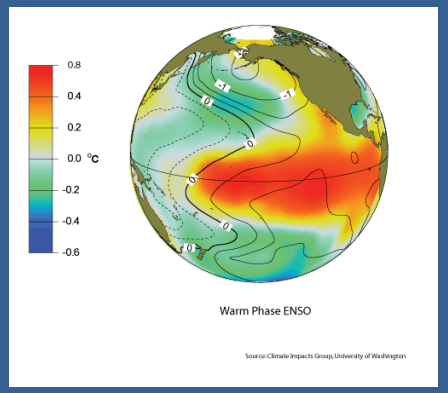


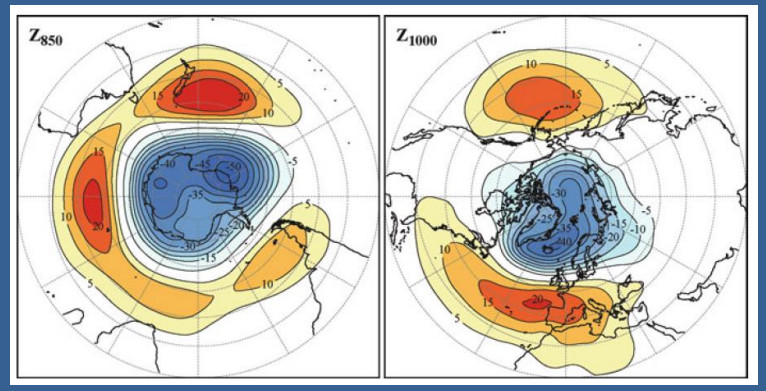
CONICET CADIC

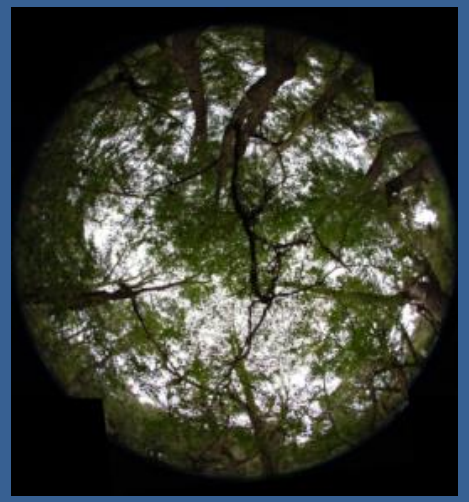
MODIS
MODERATE RESOLUTION IMAGING SPECTRORADIOMETER

We employed long-term data in managed and unmanaged *Nothofagus pumilio* forests in Tierra del Fuego and Santa Cruz provinces. We also employed long-term satellite data from MODIS mission (land and sea surface temperature, rainfall, primary productivity net) and climate indexes (ENSO, SAM).









CONICET CADIC

Two research strategies are indispensables to this task: (i) BACI approach (before- after-control-impact), and (ii) long-term monitoring.

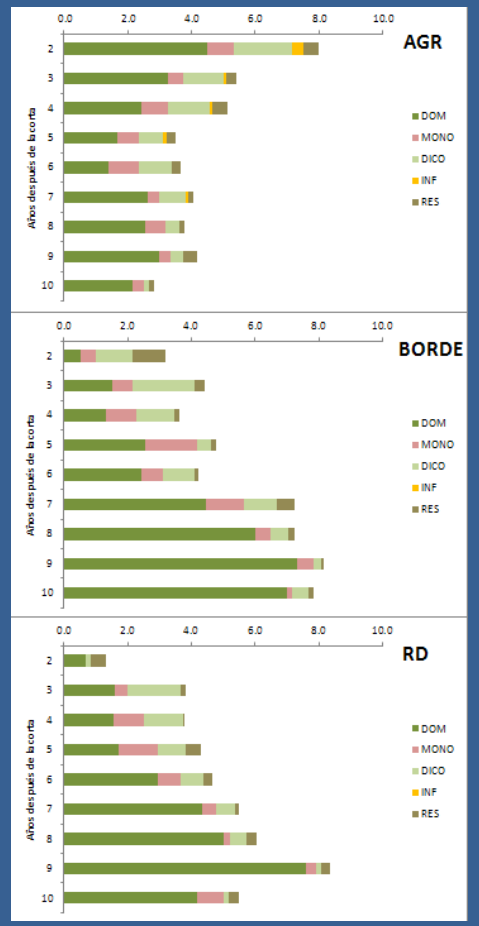
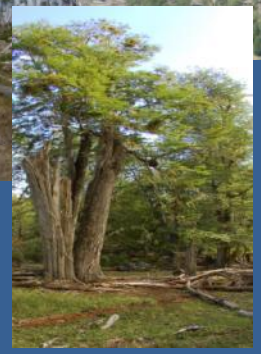


Tabla 1. Primeras parcelas de estudio a largo plazo en bosques de Patagonia Austral.
First long-term study plots in southern Patagonian forests.

Parcela	Año	Objetivos del estudio	Provincia
Laguna Negra	1965	Raleos	Tierra del Fuego
Río Tristen - Vega Café	1965	Talas rasas	Tierra del Fuego
Lago Roca	1965	Cortas de regeneración	Tierra del Fuego
Río Tierra Mayor	1965	Talas rasas	Tierra del Fuego
Aguas Blancas	1965	Talas rasas, raleos y podas	Tierra del Fuego
Monte Redondo	1966	Talas rasas	Tierra del Fuego
Cañadón del Toro	1966	Raleos y cortas de regeneración	Tierra del Fuego
Lapataia - Ensenada	1966	Raleos	Tierra del Fuego
Lago Escondido	1966	Raleos	Tierra del Fuego
Río Milnak	1966	Raleos	Tierra del Fuego

Referencias: Cozzo et al. (1967; 1969), Mutarelli y Orfila (1969).

Old plots in Tierra del Fuego



New plots in Tierra del Fuego

Tabla 2. Parcelas de estudio permanentes a largo plazo existentes en Patagonia Austral.
Current long-term study plots in southern Patagonia.

Parcela	Año	Objetivos del estudio	Provincia
Aguas Blancas	1965	Talas rasas, raleos y podas	Tierra del Fuego
Moat	1993	Raleos	Tierra del Fuego
San Justo	1996	Estrategias de raleo para reducir la caída por viento	Tierra del Fuego
Stag River	1996	Raleos bajo diferentes niveles de cobertura del dosel	Santa Cruz
San Justo - Rodal 13	1997	Cortas de regeneración	Tierra del Fuego
San Justo - Rodal 4	2001	Cortas de regeneración con retención variable	Tierra del Fuego
Tres Marías	2003	Sistemas silvopastoriles	Santa Cruz
Cancha Carrera	2003	Sistemas silvopastoriles	Santa Cruz
Los Cerros	2004	Cortas de regeneración con retención variable	Tierra del Fuego
Nibepo Aike	2004	Sistemas silvopastoriles	Santa Cruz
San Pablo	2009	Raleos y sistemas silvopastoriles	Tierra del Fuego
Parque Nacional	2010	Comunidades de aves y cambio climático	Tierra del Fuego
Lago Escondido	2012	Raleos y cortas de regeneración	Tierra del Fuego
Cerro Gloria	2013	Vegetación alpina y cambio climático	Tierra del Fuego
Lago Viedma	2014	Vegetación alpina y cambio climático	Santa Cruz
Pirinaica	2014	Sistemas silvopastoriles	Tierra del Fuego

Referencias: Cozzo et al. (1969), Mutarelli y Orfila (1973), Martínez Pastur et al. (1999; 2001; 2002; 2007; 2010; 2013; 2015), Peri et al. (2002; 2013a; 2013b), Bahamonde et al. (2012; 2013a; 2013b; 2015), Lencinas et al. (2014), Soler et al. (2015).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ELSEVIER

Biodiversity and ecological long-term plots in Southern Patagonia to support sustainable land management: The case of PEBANPA network

Pablo Luis Peri[a,b,c,*], María Vanessa Lencinas[d], Jeffrey Bousson[e], Romina Lasagno[a], Rosina Soler[d], Héctor Bahamonde[a,b], Guillermo Martínez Pastur[d]

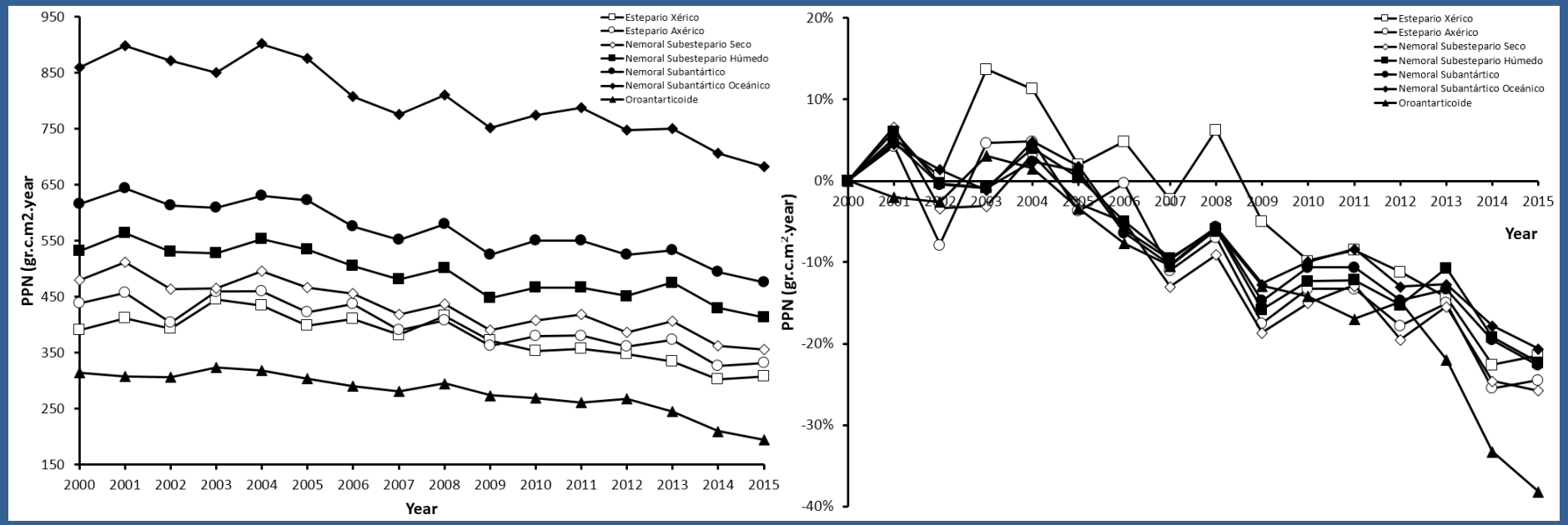
[a] Instituto Nacional de Tecnología Agropecuaria (INTA), CC 332 (9400) Río Gallegos, Santa Cruz, Argentina
[b] Universidad Nacional de la Patagonia Austral (UNPA) Río Gallegos, Santa Cruz, Argentina
[c] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) Buenos Aires, Argentina
[d] Centro Austral de Investigaciones Científicas (CADIC) Ushuaia, Tierra del Fuego, Argentina
[e] Climate Science and Solutions Professional Science Masters Program, Northern Arizona University, 5 San Francisco Street, Flagstaff, AZ, 86001, USA

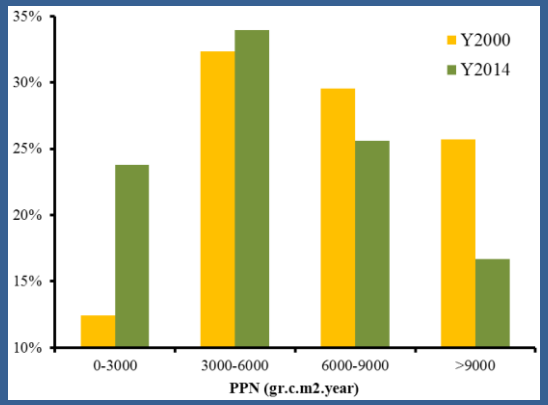
PEBANPA network (Biodiversity and Ecological Long-Term Plots in Southern Patagonia).

GLORIA GLOBAL OBSERVATION RESEARCH INITIATIVE IN ALPINE ENVIRONMENTS

CONICET CADIC

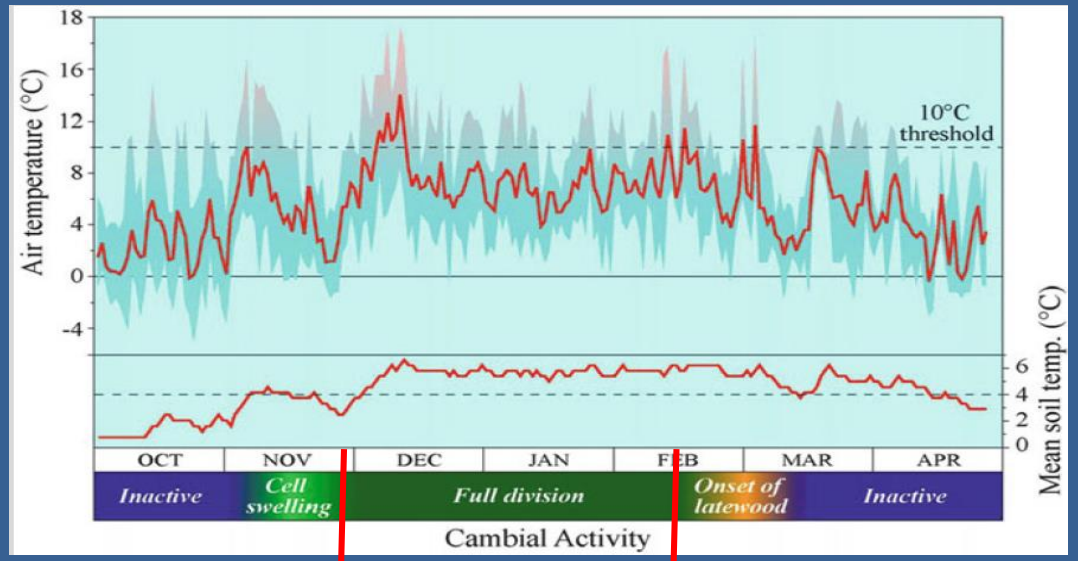
Primary Productivity Net were related to temperature and rainfall gradients, and extreme events (e.g. ENSO, SAM) influencing growing season, and consequently over plant growth.

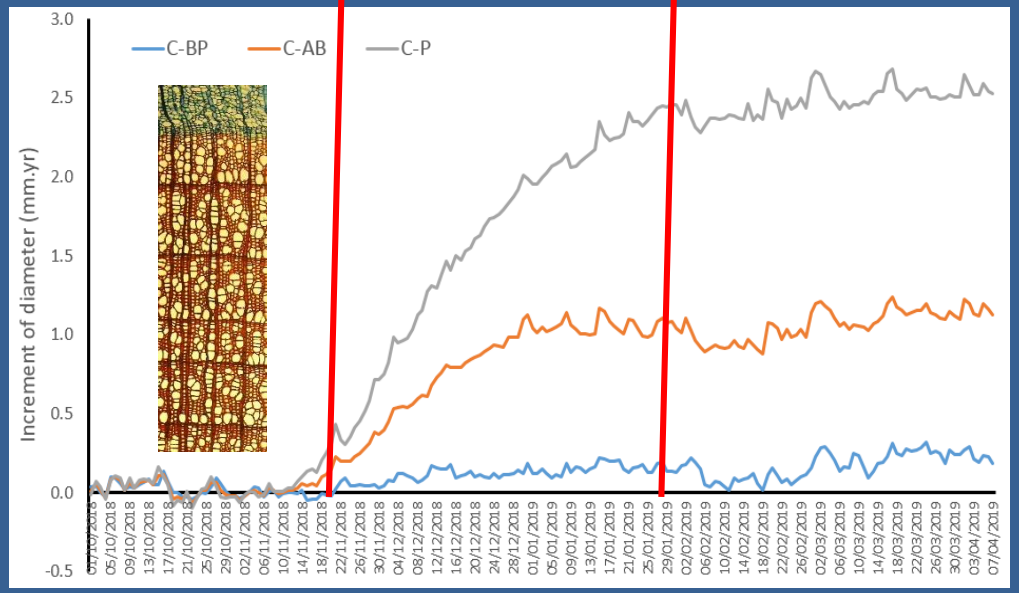


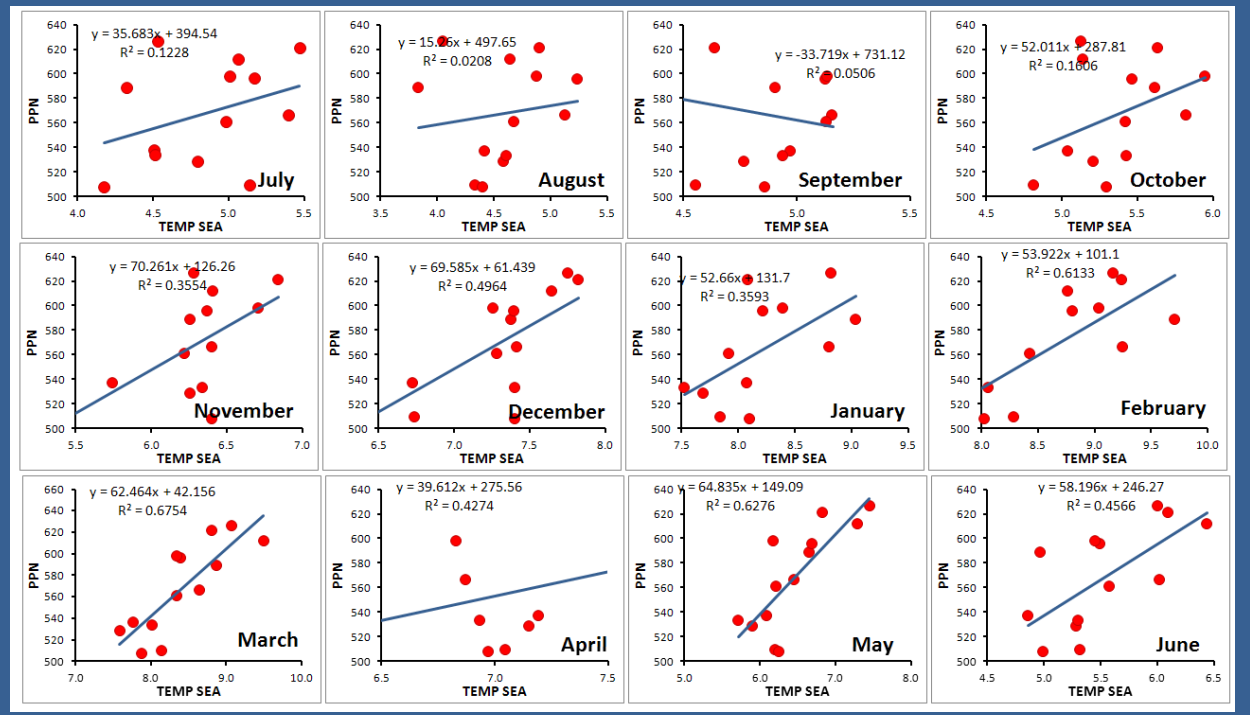


CONICET CADIC

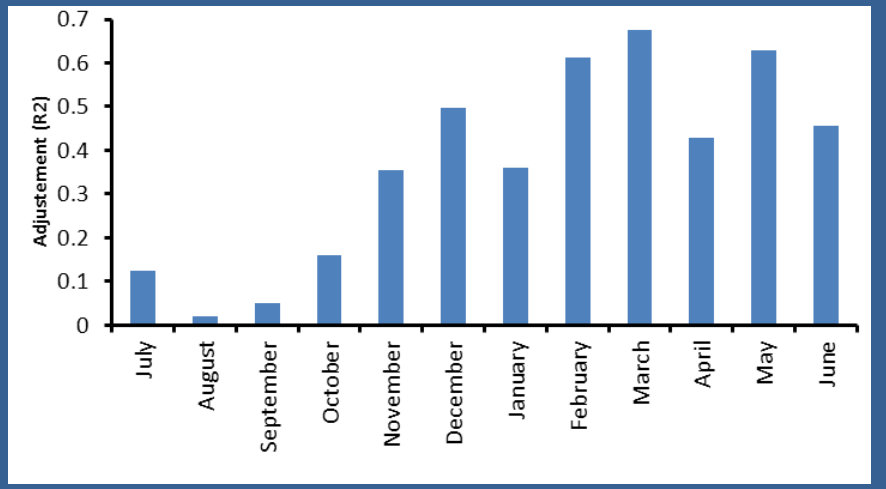
Primary Productivity Net were related to temperature and rainfall gradients, and extreme events (e.g. ENSO, SAM) influencing growing season, and consequently over plant growth.







PPN and sea surface temperature



Growth and forest dynamics are influenced by the climate change during the last century.

BOSQUE 33(3): 267-270, 2012 DOI: 10.4067/S0717-92002012000300006

Changes in height growth patterns in the upper tree-line forests of Tierra del Fuego in relation to climate change

Cambios en los patrones de crecimiento de los bosques del límite superior altitudinal de Tierra del Fuergo en relación al cambio climático

Horacio S Ivancich *[a], Guillermo J Martínez Pastur [a], Fidel A Roig [b], Marcelo D Barrera [c], Fernando Pulido [d]

*Corresponding author: [a] Centro Austral de Investigaciones Científicas (CADIC-CONICET), Bernardo Houssay 200, Ushuaia, Tierra del Fuego, Argentina, horacioivancich@yahoo.com.ar
[b] Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales (IANIGLA-CONICET), Mendoza, Argentina.
[c] Universidad Nacional de La Plata, LISEA, Facultad de Ciencias Agrarias y Forestales, La Plata, Argentina.
[d] Universidad de Extremadura, Spain.

SUMMARY

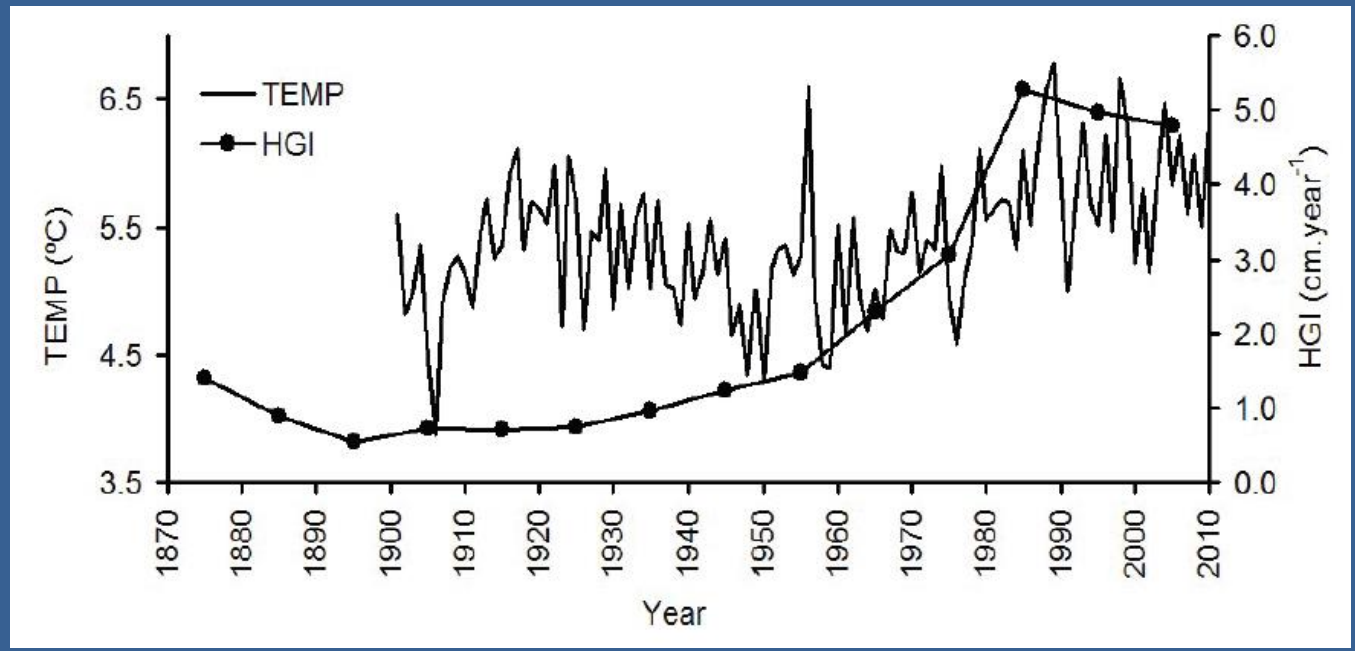
Nothofagus pumilio occupy the mountain slopes reaching to the upper altitudinal limit of the forests. This extremely stressful environment represents the optimum conditions to study changes in growth patterns due to climate variations. Our goal was to analyze recent changes in stem height growth in forests located in the upper altitudinal tree-line along Tierra del Fuego (Argentina), and establish possible linkages to changes observed in surface temperature during the last decades. Nine locations were sampled, and four plots were measured in each location. Forest structure was characterized, and stem analyses were performed to assess height growth patterns. ANOVAs and classification analyses were conducted using location and time as main variables. Tree-growth height increased with time, e.g. 1.0 cm year^{-1} during 1870-1959, 2.7 cm year^{-1} during 1960-1979, and 5.0 cm year^{-1} during 1980-2010. These differences were significant between periods and locations, and can be related to its geographical situation. Increment in stem height growth seems to be related with the worldwide surface air temperature. A decline in stem height growth registered during the last two decades can also be related with the regional decrease in the mean air temperature. The analysis of stem height growth is a useful tool to evaluate the incidence of climate change over trees growing under extreme environmental conditions.

Key words: tree-line, *Nothofagus*, height growth, climate change, forest structure.

RESUMEN

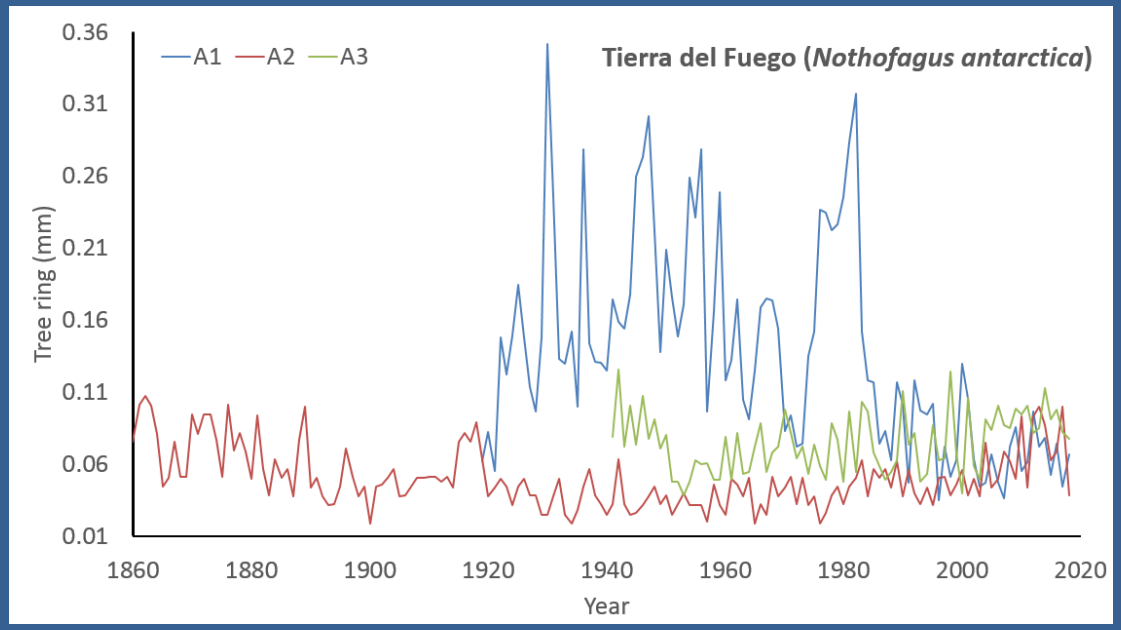
Los bosques de *Nothofagus pumilio* ocupan las laderas de montaña hasta alcanzar el límite altitudinal del bosque. Estos ambientes extremos, donde los bosques están bajo condiciones de estrés ambiental, son óptimos para estudiar patrones de cambio debidos a variaciones climáticas. El objetivo fue analizar cambios recientes en el crecimiento en altura en bosques localizados en el tree-line altitudinal en Tierra del Fuego (Argentina) y establecer posibles vinculaciones con cambios en la temperatura observados durante las últimas décadas. Se muestrearon nueve sitios, y se midieron cuatro parcelas en cada sitio. Se determinó la estructura forestal y se realizaron análisis fustales para evaluar los patrones de crecimiento en altura. Se realizaron ANOVA y análisis de clasificación usando como factores principales al sitio y al tiempo. El crecimiento en altura aumentó a lo largo del tiempo, *e.g.* 1,0 cm año^{-1} durante 1870-1959, 2,7 cm año^{-1} durante 1960-1979 y 5,0 cm año^{-1} durante 1980-2010. Esas diferencias fueron significativas entre períodos de tiempo y sitios, pudiendo estar relacionadas con la localización geográfica. El incremento en el crecimiento en altura observado está relacionado con los cambios en la temperatura de superficie experimentada en todo el mundo. Una declinación en el crecimiento en altura durante las últimas dos décadas, también puede estar relacionada con una disminución regional de la temperatura de aire. El análisis del crecimiento en altura es una herramienta de utilidad para evaluar la incidencia que tiene el cambio climático sobre el crecimiento de los árboles que crecen en ambientes extremos.

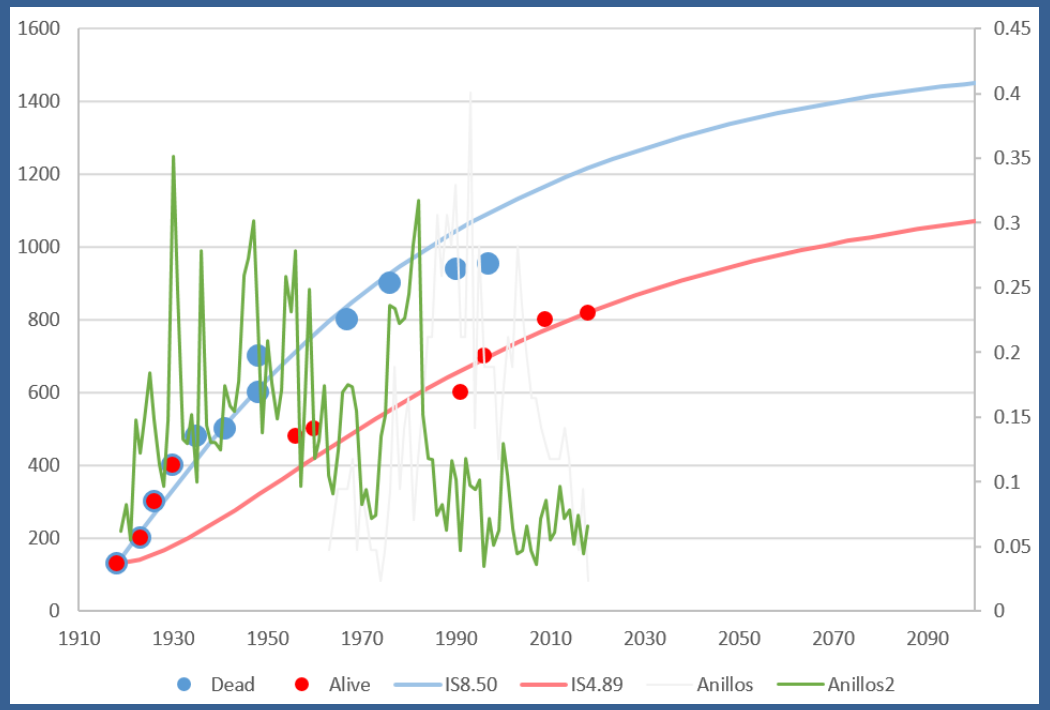
Palabras clave: bosque altitudinal, *Nothofagus*, crecimiento en altura, cambio climático, estructura forestal.

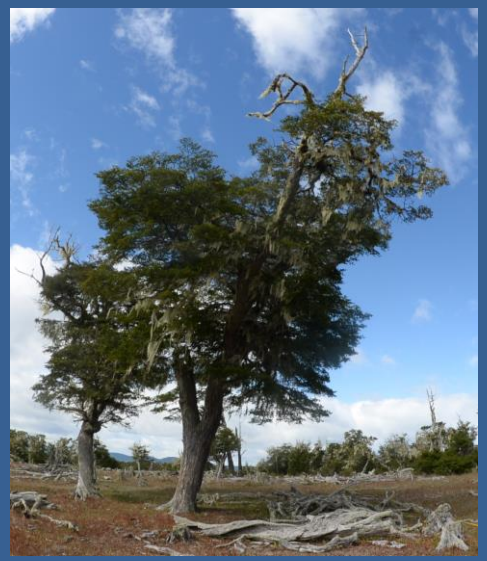


Tree height growth in tree-line increases from 1930 to 1990 and then begin to decreases until present.

Also, crown dieback was detected resulting in changing site quality of the natural forests in the steppe ecotone (less rainfall, higher summer temperature).







Tree mortality in natural stands can be related with climate too, where yearly rainfall (drought during summer) and primary productivity net (stand growth) explain most of the tree losses.

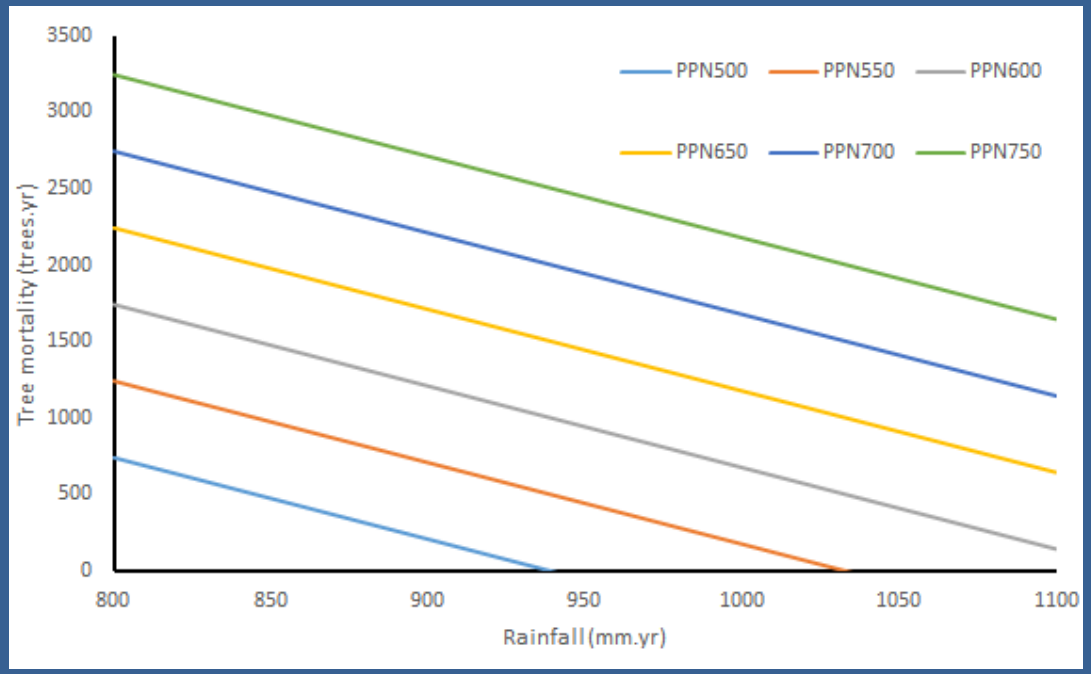
Parámetro	Estimación	Error Estándar	Estadístico T	Valor-P
PP	-532,927	220,761	-241,404	0.0313
PPN	10,013	32,987	303,543	0.0096

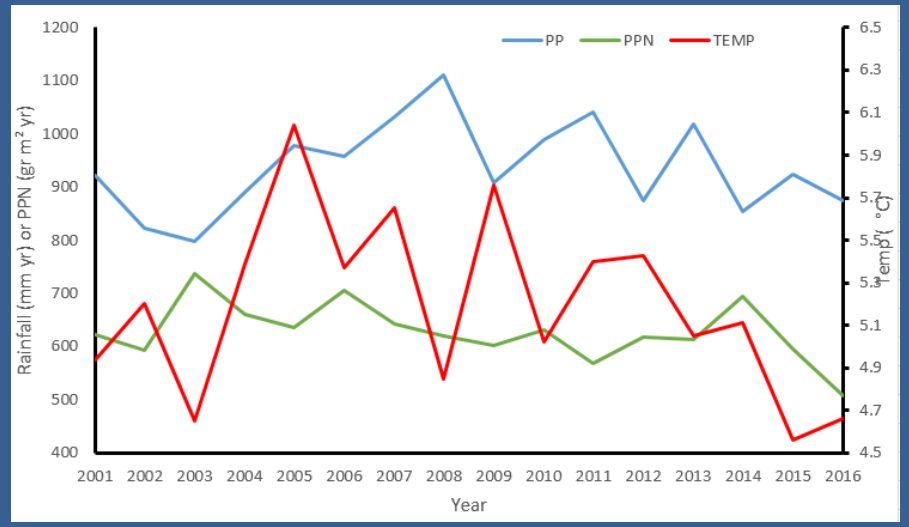
Análisis de Varianza

Fuente	Suma de Cuadrados	Gl	uadrado Medi	Razón-F	Valor-P
Modelo	3.42E+12	2	1.71E+12	13.82	0.0006
Residuo	1.61E+12	13	1.24E+11		
Total	5.02E+10	15			

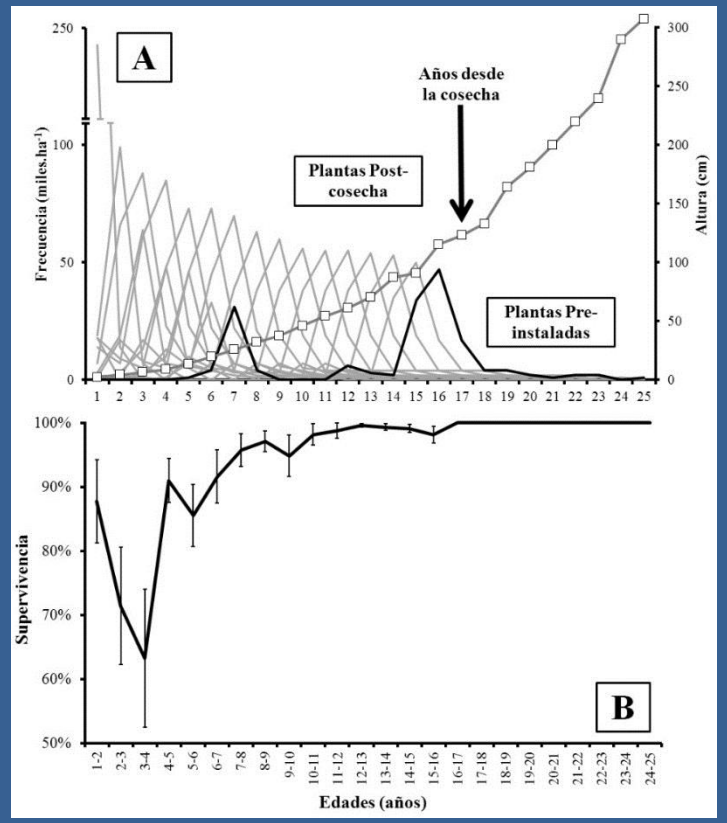
R-cuadrada = 68.0081 porciento
R-cuadrado (ajustado para g.l.) = 65.5472 porciento
Error estándar del est. = 1111.81
Error absoluto medio = 700.558
Estadístico Durbin-Watson = 1.06329
Autocorrelación de residuos en retraso 1 = 0.152612

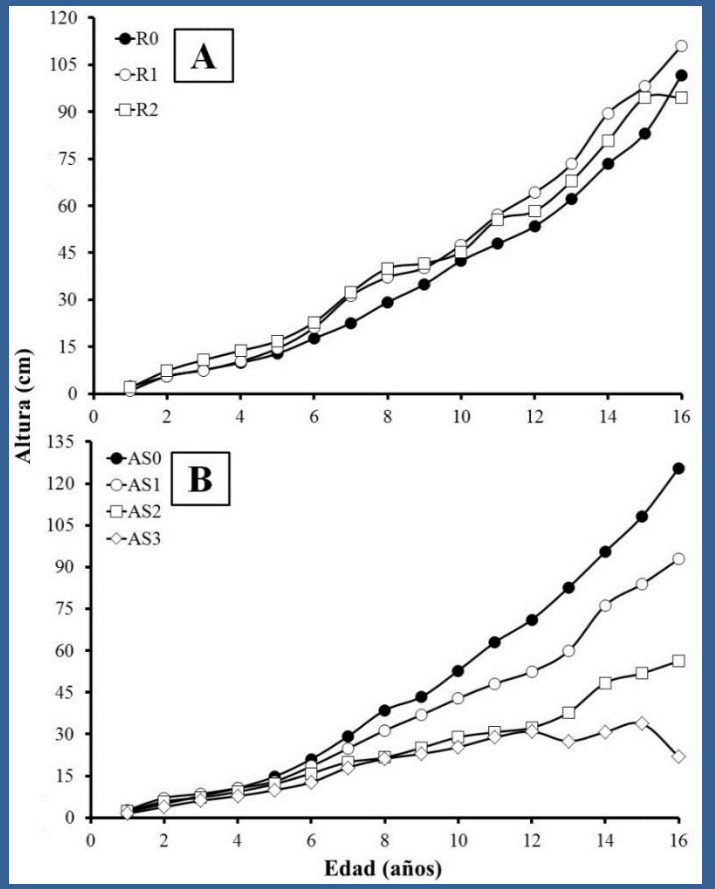
Global = -5.32927*PP + 10.013*PPN





Slightly variation mainly influence over season length, affecting the tree and plant growth including reproduction, food availability for mammals, birds and insects, and in consequence over the primary and secondary productivity.





Seed production, recruitment and seedling mortality are related to land and sea surface temperature and rainfall gradients, both, during the previous winter and middle summer.

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http://dx.doi.org/10.5424/fs/2015241-06403
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)

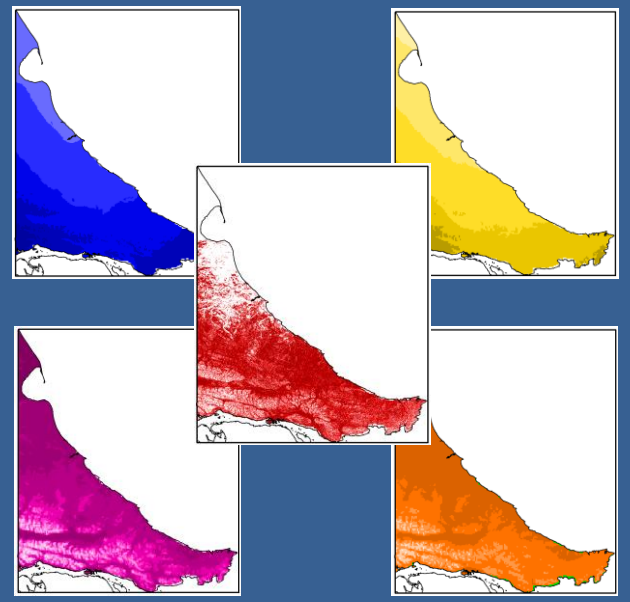
RESEARCH ARTICLE

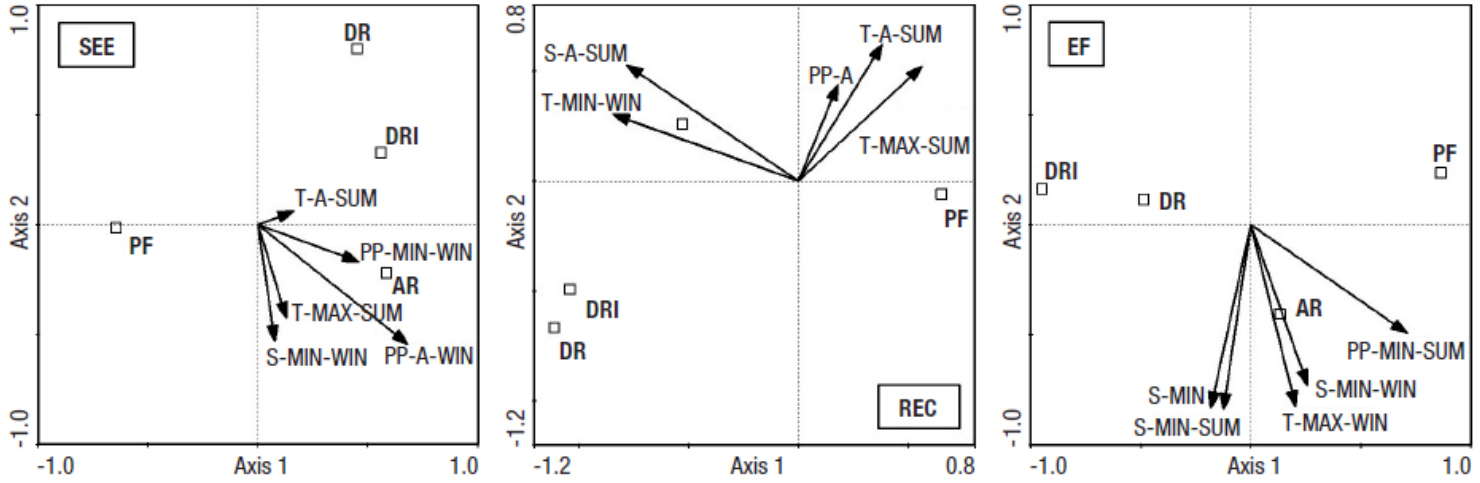
OPEN ACCESS

Seed production and recruitment in primary and harvested *Nothofagus pumilio* forests: Influence of regional climate and years after cuttings

Ana D. Torres[1], Juan M. Cellini[1], María V. Lencinas[2], Marcelo D. Barrera[1], Rosina Soler[2], Ricardo Díaz-Delgado[3] and Guillermo J. Martínez Pastur[2,*]

[1]*Centro Austral de Investigaciones Científicas (CADIC) - Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). Ushuaia, Tierra del Fuego, Argentina* [2]*Laboratorio de Investigaciones de Sistemas Ecológicos y Ambientales (LISEA) - Universidad Nacional de La Plata (UNLP). La Plata, Buenos Aires, Argentina* [3]*Laboratorio de SIG y Teledetección, Estación Biológica de Doñana (CSIC). Sevilla, España*





Codes of climate variables are described in material and methods

Figure 1. Canonical correspondence analysis (CCA) for the seed production (SEE), recruitment of seedlings (REC) and recruitment efficiency (EF) of the unmanaged primary forests (PF) and harvested stands with variable retention (AR = aggregated retention, DRI = dispersed retention under the aggregated influence, DR = dispersed retention without aggregate influence).

Table 3. ANOVAs for the seed production (SEE), recruitment of seedlings (REC) and recruitment efficiency (EF) of harvested stands with variable retention along the years after harvesting (3 to 10 years).

	SEE (mill.ha^{-1}.year^{-1})	REC (n.m^{2}.year^{-1})	EF (%)
3	4.01 ab	8.3 ab	2.12 ab
4	7.20 b	19.2 b	3.96 b
5	3.09 a	11.5 ab	3.53 ab
6	3.01 a	2.2 a	1.62 ab
7	4.74 ab	0.7 a	0.18 a
8	5.10 ab	0.7 a	0.06 a
9	2.34 a	0.3 a	0.08 ab
10	2.57 ab	0.1 a	0.02 a
F(p)	*3.14(0.003)*	*3.91(<0.001)*	*3.24(0.002)*

F= Fisher test; (p) = probability. Different letters showed differences at p <0.05 with Tukey test.

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Understory development were related to the summer length, where food availability decrease in late spring for herbivorous. In consequence, browsing over seedlings due to natural populations of *Lama guanicoe* increased.

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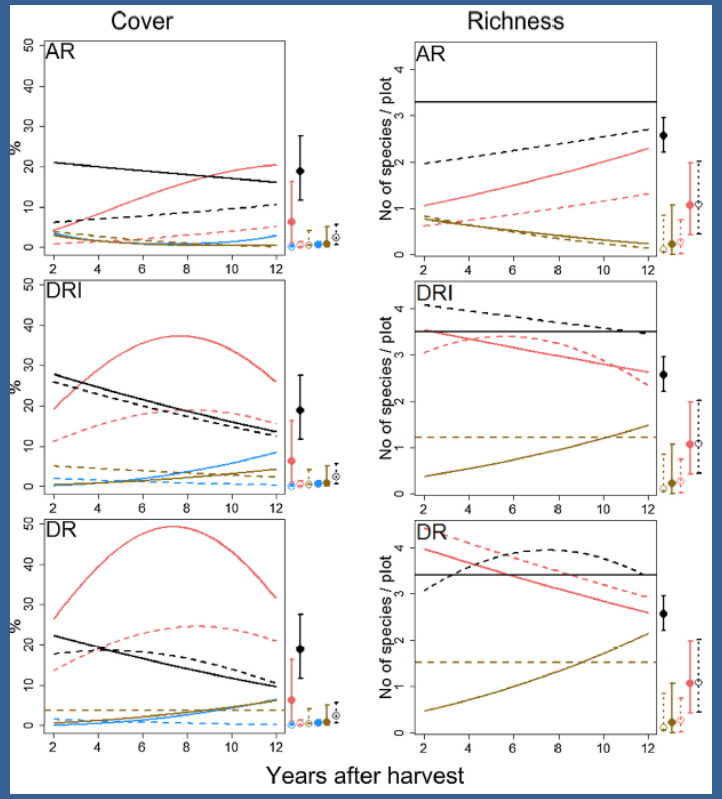
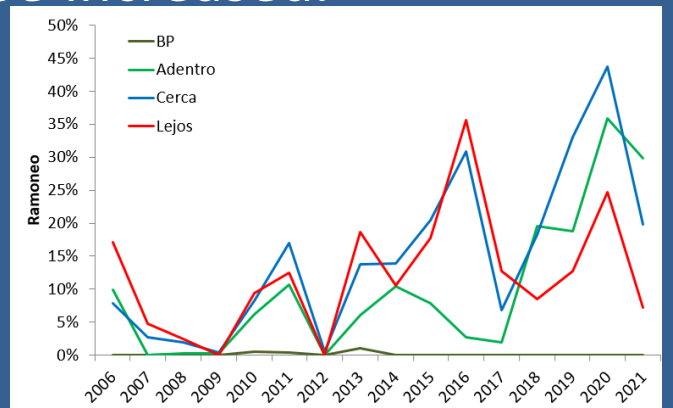
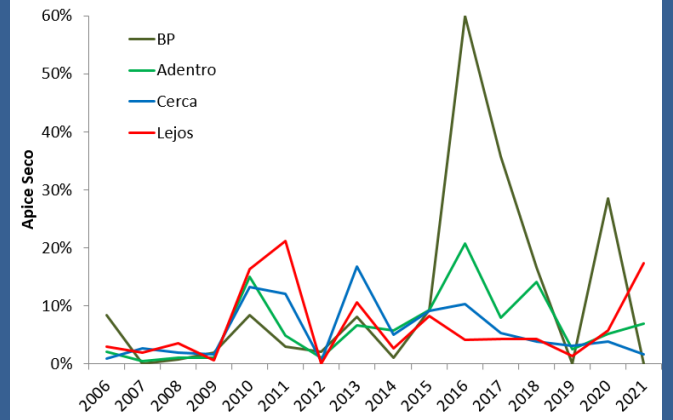
Twelve-year dynamics of alien and native understorey plants following variable retention harvesting in *Nothofagus pumilio* forests in Southern Patagonia

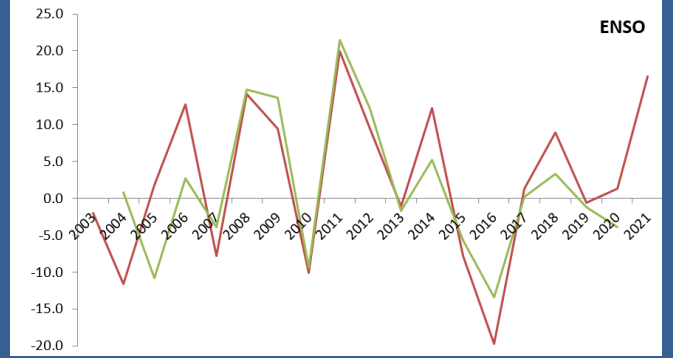
Rosina Soler[a,b,*], Sabine B. Rumpf[c,d], Stefan Schindler[c,e], Guillermo Martínez Pastur[a,b], Marcelo Barrera[f], Juan Manuel Cellini[f], Magalí Pérez Flores[b,f], Franz Essl[c,e], Wolfgang Rabitsch[e], María Vanessa Lencinas[a,b]

[a] Centro Austral de Investigaciones Científicas (CADIC), Houssay 200, Ushuaia, Argentina
[b] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina
[c] Department of Botany and Biodiversity Research, University of Vienna, Austria
[d] Department of Botany, University of Otago, New Zealand
[e] Department of Biodiversity and Nature Conservation, Environment Agency, Austria
[f] Universidad Nacional de La Plata (UNLP), Argentina

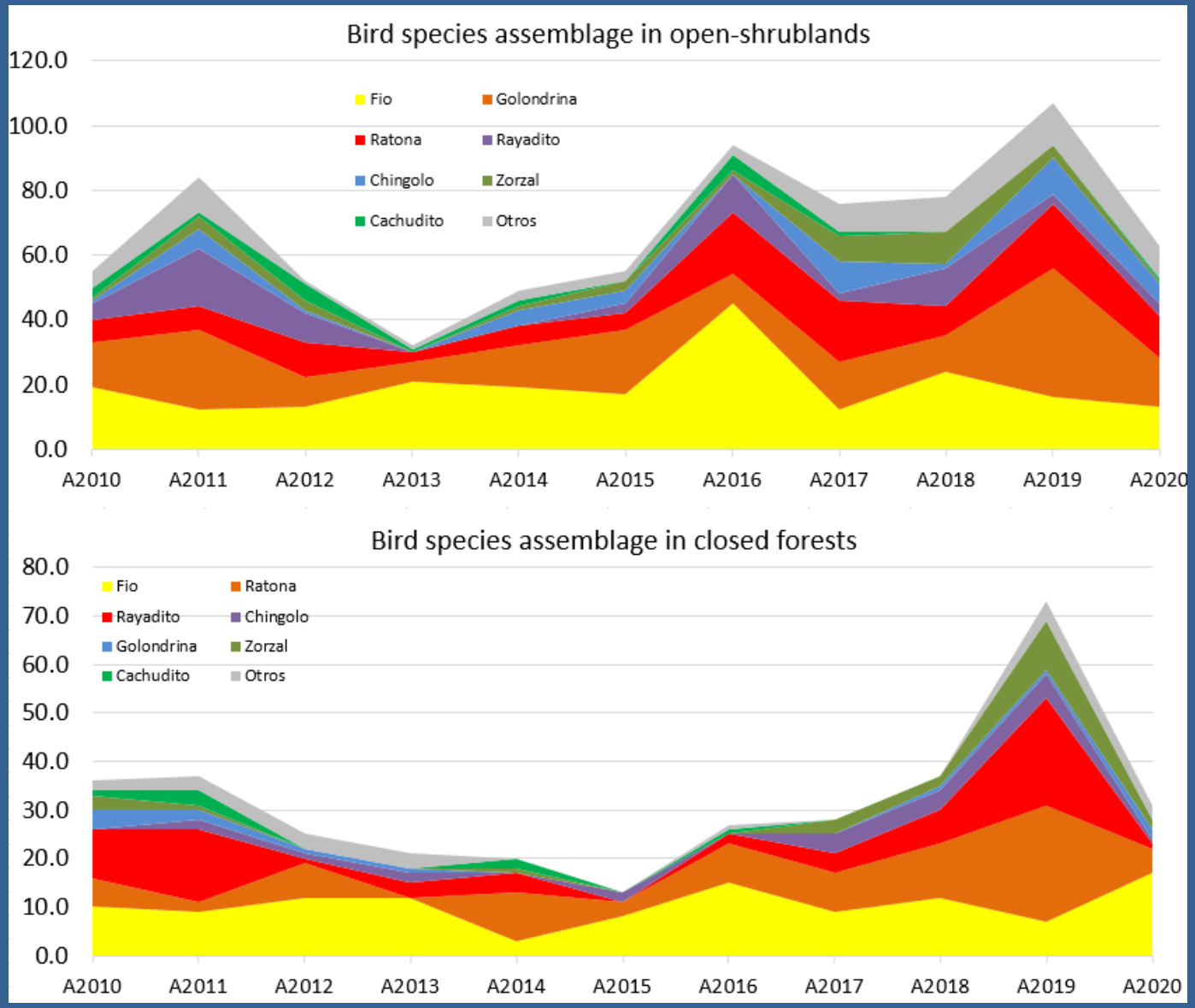








Finally, we also related secondary productivity (e.g. forest bird biomass) with primary productivity of forests, and it changed according this variable along the years.



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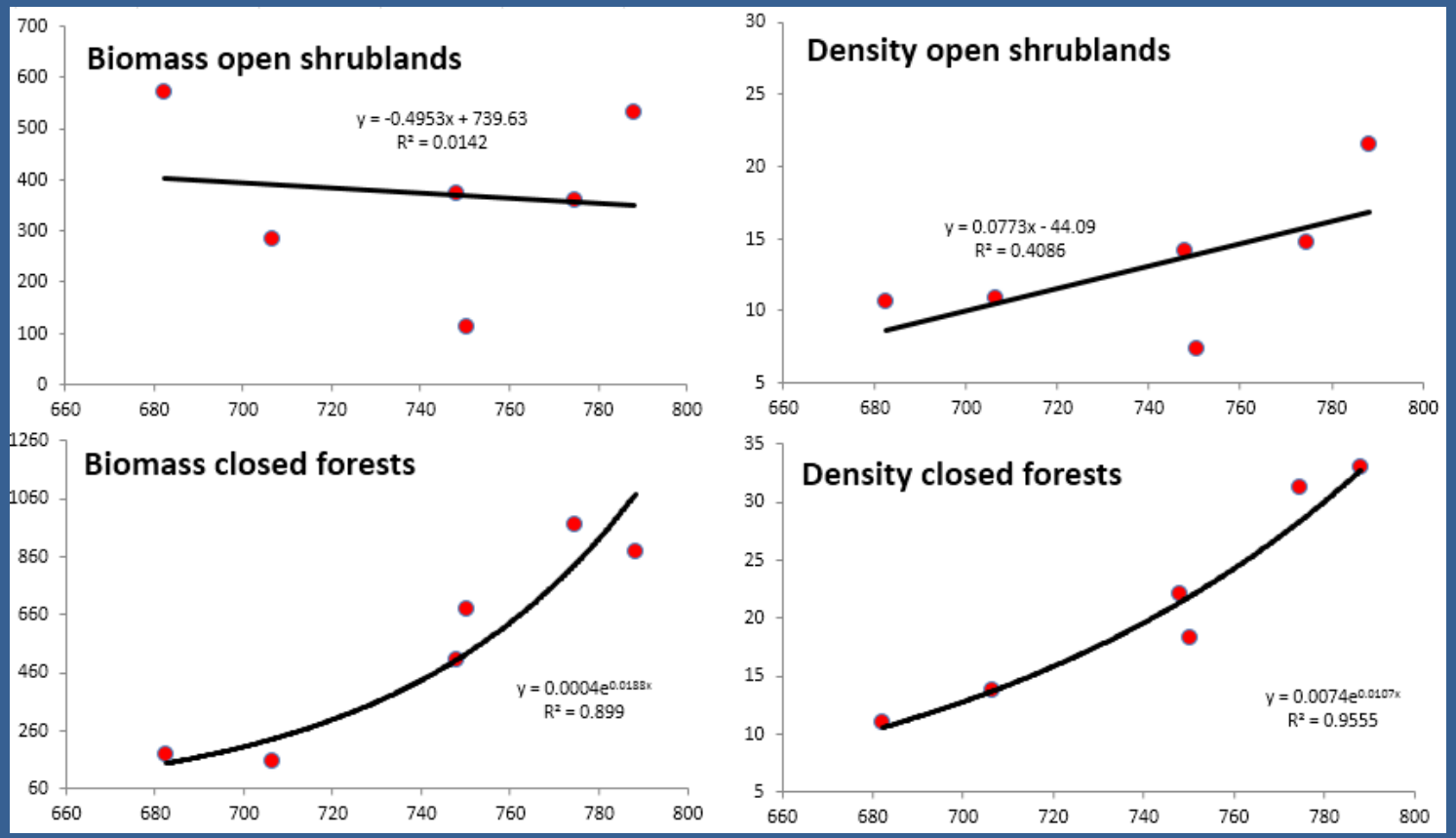

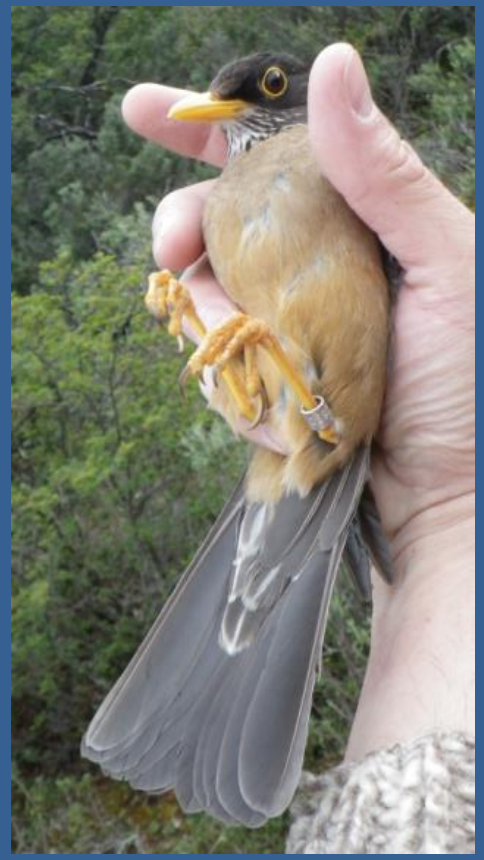

Significant relationships were observed in biomass and density of forest birds with PPN estimated through MODIS satellite images.

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Long-term research allowed to understand the observed changes in the forest ecosystem processes in the framework of management proposals and climate change.

This monitoring is essential to develop new management and conservation strategies to increase the resilience of the natural forests.

gpastur@conicet.gov.ar
yamicarosas@gmail.com
toro.manriquez.monica@gmail.com
alejandrohuertasherrera@gmail.com
jbenitezgaias@gmail.com
paublazina@gmail.com
mvlencinas@conicet.gov.ar
rdiaz@ebd.csic.es
peri.pablo@inta.gob.ar
marco.ferretti@wsl.ch

Thanks!