High Andean Wetlands, Climate Change and Ecosystem Services

WHAT DO WE KNOW?

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1. Background and Motivation
2. Systematic Literature Review
3. Results and Discussion
4. Conclusion and Outlook

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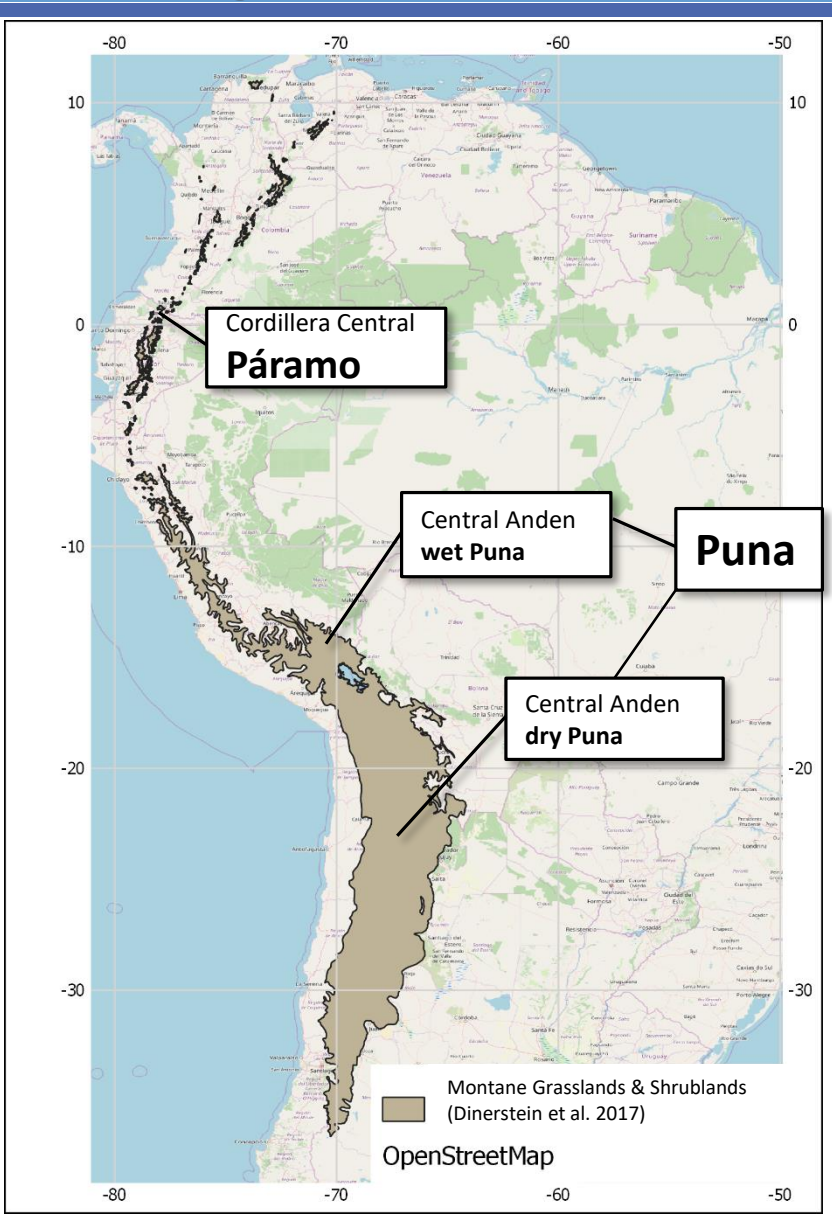
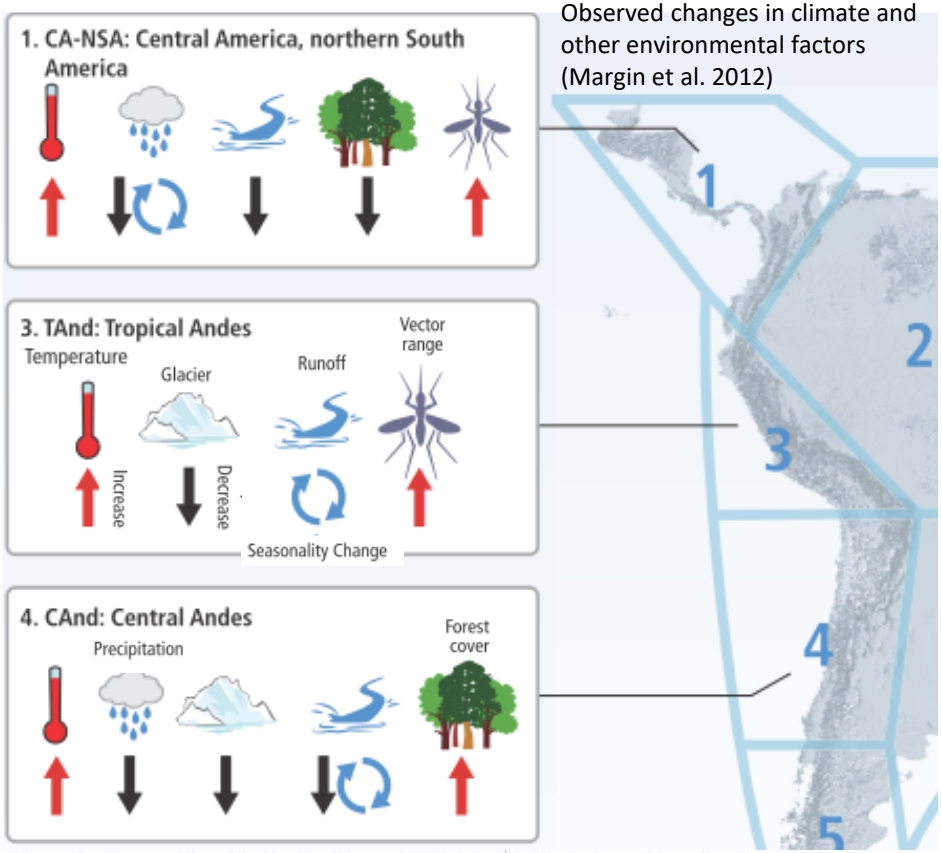
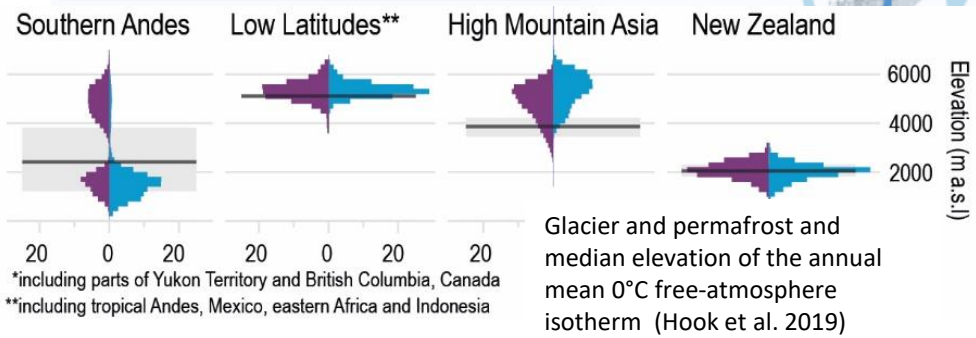
1. Background and Motivation



Observed changes in climate and other environmental factors (Margin et al. 2012)





Glacier and permafrost and median elevation of the annual mean 0°C free-atmosphere isotherm (Hook et al. 2019)

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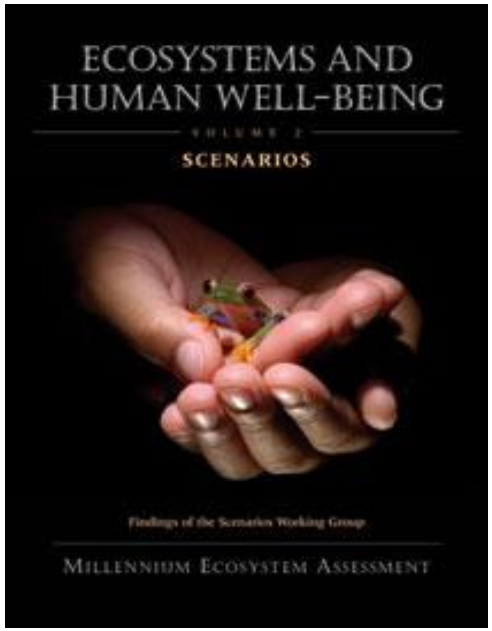
1. Background and Motivation

High Andean ecosystems are expected to face exceptionally strong warming effects during the 21st century because of their uncommonly high altitude (Bradley et al. 2006).

High Andean ecosystems provide a series of crucial ecosystem services for millions of people (Buytaert et al. 2011).



http://www.millenniumassessment.org

Ecosystem services of Wetlands (Ramsar 2011)

1 Flood control
2 Groundwater replenishment
3 Shoreline stabilisation & storm protection
4 Sediment & nutrient retention and export
5 Water purification
6 Reservoirs of biodiversity
7 Wetland products
8 Cultural values
9 Recreation & tourism
10 Climate change mitigation and adaptation

Ramsar Convention on Wetlands

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1. Questions

What does the term „High Andean Wetlands“ refers to?

What ecosystem service (ESS) are related to High Andean Wetlands?

Example: Sink or Source - Do High Andean Wetland provide ESS for climate change mitigation?

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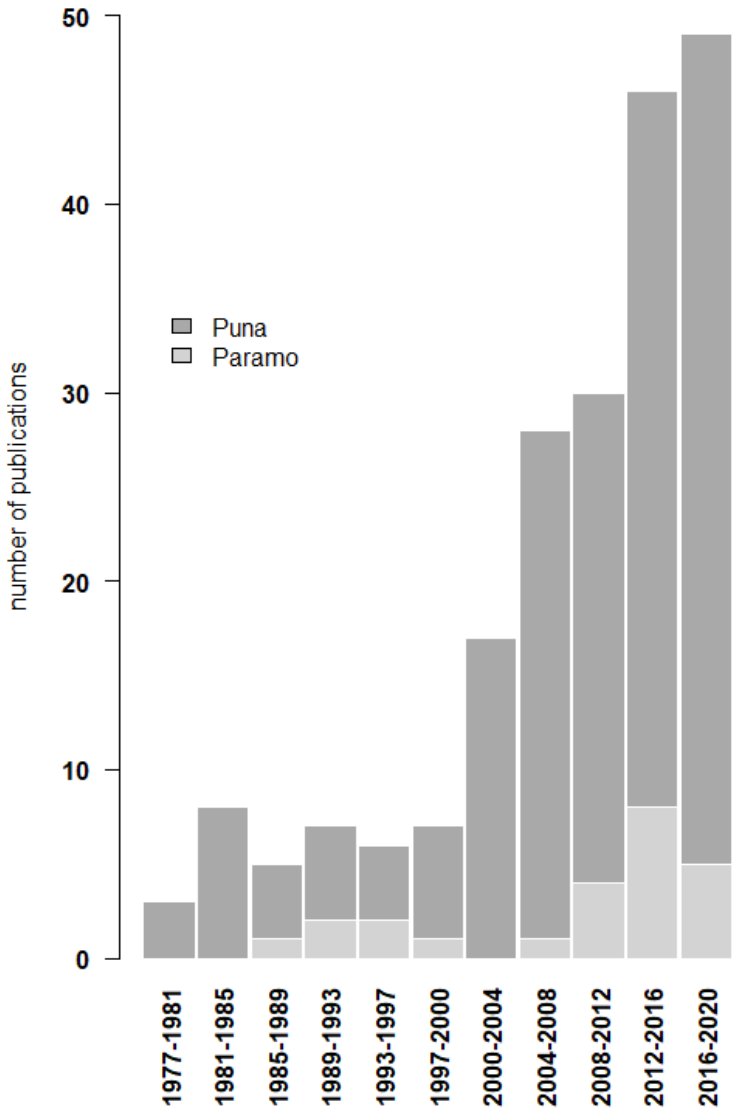
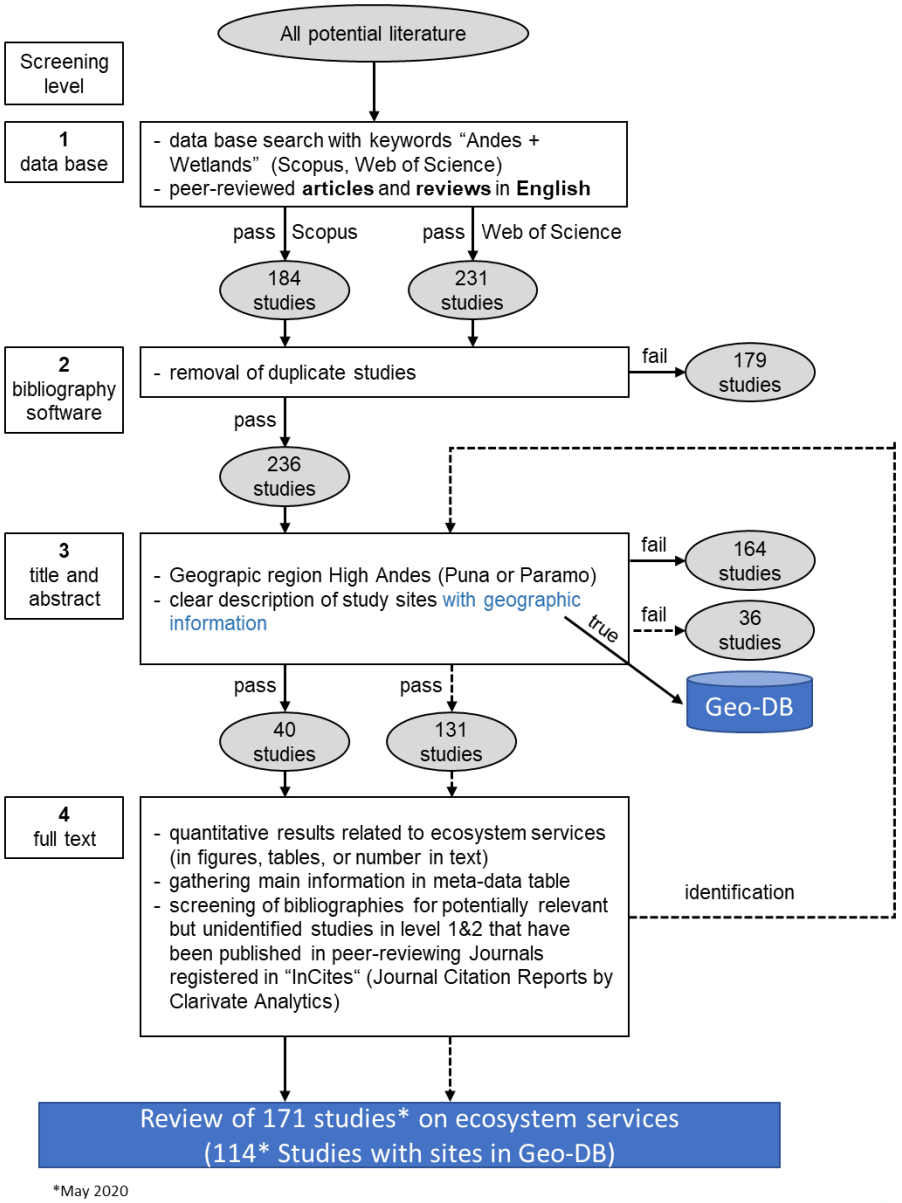
2. Literature research





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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	Authors_year	year	title	doi	Discipline	terms_used_1	terms_used_2	terms_used_3	terms_used_4	terms_used_5	terms_used_6	terms_used_7	research scope/method	ecoregion	Countrg_research_area	Countrg_first_author	spatial_scale	temporal_scale_studg	Ecosystem services	ESS_Ramsar_1	ESS_Ramsar_2	ESS_Ramsar_3	ESS_Ramsar_4
2	Araya_Lopez_et_al2018	2018	Monitoring Andean high altitude wetlands in central Chile with seasonal optical data: A comparison between Worldview-2 and Sentinel-2 imagery	10.1016/j.isprsjprs.2018.04.001	Landscape Ecology	Andean high altitude wetlands	vegas	wet meadows	NA	NA	NA	NA	wetlands, remote sensing	Puna	Chile	Germany	site	1	NA	NA	NA	NA	NA	N
3	Arroyo_et_al1988	1988	Effects of Aridity on Plant Diversity in the Northern Chilean Andes: Results of a Natural Experiment	10.2307/2399466	Plant Ecology	bogs	cushion bogs	salares	NA	NA	NA	NA	wetlands, plant composition	Puna	Chile	Chile	regional	1	habitat	Reservoirs of biodiversity	NA	NA	NA	N
4	Baied_and_Wheeler1993	1993	Evolution of High Andean Puna Ecosystems: Environment, Climate, and Culture Change over the Last 12,000 Years in the Central Andes	10.2307/3673632	Landscape Ecology	lakes	highland bogs	cushion-peat bogs	bofedales	NA	NA	NA	pollen analysis	Puna	Chile	USA	site	NA	climate archive,rangeland	Wetland products	Cultural values	Climate change mitigation and adaptation	NA	N
5	Barros_et_al2014	2014	Short-Term Effects of Pack Animal Grazing Exclusion from Andean Alpine Meadows	10.1657/1938-4246-46.2.333	Agroecology	Andean Alpine Meadows	NA	NA	NA	NA	NA	NA	ecosystem service	Puna	Argentina	Australia	site	1	Livestock grazing	Wetland products	NA	NA	NA	N
6	Benavides_2014	2014	The effect of drainage on organic matter accumulation and plant communities of high-altitude peatlands in the Colombian tropical Andes	NA	Plant Ecology	peatlands	high-altitude cushion bogs	rich fens	poor fens	high-altitude Andean peatlands	NA	NA	plant composition	Paramo	Colombia	Colombia	area	1	organic matter retention, peat accumulation, carbon accumulation	Sediment & nutrient retention and export	Climate change mitigation and adaptation	NA	NA	N
7	Benavides_and_Vitt2014	2014	Response curves and the environmental limits for peat-forming species in the northern Andes	10.1007/s11258-014-0346-7	Plant Ecology	peatlands	NA	NA	NA	NA	NA	NA	plant composition	Paramo	Colombia	USA	region	1	habitat, carbon accumulation	Reservoirs of biodiversity	Climate change mitigation and adaptation	NA	NA	N
8	Benavides_et_al2013	2013	The influence of climate change on recent peat accumulation patterns of Distichia muscoides cushion bogs in the high-elevation tropical Andes of Colombia	10.1002/2013JG002419	Plant Ecology	cushion peatlands	cushion bogs	NA	NA	NA	NA	NA	peat accumulation	Paramo	Colombia	Colombia	site	1	organic matter retention, peat accumulation, carbon accumulation	Sediment & nutrient retention and export	Climate change mitigation and adaptation	NA	NA	N
9	Blancas_et_al2018	2018	Using Foresight to Gain a Local Perspective on the Future of Ecosystem Services in a Mountain Protected Area in Peru	10.1659/MRD-JOURNAL-D-17-00090.1	Landscape Ecology	bofedales	wetlands	NA	NA	NA	NA	NA	ecosystem service	Puna	Peru	Peru	area	1	Water for human consumption, Food for alpacas, Counteracting the effect of drought, Water for aquaculture production, Water storage, Counteracting the effect of drought, Water for aquaculture	Wetland products	Groundwater replenishment	Recreation & tourism	NA	N
10	Bobadilla_et_al2013	2013	A phytoremediation approach using Calamagrostis ligulata and Juncus imbricatus in Andean wetlands of Peru	10.1007/s10661-012-2552-x	Plant Ecology	bofedales	Andean wetlands	Alpine wetlands of the Andes	NA	NA	NA	NA	bioremediation	Puna	Peru	Spain	site	1	Water filtering (bioaccumulation of metals)	Water purification	Sediment & nutrient retention and export	NA	NA	N
11	Bosman_1994	1994	Holocene mire development and climatic change from a high Andean Plantago rigida cushion mire	10.1177/095968369400400302	Paleoclimatology	high-andean cushion mires	cushion bogs	mires	NA	NA	NA	NA	pollen analysis	Paramo	Colombia	Netherlands	site	1	climate archive	Climate change mitigation and adaptation	NA	NA	NA	N
12	Bosman_et_al1993	1993	Ecology of a paramo cushion mire	NA	Plant Ecology	paramo cushion mires	sphagnum bogs	cushion bogs	fens	NA	NA	NA	plant composition	Paramo	Colombia	Netherlands	site	1	NA	Reservoirs of biodiversity	Climate change mitigation and adaptation	NA	NA	N
13	Bosq_etal2004	2004	Landsat TM inventory and assessment of waterbird habitat in the southern altiplano of South America	10.1007/s11273-005-1761-2	Ornithology	bofedales	vegas	lagunas	lakes	NA	NA	NA	habitat	Puna	Chile/Argentina	USA	region	1	habitat	Reservoirs of biodiversity	NA	NA	NA	N
14	Browman_1983	1983	Andean And Land Pastoralism and Development	NA	Landscape Ecology	bofedales	artificial marshy areas	pantones	ojhos	wayllas	qochawillas	NA	land use	Puna	Peru/Bolivia	USA	area	1	Livestock grazing	Wetland products	NA	NA	NA	N

Screenshot: subset of the meta-data table (Screening level 4)

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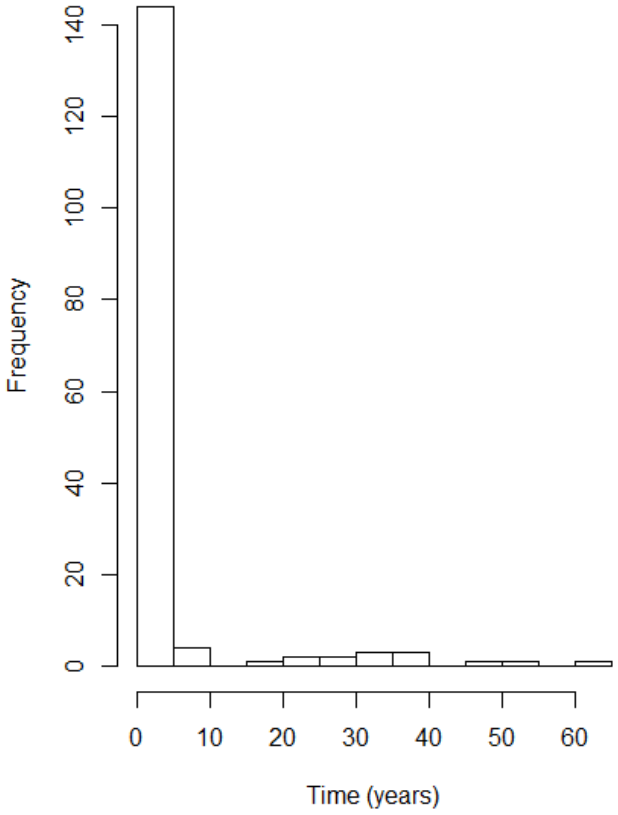
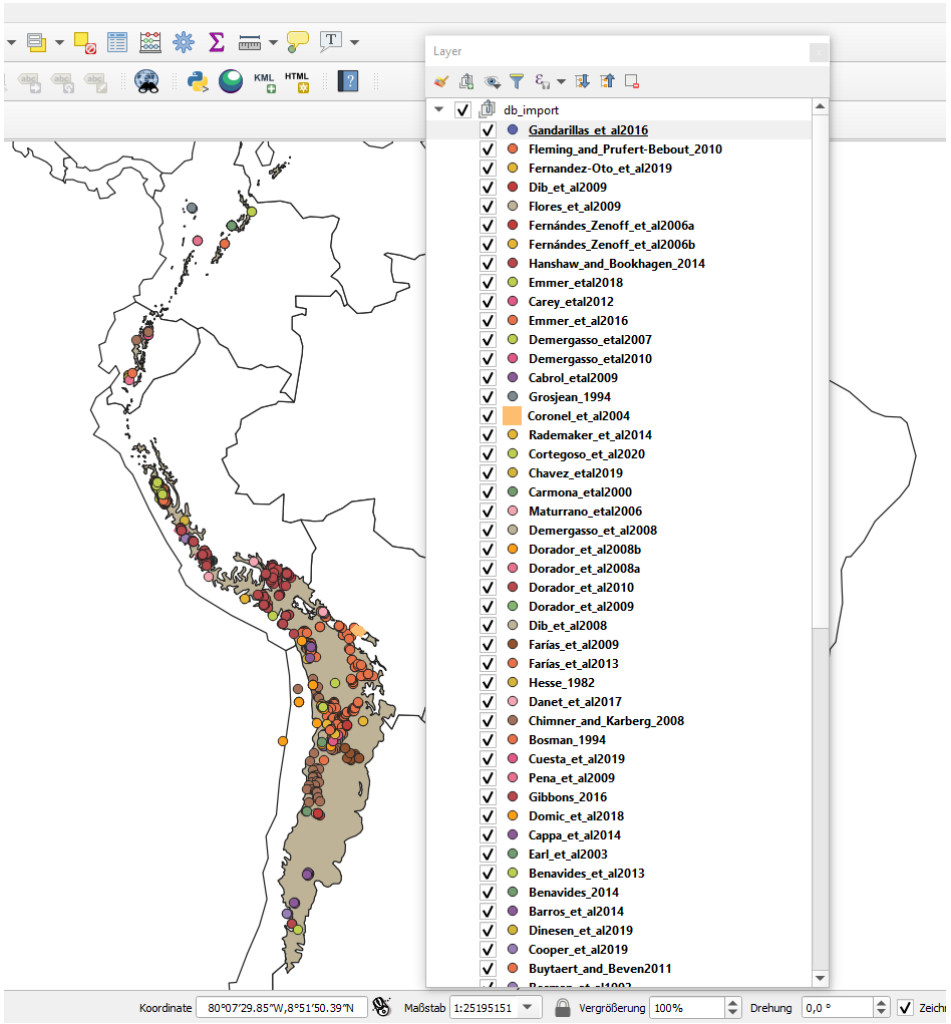
3. Results and Discussion



Histogram of the study duration (i.e. field data collection/observation/modelling)



Screenshot of the Geo-DB (QGIS-Frontend) of the study site locations found in literature within Montain Grassland & Shrubland (Páramo and Puna)

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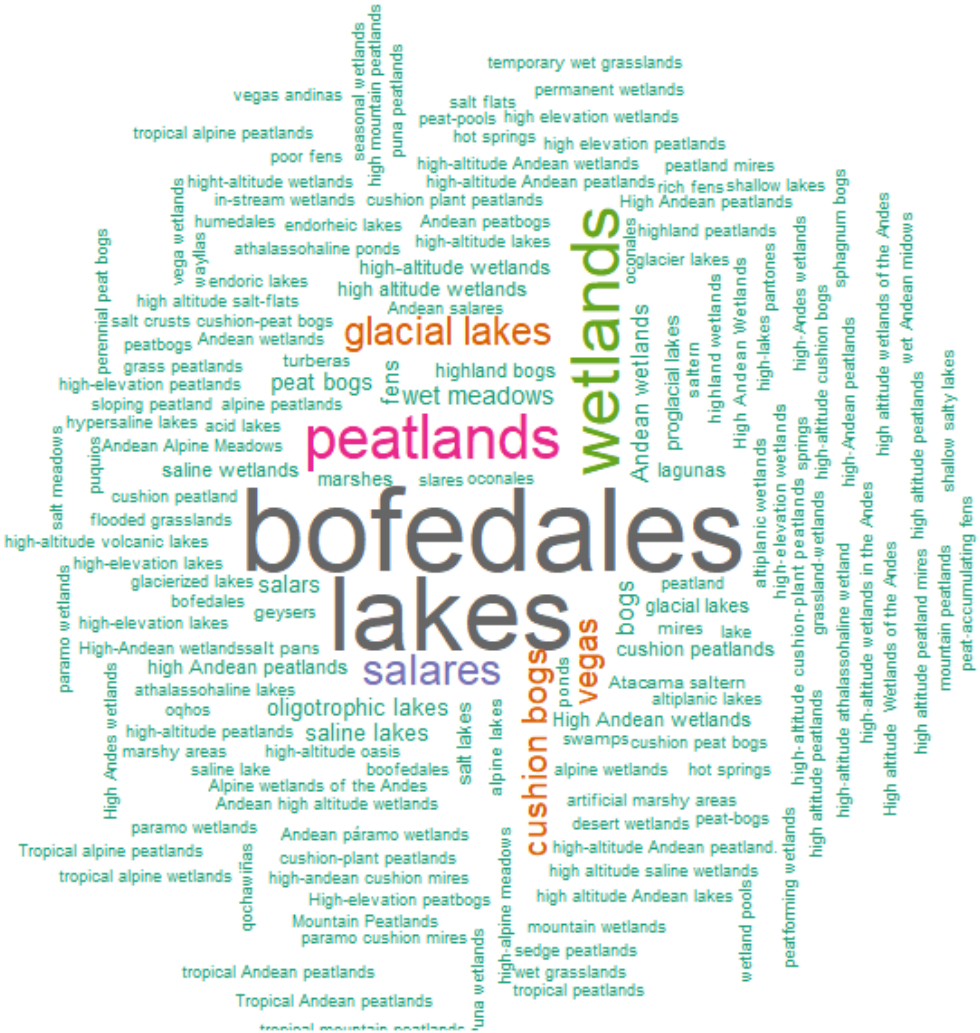

Word cloud: The bigger the letters the higher the frequency of the term used in literature on High Andean Wetlands (whole study region: Páramo + Puna)

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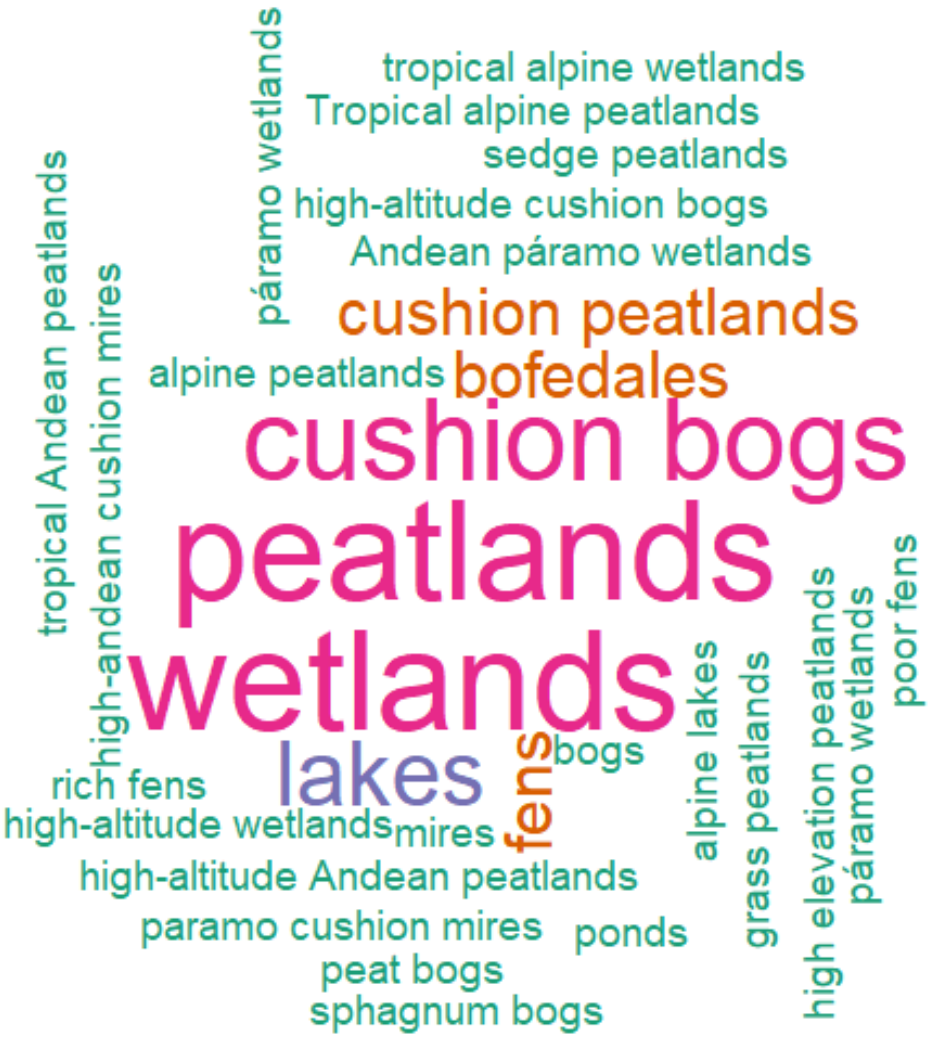

Word cloud: The bigger the letters the higher the frequency of the term used in literature on High Andean Wetlands (Páramo only)

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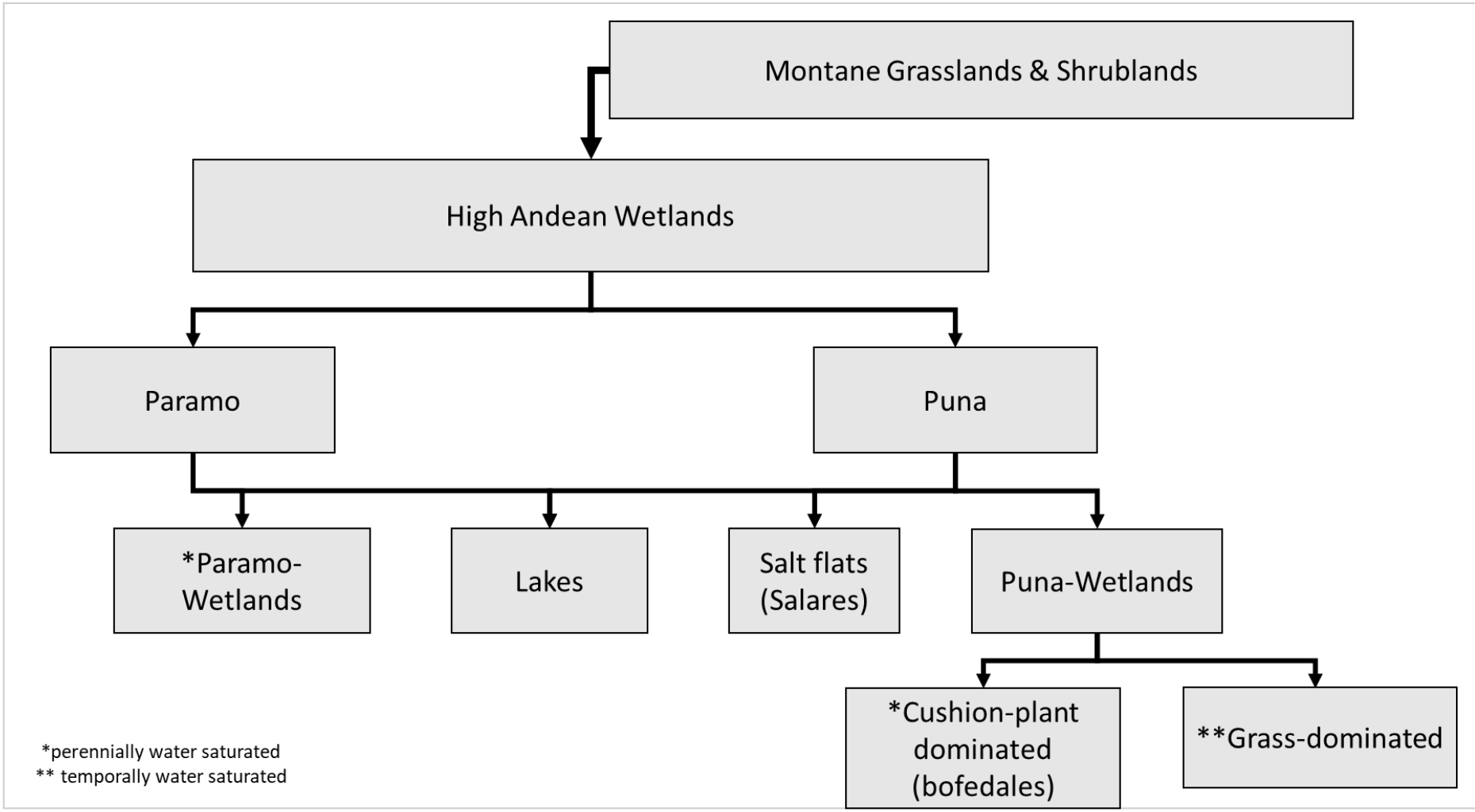
3. Results and Discussion



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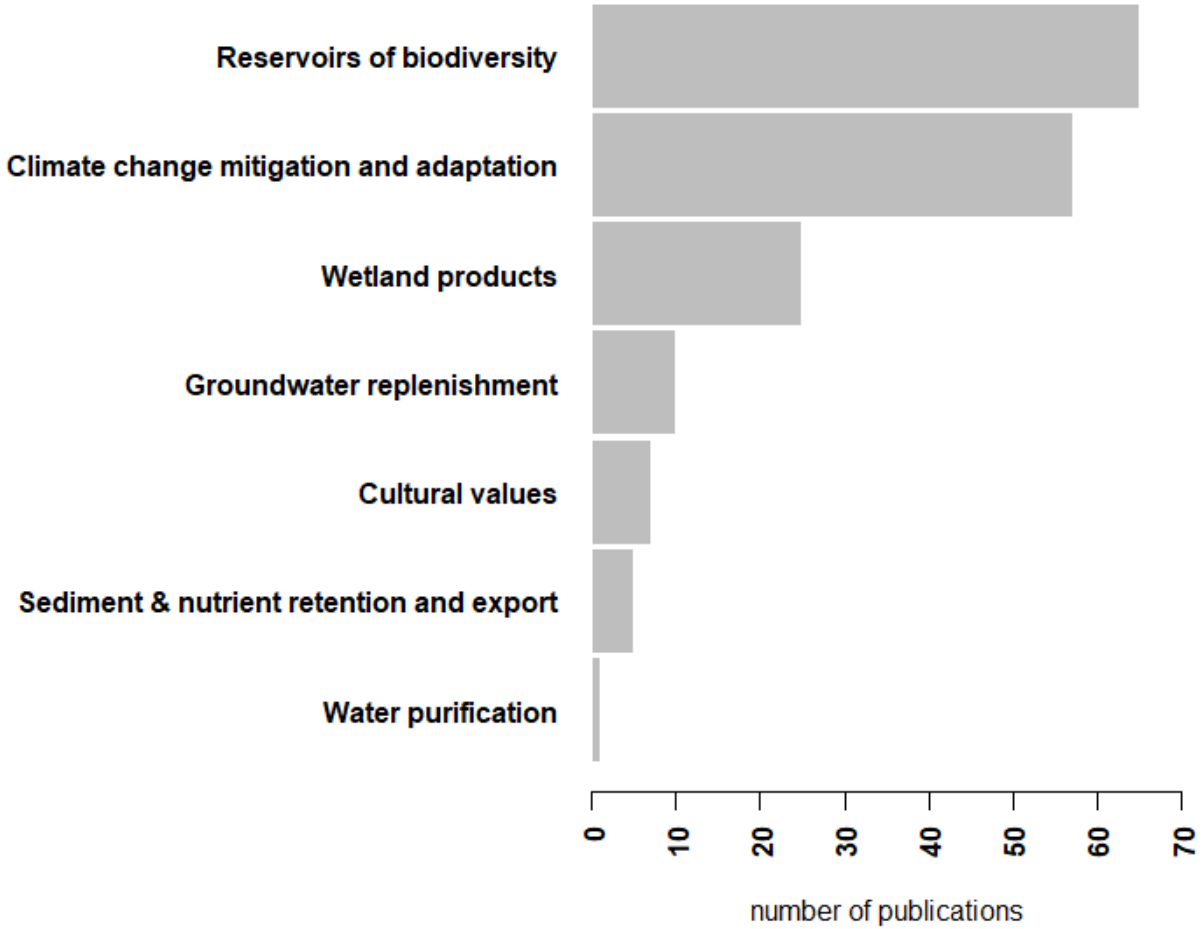
What ecosystem service (ESS) are related to High Andean Wetlands?



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Example - Climate Change mitigation:
High Andean Wetlands, a Sink or Source of GHG?

High Andean Wetlands appear to have rapid rates of net primary production and organic compound production (e.g.: Earl et al. 2003, Chimner and Karber 2008, Segnini et al. 2010, Cooper et al. 2015).

High Andean Wetlands have 3 % to 6 % land cover share in the Puna (Otto et al. 2011, Otto and Gibbons 2017) and up to 22 % in the Paramo (Hribljan et al. 2017) favouring the seasonally flooded wetlands in high carbon sequestration rates (Segnini et al. 2010).

Undrained peatlands appear to be carbon sinks (Peña 2009), highly drained peatlands under improper management were likely carbon sources (Planas-Clark et al. 2019, Hribljan et al. 2017, Peña et al. 2009, Urbina and Benavides 2015). Changes in water table conditions could convert them into GHG source under warmer and dryer conditions (Villa et al. 2019). Recent loss in glacier area was associated with increase in wetland area (Polk et al. 2017).

However, surrounding mountain grasslands can also show significant methane (CH4) emissions rates and need to be considered to understand ecosystem level exchanges of CH4 with the atmosphere (Jones et al. 2019).

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Example - Climate Change mitigation:
High Andean Wetlands, a Sink or Source of GHG?

Changes in land management may result in more intensive use of wetlands, causing decreasing vegetation trends in some locations (Mazzarino and Finn 2016). Projected decrease in annual rainfall may decrease peatland density in semi arid watersheds (Otto and Gibbons 2017). Peatlands may be susceptible to local changes in thermal and precipitation regimes (Cooper et al. 2019).

Wetlands are climate archives (approx. 25 Studies – pollen analysis, sediment/soil core sampling) and can be utilized for a better understanding of climate-driven changes and their implications for ecosystems (Baied and Wheeler 1993 and more recently: Schittek et al. 2018, Kock et al. 2019 among others).

It is necessary to further explore the integration of many aspects upon which these changes depend, such as land-use (including mining and urbanization) a historical and actual driver of ecological and social changes in the Páramo/Puna region (e.g. Casagranda et al. 2019)

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4. Conclusions

- Scientific based evidence on ESS of High Andean Wetlands has increased significantly over the last two decades.
- Most, but not all ESS have been addressed in scientific literatures with “Reservoirs of Biodiversity” and “Climate Change Mitigation and Adaptation” being most prominent
- Evidence are strong that High Andean Wetlands may serve as a GHG sink contributing to climate change mitigation
- Onsite measurements accompanied with remote sensing and application of numerical as well as statistical models have shown great potential.
- The ESS-Concept involves an integrated understanding of how High Andean Wetlands interact within a complex and remote environment such as the Montane Grasslands & Shrublands of the High Andes. Here, longer and more representative studies are needed incorporating all relevant ESS.

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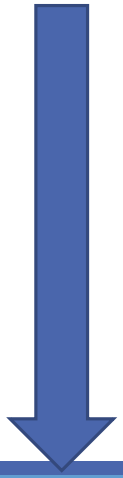
4. Outlook

The literature research will be continued incorporating detailed description of all ESS based on relevant peer reviewed studies.

The resulting Geo-DB including meta-data table will be published.

We are currently thinking of how to do this in a dynamical way, so future studies may be interactively incorporated (Web based application?).
Interested in participating? Contact us via E-Mail ☺



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Thank you for your attention!

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