Restoration of Banrock Station Ramsar wetlands, South Australia: over 20 years of successful involvement by a private agribusiness

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ABSTRACT. Banrock Station, in South Australia, was acquired by Hardys Wines (now Accolade Wines Australia Ltd.) in 1993. The 1,800 ha property lies on the shore of the Murray River, which with the Darling River creates one of the largest catchment basins in the world. Banrock Station's new owner developed 250 ha of wines on land previously cleared for fodder, pasture and crops. At the same time, an active restoration of wetlands and woodlands started through: (i) immediate removal of stockgrazing pressure; (ii) a feral- and weed-species control programme, including the construction of a 14 km feral-proof fence; (iii) reestablishment of a natural hydrological regime with a succession of dry and wet phases; (iv) the reintroduction of native threatened species; and (v) an annual revegetation programme. In 2000, the Banrock Station Wine and Wetland Centre opened for the public to enjoy wines and alfresco dining while looking out over the river floodplain. An 8 km self-guided walking trail network with boardwalks and bird-hides leads visitors to the heart of the wetland. For its unique biodiversity, its efforts in public awareness and natural-habitat conservation, the site was declared in 2002 as one of Australia's 65 "wetlands of international importance" under the Ramsar Convention. Because of its visible record in ontheground conservation (i.e., first birddiversity hotspot in South Australia and one of the top 100 in Australia), continuous partnership with state and federal authorities, its establishment as a prime tourist destination (with an average of 60,000 visitors a year), and its involvement in the engagement of local communities (up to two university/school class visits per month), the site has traversed successfully several changes in the company's ownership and management structures and Australia's worst recorded drought. After over 20 years of habitat-restoration efforts, Banrock Station is recognized worldwide as a successful model and demonstration site for the involvement of a private business in wetland conservation and sustainable use.

Restauration des zones humides de Ramsar de la Station Banrock, Australie Méridionale: plus de 20 années d'engagement réussi d'une agro-industrie privée

RÉSUMÉ: La station de Banrock, en Australie-Méridionale a été acquise par Hardys Wines (maintenant Accolade Wines Australia Ltd.) en 1993. La propriété de 1 800 ha repose le long de la rivière Murray, avec laquelle la rivière Darling crée un des plus grands bassins versants de monde. Le nouveau propriétaire de la station Banrock a développé 250 ha de vins sur des terres préalablement défrichées pour le fourrage, les pâturages et l'agriculture. Parallèlement, une restauration active des zones humides et boisées a été initiée par (i) l'élimination immédiate de la pression de la pression des pâturages; ; (ii) la mise en œuvre d'un programme d'éradication d'espèces introduites avec notamment la construction d'une clôture de 14 km de long; (iii) le rétablissement d'un régime hydrologique naturel des marées avec une succession de phases sèche et humide; (iv) la réintroduction d'espèces indigènes menacées; et (v) un programme annuel de revégétalisation. En 2000, le Centre des vins et des zones humides de la station de Banrock a ouvert ses

portes au public pour la dégustation des vins et apprécier les repas en plein air tout en profitant de la vue sur les marais. Un réseau de 8 km de chemins de randonnée avec pontons et observatoires conduit les visiteurs au cœur de la zone humide. Pour sa biodiversité unique, et ses efforts de sensibilisation du public et de conservation de l'habitat naturel, le site a été déclaré en 2002 comme l'une des 65 «zones humides d'importance internationale» d'Australie en vertu de la Convention de Ramsar. En raison de sa réputation en terme de conservation sur le terrain (notamment premier hotspot de la diversité des oiseaux en Australie méridionale et l'un des 100 hotspots les plus importants d'Australie), du partenariat continu avec les autorités fédérales et étatiques, de sa position comme destination touristique majeure dans le pays (avec en moyenne 60 000 visiteurs par an) et sa participation à l'engagement des communautés locales (jusqu'à deux visites de classes universitaires / scolaires par mois), le site a traversé avec succès plusieurs changements dans les structures de propriété et de gestion de l'entreprise et la pire sécheresse enregistrée en Australie. Après plus de 20 ans d'efforts de restauration de l'habitat, la station Banrock est reconnue mondialement comme un modèle et un site de démonstration réussis de l'implication d'une entreprise privée à la conservation et à l'utilisation durable des zones humides.

Restauración del Humedal Ramsar en la Estación Banrock, Australia del Sur: más de 20 años de exitosa participación de una agroindustria privada

RESUMEN.[1] La estación de Banrock, en Australia del sur, fue adquirida por los vinos Hardys (ahora Vinos Accolade Australia Ltd.) en 1993. La propiedad de 1800 hectáreas se encuentra en la orilla del río Murray, la que con el río Darling crea una de las cuencas de captación más grande del mundo. El nuevo propietario de la estación Banrock, desarrolló 250 ha de viñedos en tierras previamente transformadas para producción de forraje, pastos y cultivos. Al mismo tiempo, comenzó una restauración de los humedales y los bosques a través de: (i) la eliminación inmediata de la presión de pastoreo del ganado; (ii) un programa de control de especies salvajes y malezas, incluida la construcción de una cerca de 14 km a prueba de introducción de especies salvajes; (iii) el restablecimiento de un régimen hidrológico natural con una sucesión de fases secas y húmedas; (iv) la reintroducción de especies nativas amenazadas; y (v) un programa de revegetación anual. En el año 2000, se abrió al público la Estación de viñedos Banrock y el Centro de Humedales, para degustación de los vinos y un restaurante al aire libre, con la vista puesta hacia la llanura de inundación del río. Asimismo, se construyó una red de senderos auto-guiados para caminatas de 8 km, con paseos marítimos y estaciones de observación de aves, que conducen a los visitantes al corazón del humedal. Por su biodiversidad única, sus esfuerzos en la concienciación y conservación del hábitat natural, el sitio fue declarado en 2002 como uno de los 65 "humedales de Australia de importancia internacional" bajo la Convención de Ramsar. Debido a su historial visible en conservación en el terreno (por ejemplo, primer sitio de diversidad de aves en Australia del Sur, y uno de los primeros 100 en Australia), y su continua colaboración con autoridades estatales y federales, su establecimiento como un destino turístico de primer orden (con un promedio de 60.000 visitantes al año) y su involucramiento en el compromiso de la participación de las comunidades locales (con visitas de hasta dos clases de universidades/escuelas por mes), el sitio ha atravesado con éxito varios cambios en las estructuras de propiedad y la gestión de la empresa y la peor sequía registrada en Australia. Después de más de 20 años de esfuerzos de restauración de hábitat, la Estación de Banrock es reconocida mundialmente como un modelo exitoso y es un sitio demostrativo para la participación de una empresa privada en la conservación de los humedales y el uso sostenible.

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1 Translated by Professor María Elena Zaccagnini

I. BANROCK STATION: CONTEXT AND HISTORY

Banrock Station is located in the Riverland, South Australia, in the far south west of the Murray Darling Basin, 430 river kilometers from the Murray Mouth (fig. 1). The Basin is formed by the Murray and the Darling rivers and their tributaries and covers one seventh of the Australian continent, approximately 1.061 million km^2 through 5 of the 8 states and territories of the mainland (the Australian Capital Territory, Queensland, New South Wales, Victoria and South Australia).

Since its discovery and European settlement, early 1800s, the environment of the Murray Darling Basin has been modified significantly. Drovers have been following the rivers and their shores as stock (sheep and cattle) routes from and to the newly established towns across the vast plains. Up to the 1930s, the use of paddle steamers as way of communication and transport of vital goods along the Murray forever modified the landscape of the Murray River banks. River red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) trees were cut and used as fuel; logs and snags in the river were removed to free the way for boats, seriously damaging fish habitats. However, the greatest impact has been the taming of the main rivers from their source to the sea with dams, weirs and locks, stabilizing flow levels enabling steamers to navigate all year round, the production of power and abstraction of water for irrigation. The impacts of these were to reduce the frequency of small to medium-sized floods, which occurred on average every 23 years.

Today, the MurrayDarling basin contains around 42% of all Australian farms, and produces wheat, cotton, wool, sheep, cattle, dairy products, rice, oil seed, fodder, wine and fruit and vegetables for the domestic and overseas markets. The waters of the River Murray are South Australia's lifeline, supplying more than 1.25 million people living in Adelaide and in regional industrial centres (Whyalla, Port Pirie and Port Augusta). Around 80% of the River Murray's flow alone is diverted for irrigation (crops, fruits, vegetables) and the Riverland produces more than 25% of Australia's total production of wine grape, about 30% of its citrus crop, 17% of stone fruits and 18% of almonds.

From the 1850s to the 1990s, land uses on the property included sheep grazing and cereal cropping on the cleared mallee and floodplain areas, pasture production for cattle grazing on the floodplain, centrepivot irrigation for vegetable production (onions, carrots and vines) on the cleared mallee highland, and recreation including fishing, camping, duck-shooting and four-wheel driving. In 1994, The then BRL Hardy Wines (now Accolade Wines Ltd) purchased the property to develop the vineyard on land previously used for cereal cropping and centrepivot irrigation.

The new owners also became involved in wetland conservation, recognizing the importance of the area and the opportunity to utilize an environmental platform

FIGURE 1 BANROCK STATION WINE AND WETLAND CENTRE, VINEYARDS AND WETLANDS

to help in the marketing of the Banrock Station wine brand. The grazing pressure was alleviated by removing the stock from the property, and a long-term wetland restoration project launched, inspiring the construction and naming of the Banrock Station Wine and Wetland Centre, which was opened in February 1999. A series of self-guided walks were opened in May 2000, with a boardwalk component to the trails completed in 2001.

In 2002, the site was listed as a "wetland of international importance" under the Ramsar Convention and, in 2004, the first Ramsar Plan of Management was completed to guide the ongoing management of the site. Nowadays, 75% of the total area of the property are dedicated to conservation, including 1,068 ha of floodplain (classified as "Wetland Complex"), and 307 ha of mallee (dry woodland).

II. PHYSICAL, ECOLOGICAL AND CULTURAL CHARACTERISTICS OF BANROCK STATION

Upstream of Banrock Station, the River Murray has cut through the Murray group limestone creating an extensive floodplain area (5-10 km wide), which narrows to a 1 km wide floodplain within the Mallee Gorge. The alluvial soils of the floodplains comprise a grey cracking clay base overlying a coarse sand aquifer. The surface soils have been shaped over thousands years by surface water processes including flooding and erosion, thereby creating a surface soil mix of sands, silts and clays of varying portions. More recent aeolian sand deposits have been blown onto the floodplain forming lunettes whose subsequent erosion has resulted in sand dispersion onto floodplain clays. Cliff face erosion has also resulted in sandy deposits over the floodplain soils.

The River Murray and its floodplains are discharge areas for regional groundwater. The groundwater is saline, and secondary salinization of areas of the floodplain has occurred in many places within the basin, including within the boundary of the Banrock Station. The Banrock Station Ramsar Wetland Complex is however a predominantly freshwater system and although salinity fluctuates (mainly reflecting changes in the River Murray source water), the system remains fresh at all times. With 251 ha combined, the Main and Eastern Lagoons make up the largest piece of water in the Wetland Complex.

The climate is relatively unpredictable with moderate to high inter-annual variation. The regional climate is characterized as semi-arid with warm to hot, dry summers and cool winters with variable rainfall. Approximately 80 % of the rainfall falls between May and October, with the highest monthly average rainfall between 17 to 21 mm per month. Total annual rainfall is approximately 260 mm per year. Temperatures are warm to hot in summer ranging from a mean minimum of 15.5˚ C to a mean maximum of 31.1˚ C. During winter, temperatures are cooler with mean maximum temperatures of 15.2˚C falling to a mean minimum of 5.3˚C. Total annual net evapotranspiration was calculated for Banrock Lagoon to be approximately 1300 mm.

III. VINEYARD OPERATIONS

The vineyard covers 426 ha, approximately 250 ha of which are planted with vines representing 17 grape varieties. Soil-moisture monitoring and efficient irrigation technology have been put in place in the Banrock Station Vineyards in order to minimize irrigation impacts and water usage on the wetlands. In the 2000s, 60 ha of vineyard were converted to subsurface irrigation, providing the first large-scale trial of this technology for grape production in the country. The vineyard uses nowadays a computerized irrigation system regulated by 22 probes (with 5 sensors each) that record soil moisture conditions along the vines root system every half an hour twenty-four hours a day. The system provides almost real-time data and allows the water to be used more effectively minimizing stress for the vines. Water is delivered in a timely manner through the network of drippers close to the root zone. In addition, recycled material from the company's winery is used as mulch, spread around the vines to reduce evaporation losses. For a couple of years now, old wines of common grapes varieties have been gradually replaced with Mediterranean varieties, which are better adapted to hot climate and consume less water. Combined with mulching and the high-tech irrigation system, these measures are estimated to save up to 30% of irrigation-water needs. For their efforts, the Banrock Station Vineyard achieved the international environmental management system accreditation, ISO 14001, which implements a systematic approach to setting environmental objectives and targets to improve its overall environmental performance.

IV. ECOLOGICAL CHARACTERISTICS

A. Flora

Over 300 species of plants have been recorded on the site, some of which are of conservation importance for the state, such as black cotton-bush (*Maireana decalvans*), the sand lily (*Corynotheca lateriflora*), the tufted burr-daisy (*Calotis scapigera*), the waterwort (*Elatine gratioloides*), and the prickly bottlebrush (*Callistemon brachyandrus*).

The dominant wetland vegetation types on the floodplain include river red gum woodland, black box woodland, lignum (*Duma florulenta*) shrubland, common reed (*Phragmites australis*) and narrow-leaf bulrush (*Typha domingensis*) sedgeland. The "Common reed (*Phragmites australis*) grassland", the "Narrow-leaf bulrush (*Typha domingensis*) sedgeland" and "Lignum shrubland" are threatened plant communities in the South Australian part of the Murray-Darling basin, due to the impacts of grazing, changes of water regimes and salinity. The "*Tecticornia (*Samphire) shrubland" vegetation association is present due to salinization of parts of the floodplain and forms an important waterbird habitat when flooded (fig. 2).

Aquatic macrophyte herbland communities with the conservation concern. including waterwort (*Elatine gratioloides*), robust milfoil (*Myriophyllum papillosum*), duckweed (*Lemna disperma*), slender knotweed (*Persicaria decipiens*) and pale knotweed (*Persicaria lapathifolia*), are present on the wetland beds an provide an important fish and frog habitat and source of food for waterbirds.

In the mallee woodland ecosystem, blue mallee (*Eucalyptus cyanophylla)*, red mallee (*Eucalyptus oleosa*), beaked red mallee (*Eucalyptus socialis*), dryland tea tree (*Melaleuca lanceolata*), umbrella bush (*Acacia ligulata*), Oswald's wattle (*Acacia oswaldii*) and bullock bush *(Alectryon oleifolius ssp. canescens*) are the dominant species with various *Maireana sp.* and other annual herbaceous and perennial grasses. The vegetation association "Blue mallee *(Eucalyptus cyanophylla),* open mallee (open scrub) with sparse sclerophyllous shrubs*"* is endemic to the mallee and restricted to far north-western Victoria and the upper Murray mallee in South Australia. This association is considered as "poorly conserved" in South Australia and of high conservation priority.

FIGURE 2 EXAMPLES OF VEGETATION ASSOCIATIONS ON BANROCK STATION.

Top to bottom: river red gum woodland, black box woodland, *Tecticornia* (Samphire) shrublands and mallee woodland.

B. Fauna

A number of species recorded on site are listed at the state level or are considered regionally important. Banrock Station is one of the only two places in the region where the once thought to be extinct River Snail (*Notopala sublineata*) has been found in Australia. The species is currently the object of a recovery program. Fourteen species of fish have been recorded within the Banrock Station Wetland Complex.

Of these, nine species are native species including one species of conservation significance: the freshwater catfish (*Tandanus tandanus*), which is "*protected*" in South Australia. The five exotic fish species include the invasive common carp (*Cyprinus carpio*), the goldfish (*Carrasius auratus*), the common carp-goldfish hybrid (*Cyprinus carpio x Carassius auratus*), the eastern gambusia (*Gambusia holbrooki*) and, more recently, the oriental weatherloach (*Misgurnus anguillicaudatus*).

Forty-eight species of reptiles, including freshwater turtles, and eight amphibians have been also been recorded on site with the Carpet Python (*Morelia spilota*), the lace monitor (*Varanus varius*) and the broad-shelled turtle (*Chelodina expansa*) listed as "rare" in South Australia, and the Southern Bell Frog (*Litoria raniformis*) listed as "*Vulnerable*" at both the national and state level.

Over 190 species of birds have been recorded at Banrock Station including several species of national and state conservation significance such as Australasian darter (*Anhinga melanogaster*), Australasian shoveler (*Anas rhynchotis*), blue-billed duck (*Oxyura australis*), the Caspian tern (*Hydroprogne caspia*), the freckled duck (*Stictonetta naevosa*), the little egret (*Egretta garzetta*), the musk duck (*Biziura lobata*) (fig.3), the sharp-tailed sandpiper (Calidris acuminate), the white-bellied sea-eagle (*Haliaeetus leucogaster*) and the regent parrot (*Polytelis anthopeplus monarchoides*). The Banrock Station Wetland Complex provides seasonal habitat for migratory waterbirds listed under JAMBA (Japan-Australia Migratory Bird Agreement), CAMBA (China-Australia Migratory Bird Agreement) and ROKAMBA (Republic of Korea-Australia Migratory Bird Agreement) agreements. At the time of writing this article, Banrock Station has become the first bird hotspot for the year and for all years (since record keeping from the1900s) in South Australia, as well as the 35th Australian hotspot for the year and the 92th for all years.

FIGURE 3 Endemic to Australia and rare in South Australia, the musk duck (Biziura lobata), breeds at Banrock Station

Seven native mammals have been recorded on site, including the Common Brush Tail Possum (*Trichosurus vulpecula*) which is considered "*Rare*" in South Australia.

V. SOCIAL AND CULTURAL VALUES

For Indigenous Australians, cultural and natural heritage materials are significant and hold social value. They also consider land and water to be intimately intertwined; therefore the whole ecosystem has social and cultural value to the Indigenous Peoples of the region not just parts of the whole.

Banrock Station Wetland Complex contains significant artefacts that suggest that the site was used and occupied by Indigenous Peoples for a diverse range of natural resource uses and strategies (*e.g.* campsites, hearth/fire places, midden, lithic artefacts and scar trees). There is strong belief that Banrock Station Wetland Complex was important for trade and access to the River Murray by Aboriginal groups, as the site is near to Overland Corner, a ration station in the 1880s, and lies probably on the past boundary of two Aboriginal groups (Erawirum and Nawait). The site is recognized for its cultural significance to Indigenous Australians.

From a more recent history perspective, European association with the site began in the 1800s. In 1851, a grazing lease was issued to Thomas Henry Wigley over the lands that are now Banrock Station. He built a small homestead on the floodplain now known as Wigley Reach and his animal yards remain. The floodplain on Banrock Station was logged to supply

firewood to power paddle-steamers from the 1850s to the 1920s as can be seen by the many old stumps that remain along the river and floodplain.

Each year, official representatives of the South Australian and inter-state polices meet by a memorial on Banrock Station on the shores of the River Murray, to attend the National Police Remembrance Day Memorial Service, in memory of police officers killed in the performance of their duty in Australia. Just three kilometres from of the memorial, on the 7 May 1847, Lance Corporal Wickham and Mounted Constable Carter policemen drowned while trying to cross the river on a canoe; they were the first casualties suffered by the South Australian Police.

The wetland restoration project inspired the construction and naming of the Banrock Station Wine and Wetland Centre which was opened in February 1999, featuring the latest environmental building developments at the time including stabilized rammed earth construction using regional soil, steel framing and timbers from sustainable sources, a building layout, orientation, materials and insulation designed to maintain comfort by natural means as much as possible and a rainwater collection to supplement water supply. The environmentally focused building features a wetland interpretative display, wine tasting area, café and conference facilities (fig. 4). The restaurant promotes local produces and native foods. Banrock Station Wetland Complex has become a popular tourist and educational destination: on average 60000 visitors (up to 100,000) have been utilizing the visitor education and wine tasting centre, restaurant facilities as well as the walking trails (opened in May 2000) and boardwalks (completed in 2001) (fig. 5), including nature information huts and bird hides.

FIGURE 4 BANROCK STATION WETLANDS FROM THE WINE AND WETLAND CENTRE DECK

FIGURE 5 ONE OF BANROCK STATION BOARDWALKS AT SUNSET.

The site hosts on average two school/university visits per month. Through a network of relationships with the state education institutions, Banrock Station has engaged children in habitat restoration and wetland monitoring and awareness programmes, longest partnerships being with the local Kingston-on-Murray Primary School and Blackforest Primary School in Adelaide since the 1990s.

The interest on Banrock Station as an environmentally educational space has gone beyond the state and even the national borders. Since 2005, the International Student Volunteers (ISV) programme has been welcoming international volunteers, who have planted thousands of trees, tracked feral animals, installed nesting boxes for birds and bats, completed construction projects, fencing, ecological monitoring and controlled infestations of serious environmental weeds throughout the property.

VI. OVER 20 YEARS OF HABITAT RESTORATION

A. Wetland Rehabilitation

At the time of its Ramsar listing (2002), the wetland, floodplain and mallee landscapes have been identified with a depleted understorey and biodiversity due to past land uses including timber cutting, sheep and

FIGURE 6 Example of significant changes in habitat at Banrock Station Wetland Complex between 1993 (start of wetland rehabilitation) and 2013 at "Blackforest DU7B site".

cattle grazing, and invasive species pressure". Some parts of the site the vegetation had significant areas of stressed mature and young river red gums and mature black box caused by raised saline groundwater levels and past grazing impacts.

Prior to the construction of Weir and Lock 3 on the shores of Banrock Station in 1925, the main wetland areas of the property would have exhibited a temporary water regime determined by the Murray River flooding regime which would have varied considerably from year to year but with a pronounced seasonal pattern, resulting in significant water level fluctuations and varying lengths of inundation of the wetland. The wetland and floodplain would have been mostly flooded in spring with the melting of snow cap and/or winter heavy rainfall in the western slopes of the Great Dividing Range. From time to time, monsoonal precipitations in the north of the Murray-Darling catchment basin (Queensland) during summer could as well flood the wetland. Banrock lagoons and creeks would then have undergone frequent drying in most summers and during droughts, when the Murray River levels dropped below the sill level of the wetlands inlets, and water subsequently evaporated from the wetland. The installation of Weir and Lock 3 adjacent to the wetland converted what was previously a seasonally flooded system of shallow lagoons into a permanently inundated one.

In 1992, the newly formed wetland management organization Ducks Unlimited Australia (which became later on Wetland Care Australia) commenced working with the landowners, Bruce and Teri Engel, to install water control structures on the main lagoons to enable partial drying or flooding of the wetland. The project was funded by the Murray-Darling Basin Commission and a private donor, Norman Marsh. The Banrock Station wetland was the first wetland on the River Murray to install such infrastructure to enable partial drying in the wetland and water level manipulation.

Up until 2006, the Banrock Main Lagoon retained water all year round for irrigation of the vineyard. Only after the removal of the irrigation pump from the wetland in 2007 was this wetland able to be fully dried. Since then, the wetland's water regime has returned to an intermittent inundation pattern with complete drying phases of the main wetland. The river red gum and black box woodlands, lignum shrubland, common reed and narrow-leaf bulrush sedgeland have expanded (fig. 6).

European carp were released into the Murray River in 1964. Today, they make up more than 80% of the fish in the river and have become the dominant species in many fish communities in south-eastern Australia. Locals call it the "river rabbit", because of its incredible reproduction rate, its damage to the aquatic fauna and flora and its profound impact on the whole freshwater ecosystems.

Unlike native species that have adapted to the natural seasonal fluctuation of the River Murray water levels, European Carp is a species of permanent water bodies. Along the river, carp tend move from the river main channel into the floodplain wetlands in spring-summer to spawn.

Until 2007 and the subsequent reestablishment of dry phases, the invasive European carp was thriving in Banrock Station main lagoon as it was permanently flooded. Their impact on the wetland ecosystem was considerable (fig. 7). A combination of carp screens on the wetland inlets and succession of dry phases has proven efficient in reducing the impact of the invasive alien: during the first complete dry phase (2007), 60 tonnes of carp were removed from the 120 ha main lagoon alone, during the second dry phase (2009), 6 tonnes, and in 2015, only 2 tonnes.

FIGURE 7 Banrock Station wetland dry phase revealing sedges (*Cyperus sp.*) growing within an exclosure built on the wetland bed to study the impact of invasive European Carp (inside of the pen: no access to carp).

Acid sulphate soils (ASS) are soils that either contain sulfuric acid or have the potential to form sulphuric acid if in contact with air. They can develop naturally under waterlogged conditions where anaerobic bacteria have access to sulphate, iron and organic matter. River Murray flow regulation have enhanced the formation of these ASS at Banrock Station compared to the pre-European water regime. Conversion of the Main Lagoon to permanent wetland has meant that the ASS that have formed have not been "burnt off" by frequent drying cycles to the same extent as pre-river regulation times, and are deeper and more widespread than it would have been if it had remained intermittent. Preliminary studies suggest that the return of the Banrock Station wetlands back to their original intermittent type with dry/wet cycles has prevented the expansion of ASS; hypersulphidic soils sampled in 2008 shifting to hyposulphidic soils in 2013.

In addition to return the wetlands to healthy functioning ecosystem, through removing introduced European Carp, improving soil health, encouraging the return of native fish and bird species along with native flora, the reestablishment of a dry cycle to Banrock Station Lagoon also saves precious water. An estimated 1.15 gigalitres of river water, which is the equivalent of 1,150 Olympic-sized swimming pools, is saved from evaporation over a two-year wet/dry cycle.

Because of its environmental credentials, Banrock Station has been successful to attract governmental help to improve its wetland management. During the Millennium Drought prolonged period of dry conditions that lasted from late 1996 to mid-2010 in much of southern Australia (except parts of central Western Australia), Banrock Station was guaranteed environmental water to sustain the wetland and river red gum woodlands, In 2007, the relocation of the Banrock Station vineyard irrigation pumps from the wetland to the river was initiated with funding assistance from the state government in return for water savings achieved by drying the wetland. In 2014, Banrock Station benefited from a grant from the commonwealth and the state government through the riverine recovery project (RRP) to upgrade its main outlet regulator. The RRP aims to improve and secure environmental management of wetlands and floodplains as well as ensure efficient environmental water use in the River Murray. Recognizing the economic benefits of environmental water in the tourism and wine sector, Banrock Station sought out and established an important three-year partnership with the Commonwealth Environmental Water Holder in 2015. This ongoing partnership will see Banrock Station annually deliver up to 2,004 megalitres of Commonwealth environmental water to a number of sites across the extensive 1,000 ha Ramsar floodplain.

B. Revegetation

Since 1993 and the removal of stock on the property, the company has implemented several revegetation projects on site including direct seeding using machinery for largescale areas and tube stock planting with native species. Most of the seeds and plant material for propagation have been collected on Banrock Station or acquired from local native plant nurseries. The native seed bank currently holds 53 species of mallee and floodplain habitats. Since 2012, the native plant nursery capacity on site has been dramatically increased (by 400%, in excess of 18500 seedlings) with the upgrade of the irrigation system, construction of extra benches and mixing station. Since 2013, an average of 10000 seedlings of native trees, bushes and grasses are planted annually on site, by staff and approximately 200 children and dozens of volunteers.

In 2015, Banrock Station partnered with two NGOs: Landcare Australia and Trees For Life SA to implement the Australian Department of Environment's 20 Million Trees campaign at Banrock Station with the aim of restoring previously cleared mallee (eucalypt species) habitats and restore floodplain river red gum/black box woodlands to create a habitat for species such as the regent parrot, and replacing the non-local native swamp sheoak (*Casuarina glauca*) previously planted as vineyard wind-break, which requires constant watering. In June this year, 100 kg of locally sourced seeds of 37 local species across the two vegetation communities were sown across 66 ha of mallee and 34 ha of river red gum/black box.

C. Feral and Weed Species Control

More than 50 introduced flora species have been found at Banrock Station. Of these 5 are declared as Weed of National Significance (WoNS) based on their invasiveness, potential for spread and environmental, social and economic impacts. These WoNS, and 10 others considered of local and regional importance, are the object of recurrent eradication by staff through slashing, herbicide treatment and hand-pulling.

Imported by Europeans for hunting, sport or as pets, European rabbit (*Oryctolagus cuniculus),* hare (*Lepus europaeus*), red fox (*Vulpes vulpes*) and domestic cat (*Felis catus*) have swarmed into Australia causing widespread destruction of native fauna and flora. Since early 1990s, Banrock Station has been implementing a feral species eradication programme using baiting, poisoning, trapping and shooting. In 2005, a threatened species recovery programme was launched which involved the erection of a 14 km feralanimal exclusion fence enclosing the totality of the Ramsar Wetland Complex. The rabbits and hare population at Banrock Station has been reduced through eradication and biological control (myxomatosis, rabbit hemorrhagic disease virus) and is now considered at a non-threatening level.

D. Reintroduction of Threatened Native Species

In 2005, nationally threatened brush-tailed bettong (*Betongia penicillata*) and greater bilby (*Macrotis lagotis*) were reintroduced on site as part of Banrock Station's threatened species recovery programme. The programme was a trial but showed that the operation was feasible if the impact of predation by feral species was alleviated.

Because of its environment credentials and location across the river from the last sighting of the species in 1910, Banrock Station was selected in 2013 to reintroduce the Spiny Daisy (*Acanthocladium dockeri*), a nationally threatened species considered extinct before being rediscovered in Mid-North South Australia 1999. Cuttings were collected, propagated at the Banrock Station native plant nursery and planted on site in 2014.

To date, the trial has been very successful, with a 275% increase in abundance of the translocated population. Banrock Station has become a stepping-stone to establish the species at other Murraylands sites. The project has been a great opportunity to engage the local and international community in the planting, monitoring and maintenance of the translocation sites (fig. 8). Much of the project success has been due to the unique partnership between the state environment agency, NGOs and a private business, Accolade Wines Ltd.

FIGURE 8 EXAMPLE OF NATIVE THREATENED SPECIES REINTRODUCTION AT BANROCK STATION, THE SPINY DAISY (*ACANTHOCLADIUM DOCKERI*)

Top to bottom: planting by the local community, monitoring by International Student Volunteers (ISV) and close-up of the species

VII. BEYOND BANROCK STATION WETLANDS

As a well-known, successful, ecologically sustainable business, Banrock Station has growing social significance for the region and the local community. The site has high value as a demonstration site for the Ramsar concept of "wise use" and provides for recreation, tourism, education and scientific research. It is used by private business, NGOs, and GOs as a case study for how degraded floodplains, common along the River Murray, can be restored to productive ecosystems, while maintaining a financially viable business enterprise.

For nearly 20 years, Banrock Station wines have brought the pleasure of fine Australian wine and the message of conservation to the world. Banrock Station produces full flavored, value for money Australian wines of varietal integrity, demonstrating respect from the good earth from which they came. Central to Banrock Station's success is a genuine commitment to the environment, and through the Banrock Station Environmental Trust, the company is re-investing part of its profit to supporting environment conservation projects around the world with a focus on wetland rehabilitation climate change, water conservation, ecosystem loss and species loss. Banrock Station Environmental Trust's commitment to date exceeds $6 million Australian dollars to more than 130 projects in 13 countries. Banrock Station has supported returning salmon to rivers in Canada, otter protection in Denmark, bee recovery in the United Kingdom, wetlands restoration in Hong Kong, whitebark pine preservation in the United States, etc. Recently, Banrock Station has partnered with NGOs, governmental and scientific institutions to establish a largescale monitoring scheme for sea turtles and their habitats on the Great Barrier Reef to help to better manage and protect this iconic natural heritage of Australia.

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BANROCK STATION-ACCOLADE WINES LTD

Accolade Wines Ltd is the 5th largest wine business globally, with operations in North America, UK, Ireland, mainland Europe, South Africa, Australia, New Zealand and Asia. Accolade Wines delivers approximately 38 million cases to more than 140 countries annually; including Australia, the UK, Mainland Europe, the US, Canada, Japan, New Zealand and China.The business is the largest wine company by volume in the UK and Australia, Its portfolio includes more than 48 wine brands including Banrock Station wines that have been produced and sold globally since 1996. Up to 4.5 Million glasses of Banrock Station are enjoyed each year in more than 60 countries.

Since 1993, Banrock Station environment has been subject to an intensive restoration project. The wetlands were included in the List of Wetlands of International Importance under the Ramsar Convention in 2002, as a demonstration site for the concept of "wise use" providing for recreation, tourism, education and scientific research. In addition to on-site conservation, the company is re-investing part of its profit through the Banrock Station Environmental Trust, into supporting environment conservation projects around the world with a focus on wetland rehabilitation climate change, water conservation, ecosystem loss and species loss. Banrock Station Environmental Trust's commitment to date exceeds AUD$6 million to more than 130 projects in 13 countries.