An introduction to the bofedales of the Peruvian High Andes

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SUMMARY

In Peru, the term “bofedales” is used to describe areas of wetland vegetation that may have underlying peat layers. These areas are a key resource for traditional land management at high altitude. Because they retain water in the upper basins of the cordillera, they are important sources of water and forage for domesticated livestock as well as biodiversity hotspots. This article is based on more than six years’ work on bofedales in several regions of Peru. The concept of bofedal is introduced, the typical plant communities are identified and the associated wild mammals, birds and amphibians are described. Also, the most recent studies of peat and carbon storage in bofedales are reviewed. Traditional land use since prehispanic times has involved the management of water and livestock, both of which are essential for maintenance of these ecosystems. The status of bofedales in Peruvian legislation and their representation in natural protected areas and Ramsar sites is outlined. Finally, the main threats to their conservation (overgrazing, peat extraction, mining and development of infrastructure) are identified.

KEY WORDS: cushion bog, high-altitude peat; land management; Peru; tropical peatland; wetland

INTRODUCTION

The Tropical Andes Cordillera has a complex geography and varied climatic conditions, which support an enormous heterogeneity of ecosystems and high biodiversity (Sagástegui *et al*. 1999, Josse *et al*. 2009). In Peru, moisture is one of the main features that differentiate the Andean biomes páramo, jalca and puna. The páramo has the highest humidity and is located towards the north, close to Ecuador, above 3000 m a.s.l. The jalca, from 3100 m a.s.l. in the north-east, is the transition between páramo and puna. Of the three biomes, the puna occupies the largest area within the country, at altitudes between 3200 and 6000 m a.s.l. It has lower annual precipitation than the páramo and the jalca and, therefore, greater differentiation between dry and wet seasons. This is more pronounced in the south, where we can find the xerophytic puna, which is much drier than the wet puna in the rest of the country (Josse *et al*. 2009, Maldonado Fonkén & Maldonado 2010, Anderson *et al*. 2011).

Bofedal (plural “bofedales”) is the local name that is used to describe various types of wetland plant communities in the Peruvian Andes. One of the main characteristics of bofedales is constant edaphic humidity throughout the year. They usually develop in flat areas around small ponds and along small streams and springs. Bofedales can be seasonal or permanent, as well as natural or artificial (made by man). Other features are the presence of organic soil or peat and a year-round green appearance which contrasts with the yellow of the drier land that surrounds them. This contrast is especially striking in the xerophytic puna. Bofedales are also called “oconales” in several parts of the Peruvian highlands; a name derived from the word “ocko” (meaning “wet”) in the Quechua language. Cerrate (1979) reports this type of wetland from 3100 m a.s.l., although most authors consider that it occurs only above 3800 m a.s.l. (Rivas-Martínez & Tovar 1982, Flórez Martínez 1992, Maldonado Fonkén 2010). The 1999 Ramsar Convention classification of wetland types categorises bofedales as peatlands without forest (Blanco & de la Balze 2004).

The extent of bofedales in Peru is now estimated at 549,360 hectares (about 0.4 % of the country) (MINAM 2012), but previous references (e.g. INRENA 2002) report only 91,700 ha of bofedales. In view of the threats that can affect bofedales, periodic updating of their extent is recommended.

According to Lumbreras (2006), proximity to bofedales was one of the factors that determined the location of villages and hamlets in the puna during the settlement process over 5,000 years ago. Most Andean habitats in Peru have been strongly influenced by human activities. In some cases they have become "cultural landscapes", i.e., ecosystems that are maintained by the ceaseless activity of man and whose biota consists of strong, adaptable species. Consequently, sensitive and specialised

species are now restricted to the remaining fragments of undisturbed natural landscape. In this context, bofedales have become biodiversity hotspots and an important resource for people.

This article arises from more than six years' work on Peruvian bofedales in Cajamarca, Cuzco, Ayacucho, Huancavelica, Apurimac and Moquegua regions (Figure 1, Table 1). It gives a comprehensive review of available information on biological (flora and fauna), physical (water, peat, carbon) and sociocultural (importance to people, traditional management) aspects, describes the legislative provision for their conservation, and identifies the main threats to these ecosystems.

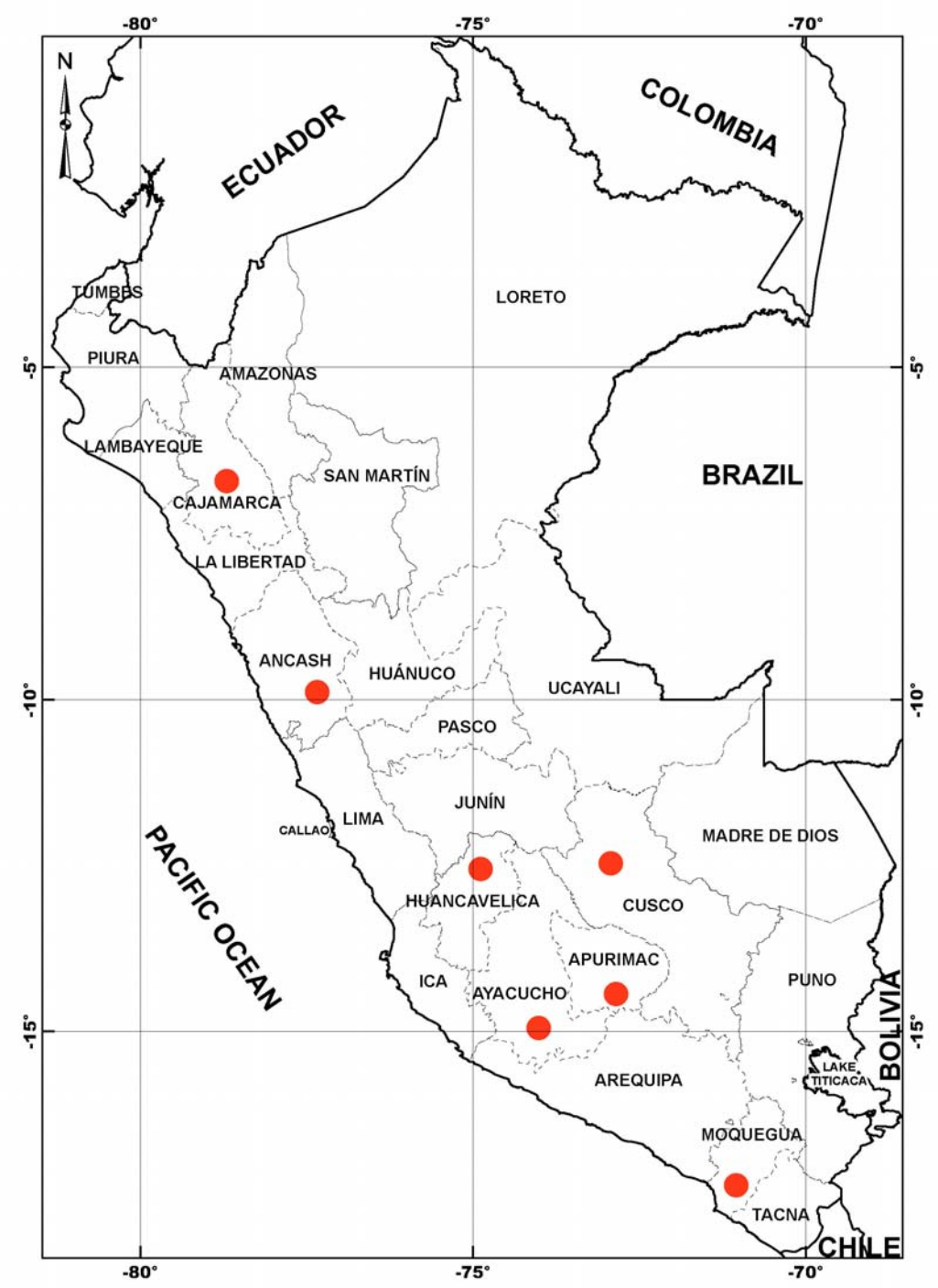

Figure 1. Map of Peru showing administrative regions. The regions mentioned in this article are identified by red spots ( ).

Table 1. Background information about the locations and characteristics of the bofedales that were studied during this work.

Region	Province	District	Number of study sites	Altitude range (m a.s.l.)	Main plant communities recorded	Livestock	Peat extraction
Apurimac	Cotabambas	Coyllurqui	1	4027–4081	*Distichia* peatland; stream grassland	cattle, horses, sheep	no
		Tambobamba	1	4104–4366	*Distichia* peatland; stream grassland	horses, llamas, sheep	no
Ayacucho	Cangallo	Paras	1	4460–4473	*Distichia* peatland	alpacas, horses, llamas, sheep	no
	Huamanga	Chiara	1	4071–4113	stream grassland	sheep	no
		Vinchos	4	4305–4709	*Distichia* peatland; peatland of *Distichia* and *Plantago rigida*	alpacas, horses, llamas, sheep	yes[1]
	La Mar	Anco	1	3910–3913	stream grassland	cattle, sheep	no
Cajamarca	Cajamarca	La Encañada	4	3719–3890	peatland with mosses and shrubs; stream grassland, peaty meadow	cattle, horses, sheep	no
	Celendin	Sucre	1	3790–3799	peatland with mosses and shrubs	cattle, horses, sheep	no
Cuzco	Chumbivilcas	Chamaca	2	4566–4678	*Distichia* peatland; stream grassland	cattle, horses, sheep	no
		Velille	1	4308–4319	*Distichia* peatland; stream grassland	alpacas, cattle, horses, llamas, sheep	no
	Espinar	Espinar	12	4054–4713	*Distichia* peatland, stream grassland; peaty meadow	alpacas, cattle, llamas, sheep	no
Huancavelica	Huaytará	Pilpichaca	3	4090–4770	*Distichia* peatland, stream grassland; peaty meadow	alpacas, cattle[2], horses, llamas, sheep	no
Moquegua	Mariscal Nieto	Carumas	6	4329–4424	*Distichia* peatland; stream grassland	alpacas, cattle, llamas, sheep	no

[1]at only one site; [2]in a lower altitudinal range, between 4200 and 4300 m a.s.l.

FLORA AND VEGETATION

The botanical composition and diversity of bofedales exhibits considerable variation with location, altitude, topography, moisture, exposure, latitude, livestock influence, *etc*., and most bofedales are complexes of different plant communities (Ruthsatz 2012). Weberbauer (1945) describes four hydrophytic plant communities that can be associated with wetland systems that Peruvians typically call bofedales in different parts of the country (Figure 2), namely: *Distichia* peatland, peatland with mosses and shrubs, peaty meadow, and stream grassland.

Distichia peatland (turberas de *Distichia*)

This plant community of the puna is characterised by the hard cushions typically formed by species of the genus *Distichia* (Figures 2a, 3a), the absence of shrubs, a low frequency of mosses and grasses and, usually, the absence of *Sphagnum*. It occurs mainly in central and southern Peru (Weberbauer 1945). Most local authors (Tovar 1973, Canales & Tapia 1987, Flórez Martínez 1992, Salvador 2002, Salvador & Cano 2002, Flores *et al*. 2005, Flórez Martínez 2005) identify this community as bofedal, particularly in the altitude range 4000–4200 m a.s.l. (Maldonado Fonkén & Maldonado 2010). *Distichia* is similarly prominent in the highest cushion bogs of the páramo in Ecuador and Colombia; the term 'bofedales' is not used in Colombia.

In Peru, the dominant species is usually *Distichia muscoides* Nees & Meyen (Juncaceae, Figure 3a) (common throughout Peru) or *Distichia acicularis* Balslev & Lægaard (most usually recorded in the north of the country). It is worth mentioning that,

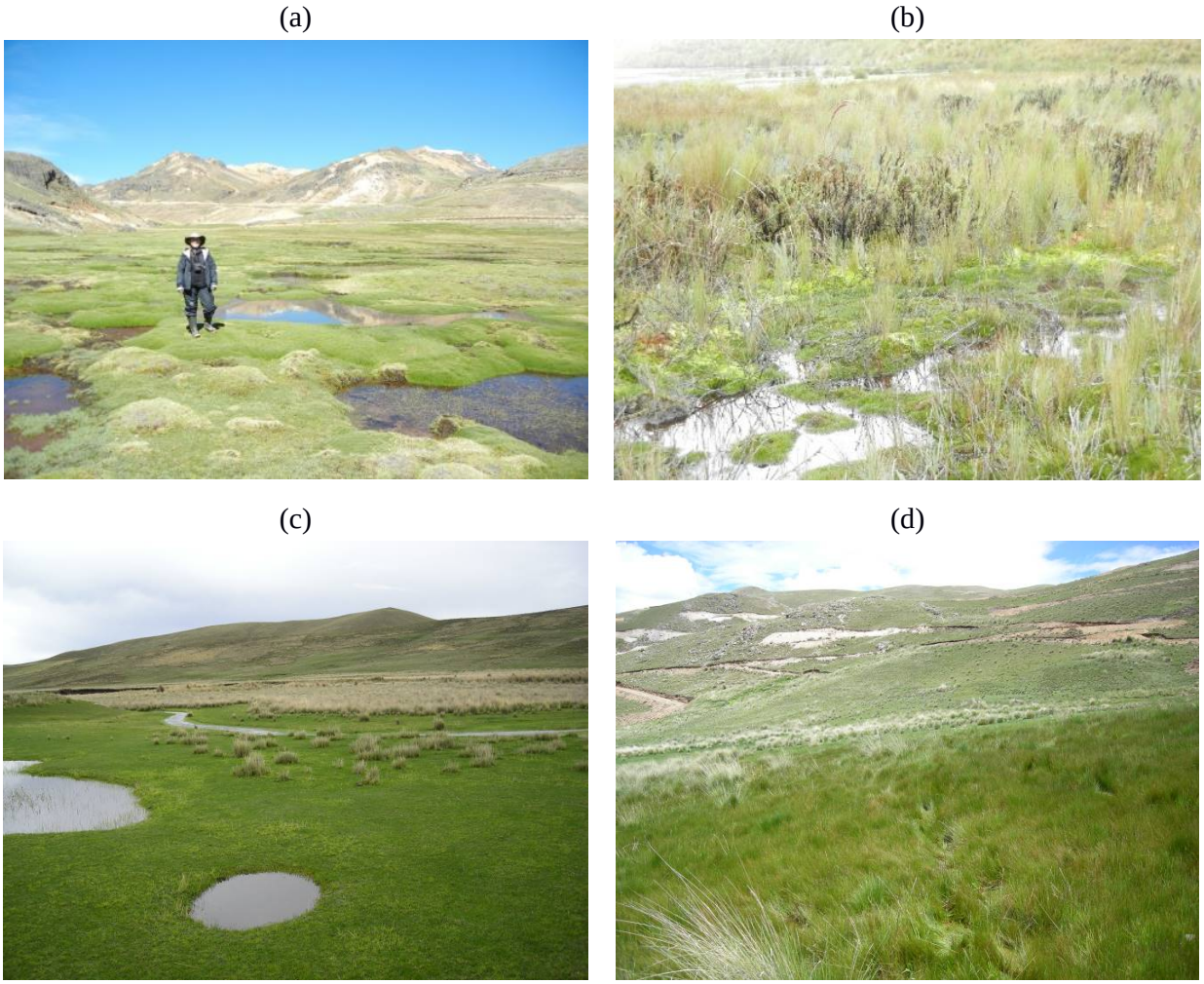

Figure 2. (a) *Distichia* peatland in Huancavelica (4756 m a.s.l.), April 2012; (b) peatland with mosses and shrubs in Cajamarca; (c) peaty meadow in Cuzco (4000 m a.s.l.), January 2010; (d) stream grassland in Cuzco, (4200 m a.s.l.), January 2010.

Figure 3. (a) *Distichia muscoides* Nees & Meyen and (b) *Plantago tubulosa* Decne.

according to Ramirez (2011), it is possible to find a third species, namely *Distichia filamentosa* Buchenau, in Peruvian bofedales (Ancash). *D. filamentosa* has been recorded in Bolivian and Chilean bofedales (Ruthsatz 2012), which means it is very likely also to be present in southern Peru.

Field experience confirms that mosses are present in much smaller quantities than *Distichia* species, and that the other accompanying plants are usually common to more than one of the communities that are referred to as bofedales. *Distichia muscoides* is a desirable food species for alpacas, sheep and llamas (Maldonado Fonkén 2010), and is also highly palatable to horses. Therefore, *Distichia* peatland is often subject to heavy grazing pressure.

Peatland with mosses and shrubs (turberas con musgos y arbustos)

This type of bofedal is characterised by an abundance of mosses, especially *Sphagnum* species, and scattered ericaceous shrubs. It is uncommon in Peru, occurring in the east and north of the country (Weberbauer 1945) associated with areas of páramo and jalca. It is very similar to plant communities that can be found in Ecuador and Colombia and resembles the páramo *Sphagnum* bogs described by, for example, Cleef (1981), Cuello & Cleef (2009) and Cooper *et al*. (2010).

The typical shrubs of this plant community include *Vaccinium floribundum* Kunth (Ericaceae) and *Loricaria ferruginea* (Ruiz & Pav.) Wedd. (Asteraceae). Some species of the genus *Puya* (Bromeliaceae) can also be found. Although grazing pressure depends upon the site-specific composition of vegetation, these bofedales are generally dangerous for livestock because the ground is so soft that animals can easily sink into it.

Peaty meadow (prados turbosos)

Peaty meadow communities are characterised by the presence of many species of the Poaceae family and the absence of *Sphagnum*. They occur in inter-Andean landscapes and on western Andean slopes throughout Peru (Weberbauer 1945). The dominant vascular plants are typically Cyperaceae (*Carex*, *Eleochari*s, *Phylloscirpus* and *Scirpus* species), Juncaceae (*Juncus* and *Luzula* species) or tall grasses, usually *Festuca* and *Calamagrostis* species. In the latter case, this plant community may be referred to as flooded grassland. The abundance of Cyperaceae and Juncaceae usually offers good grazing, although fodder quality varies with the specific vegetation composition at each site.

Stream grassland (césped de arroyo)

Stream grassland is characterised by the presence of very low-growing plants that form a carpet. It is usually located on riverbanks (Weberbauer 1945) and around other sources of water, or in areas with high humidity. Like peaty meadow, stream grassland has no *Sphagnum* and occurs in inter-Andean landscapes and on western Andean slopes throughout the country (Weberbauer 1945). *Plantago tubulosa* Decne. (Figure 3b) and *Werneria pygmaea* Gillies ex Hook. & Arn. are characteristic, along with several other species of Asteraceae, Cyperaceae and Juncaceae. *Plantago tubulosa* is an undesirable species for alpacas, llamas and sheep (Maldonado Fonkén 2010), so when *P. tubulosa* is dominant the grazing value of this plant community is lower than that of other bofedal types.

It is important to note that the plant communities quite usually occur in association with one another. For example, areas covered by the peatland communities are often surrounded by stream grassland or peaty meadow. This could be due to a combination of factors such as variations in water availability, succession and/or livestock pressure.

Other plant communities do occur in areas that are considered to be bofedales, but are much less common than those listed by Weberbauer (1945), whose classification is still the most useful at national level. For example, Tovar (1973) and Smith (1988) describe bofedales of *Distichia muscoides* and *Plantago rigida* Kunth, where the latter species also forms cushions. Although rare, peatlands of this type, including some dominated by *P. rigida* alone, have been found in different parts of Ancash and Ayacucho regions (Maldonado Fonkén & Maldonado 2010, Maldonado Fonkén 2010). In other bofedal plant communities that occur in southern Peru (Moquegua), *Oxychloe andina* Phil. (Juncaceae) is the dominant species.

FAUNA

Bofedales are an important resource for wild animals, providing them with water, food, shelter and nesting sites (Maldonado Fonkén & Maldonado 2010). In these habitats, “vicuña” *Vicugna vicugna* and “guanaco” *Lama guanicoe* (wild camelids) can be observed feeding or drinking water. The same is true for white-tailed deer *Odocoileus virginianus* and Andean deer *Hippocamelus antisensis*, the latter being the only deer species whose range extends to the snowline. Rodents such as "vizcacha" *Lagidium peruanum* (Figure 4a) and mice (*Akodon boliviensis*, *Auliscomys pictus*, *Calomys lepidus*, *Necromys amoenus*, *Phyllotis osilae*, *Phyllotis xanthopygus*, *etc*.) also feed in these habitats. Attracted by the presence of herbivores, as well as by the water, carnivores including the puma *Puma concolor*, Andean fox *Lycalopex culpaeus* and pampas cat *Leopardus colocolo* may also visit bofedales.

According to Tellería *et al*. (2006), bofedales operate as local “hotspots” for birds by maintaining species that are primarily associated with a variety of other habitats such as rivers and lakes (e.g. ducks including *Anas flavirostris* and *Anas specularoides*; Figure 4b), wet meadows (Andean Lapwing *Vanellus resplendens*, Andean Goose *Chloephaga melanoptera* (Figure 4c), Buff-winged Cinclodes *Cinclodes fuscus*, Andean Negrito *Lessonia oreas*, *etc*.) and bunchgrass (Golden-spotted Ground Dove *Metriopelia aymara*, Grey-breasted Seedsnipe *Thinocorus orbignyianus*, *etc*.). The richness of the bird fauna is positively correlated with both bofedal size and proximity to permanent open water bodies. Maldonado Fonkén & Maldonado (2010) list several other birds recorded on bofedales in Ancash region. A characteristic bird of the southern Peruvian Andes is the “suri” *Rhea pennata*, which has been observed on xerophytic puna in Moquegua region.

Bofedales are also important for animals that live in wet meadows and ponds, such as amphibians (Tellería *et al*. 2006). These include the toad *Rhinella spinulosa* (Figure 4c) and the frogs *Gastrotheca marsupiata*, *Pleurodema marmorata* and *Telmatobius jelskii*. The first three of these species breed in slow-flowing streams (Angulo *et al*. 2004, 2010; Cortez *et al*. 2010).

WATER, PEAT AND CARBON STORAGE

Bofedales occupy areas that receive water from melting glaciers, rivers, lakes and underground aquifers (groundwater) in addition to precipitation, and store it in the upper basins of the cordillera. Runoff from bofedales is slow and, in many cases, water is filtered through the ground before resuming channelled flow at a lower level. In this way, bofedal ecosystems regulate the downhill flux of water and ensure the stability of the soil. Although they may not replace the water storage function of glaciers, bofedales also store considerable quantities of water, which is important in the context of climate change (Maldonado Fonkén 2010).

In any study of a wetland for conservation or management purposes, it is very important to determine the origin of the water supply and whether there are hydrological connections with other wetlands or water bodies. The associations of bofedales with water bodies are variable. Some are linked to watercourses such as rivers, creeks, streams, lakes or ponds; and others to “ojos de agua” (small ponds usually fed by groundwater). In the case of seasonal bofedales, the water is usually visible only during the wet season.

As mentioned above, the presence of peat or organic soil should be a characteristic feature of bofedales. However, there have been few studies of the depth or characteristics of peat in Peruvian bofedales. Cooper *et al*. (2010) studied four plant community types (cushion plants, wet grasslands, bryophytes and lichens, rushes and sedges) in Cajamarca (northern Peru). The first of these (cushion plant communities comprising *Distichia* spp., *Plantago tubulosa* and/or *Oreobolus obtusangulu*s Gaudich) had the highest organic

carbon content (30–40 %) and the thickest (> 7 m) peat layer. In Arequipa and Junín, Salvador *et al*. (2014) investigated sites with at least 30 cm of peat (organic matter content > 30 %). The highest organic matter content was recorded in peatlands of *Oxychloe* (78 %), followed by those of *Distichia* (69 ± 14 %), *Plantago tubulosa* (63 %) and a mixture of *Distichia* and *Plantago tubulosa* (56 ± 26 %). Further studies are needed to clarify how the plant communities of bofedales are related to peat depth and organic carbon content.

In Puno (southern Peru), Segnini *et al* (2010) found that the carbon content of the uppermost 30 cm of soil ranged from 121.7 to 215.6 g C kg^{-1} across the sample of bofedales sites evaluated. The highest carbon content of all was found in the surface (0–2.5 cm) layer of soil from permanent bofedales, which contained 64 % more carbon than surface soil from seasonal bofedales, indicating greater accumulation of organic matter in the wetter soil systems. In contrast, the total amount of carbon stored in the 30 cm soil layer was greater in seasonal wetlands (301.7 t C ha^{-1}) than in permanent wetlands (228.9 t C ha^{-1}).

TRADITIONAL GRAZING MANAGEMENT

Because the environmental conditions above 3800 m a.s.l. usually make agriculture difficult or infeasible, the husbandry of grazing animals is a principal economic activity of people living at this altitude (Maldonado Fonkén 2010). Bofedales are important sources of food and water for the

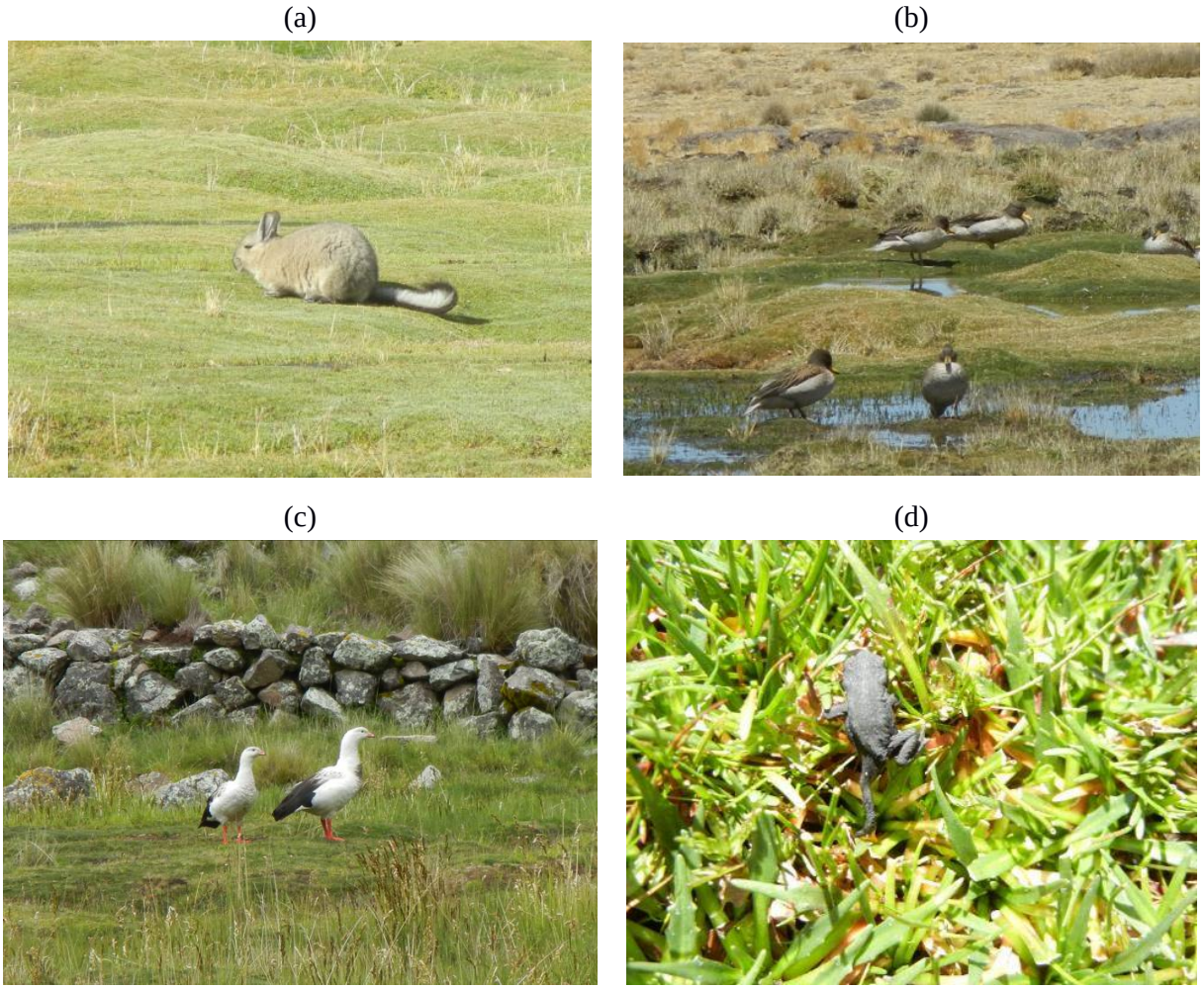

Figure 4: Some of the wild fauna of Peruvian bofedales: (a) "vizcacha" *Lagidium peruanum* on *Distichia* peatland (Moquegua region 2013); (b) ducks on *Distichia* peatland (Moquegua region 2011); (c) “huallatas” (Andean Goose *Chloephaga melanoptera*) on peaty meadow (Cusco region 2012); and (d) the toad *Rhinella spinulosa* on peaty meadow (Ayacucho region 2012).

livestock (Figure 5), especially in drier areas (e.g. xerophytic puna) with strong seasonality; and they are key elements of livestock management systems.

The traditional practice of breeding camelids (alpacas and llamas) originated in prehispanic times, along with the development of techniques for utilising bofedales to improve the success of animal husbandry. One of these was the irrigation of pastures, which has been recorded from prehispanic times in Canchis (Cuzco) and Puno. Some authors believe that this activity actually created many bofedales in the central and southern puna of Peru. There are several irrigation techniques, according to characteristics of each site such as water availability and plant species. However, the general aim is always to provide seasonally constant access to water, considering the alternation of dry and wet seasons as well as interruptions to the supply during freezing. The water may be derived from a variety of sources (rainfall, rivers, springs *etc.*) by making channels and wells (Palacios 1977, Canales & Tapia 1987, Moya *et al*. 1994, Tapia 1997, Maldonado Fonkén 2010).

In Ancash, there is evidence that raising camelids in the puna was a primary motivation for the construction of irrigation systems and catchment management in Nepeña valley (Herrera & Lane 2004). Lane (2006) describes the creation of a prehispanic bofedal of 53,125 m^2 in the Cordillera Negra (Pamparomas district, province of Huaylas). Isolated structures associated with prehispanic bofedales have also been found at the archaeological site "Pampa de Chonta Alta" of the Lacabamba community (district of the same name, province of Pallasca) (Lovera *et al*. 2007).

When the Spaniards arrived, cattle and (especially) sheep were integrated with local grazing animals in the Andean highlands. Nowadays, farmers still regard bofedales as core elements of the irrigation systems that are required to secure a good supply of food for breeding alpacas. The subsoil moisture translates into higher-quality forage, healthier animals and, ultimately, increased production of meat and fibre by both alpacas and sheep (Flórez Martínez 1992, 2005; Maldonado Fonkén 2010). Verzijl & Guerrero (2013) describe methods for bofedal water management that are currently employed by the highland community of Ccarhuanco (Huancavelica) in central Peru. These include the construction of different types of channels to supply water to the bofedal and an irrigation control system. Another technique identified, although not widely practiced, is the fertilising of bofedales with cattle manure transported using rainwater.

Bofedales must be managed as special sites of food and water supply because they are an important resource for local livestock (alpacas, llamas, sheep and eventually cattle and horses) in the dry season when forage is scarce elsewhere. Therefore, the type and number of livestock as well as grazing times must be carefully controlled so as not to harm the ecosystem, and taking into account the needs (food, water, refuge, nesting sites, *etc*.) of wild fauna. Range management involves techniques such as fencing to protect the bofedales and rotational grazing to conserve them (Moya *et al*. 1994, Pinedo 2000, Maldonado Fonkén 2010).

Andean communities collectively own their grazing areas on natural grassland (including

(a) (b)

Figure 5. The traditional (camelid) grazing animals of the Peruvian High Andes: (a) alpacas and (b) llamas.

bofedales), but livestock is owned by individual families (Flórez Martínez 1992). According to many authors, this situation can limit or favour the prospect of overgrazing (Pinedo 2000).

Local knowledge about the management of bofedales is not always used by highland communities in Peru, perhaps because it has been lost or because resources such as income or land for grazing are limited; or due to change in sources of livelihood for individual farms or farmers, local disputes over the use of communal areas, *etc*. Sometimes water management is carried out but grazing control is not. For successful bofedal management, both must be in place.

LEGISLATIVE PROTECTION

Bofedales are identified as "fragile ecosystems" for the purposes of the Peruvian General Environmental Law (Law No. 28611, Article 99) (Maldonado Fonkén 2010), not least because several species of threatened and/or endemic flora and fauna are dependent on them (Birdlife International 2003, León *et al*. 2006; MINAG 2004, 2006). According to the Peruvian Ecological-Economic Zoning Regulations (DS Nº 087-2004-PCM, Article 9) (PCM 2004), bofedales are areas for conservation or protection. Furthermore, according to the Peruvian Environmental Regulations for Mining Exploration Activities (DS 20-2008-EM, Article 11): "no exploration activity or roads may cross bofedales or wetlands, or cause placement of materials, waste or any other matter or substance on them". If they are going to be lost or affected during exploitation, compensation and management measures must be implemented to enable the replenishment (or substitution) of their environmental services (RM N° 092-2014-MEM/DM) (MEM 2014).

There is no specific information on the extent of protected bofedales in Peru, probably because none of the Protected Natural Areas has been created specifically to conserve them. Some of the designations take account of Andean wetlands associated with lakes and ponds such as those in the National Reserves of Junín (Junín y Pasco), Titicaca (Puno), and Salinas and Aguada Blanca (Arequipa), all three of which include bofedales. In other cases, bofedal plant communities are protected incidentally alongside Andean grasslands, as in Nor Yauyos Conchas Landscape Reserve (Junín, Lima), Huascaran National Park (Ancash) and the Pampa Galeras National Reserve (Ayacucho). Within each protected natural area, bofedales are present in areas that are directly or indirectly used, such as the Wildlife Area, Tourist and Recreational Area, Recovery Zone, Direct Utilisation Area and Special Use Areas (Maldonado Fonkén 2010). Moreover, at least six of the thirteen Peruvian Wetlands of International Importance (Ramsar Sites) currently include bofedales, namely: Bofedales and Lagunas de Salinas (Arequipa), Laguna del Indio - Dique de los Españoles (Arequipa), Lago Titicaca (Puno), Humedal Lucre - Huacarpay (Cusco), Laguna Las Arreviatadas (Cajamarca) and Junín National Reserve (Junín y Pasco).

The National Strategy for Wetland Conservation in Peru (INRENA 1996) makes no specific reference to bofedales, but instead emphasises the lakes and ponds of the High Andes. This strategy will be updated in 2014. At regional level, Peru is participating in the Regional Initiative for the Conservation and Wise Use of High Andean Wetlands (Ramsar 2014), part of which will focus on the Regional Strategy for Conservation and Sustainable Use of High Andean Wetlands (2005–2015).

THREATS

Several authors have referred to the problem of overgrazing in bofedales (Flórez Martínez 2005, Maldonado Fonkén 2010, Ramirez 2011, Salvador *et al*. 2014). All of the bofedales in Peru are probably grazed now and/or have been grazed in the past, and are thus continuously subject to external pressure. The degree of impact that results will vary with the type and number of livestock. Cattle and horses can generate greater impact than alpacas and sheep because they need more forage intake per animal and because their heavy bodies can harm the vegetation.

The cutting of peat (champa) for use as a fuel for cooking (Salvador *et al*. 2014) or in the manufacture of growing media for horticulture (Flores *et al*. 2005) creates high impact over a short time period. The natural regeneration of cutover bofedales is slow and difficult under the prevailing climatic conditions, especially because their vegetation has been removed. Peat cutting is practiced in only a few locations in Peru, and further studies are needed to establish the extent of its impact.

Mining is also a high-impact activity because it can both directly destroy several hectares of a bofedal and indirectly affect the rest of it by introducing contamination, altering the water regime, *etc*. According to Peruvian regulations, measures to reduce, mitigate or compensate for such impacts must be implemented. Similar regulations

apply to the activities of other extractive industries. For example, several rehabilitation and monitoring programmes have already been established in relation to the Camisea Gas pipelines that cross the Andes.

Sometimes, dams constructed to create water supply reservoirs in the High Andes (e.g. Pasto Grande in Moquegua) also generate high impacts on several hectares of bofedales by flooding them completely. Other types of infrastructure such as roads can affect bofedales by encroaching onto them or by affecting their water supplies.

Especially in the current context of climate change, it is urgently necessary to develop and formally establish appropriate national-level measures and/or protocols for the management and recovery of bofedales, in the context not only of grazing activities but also in relation to the whole spectrum of water supply needs.

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