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A Framework for Valuing Ecosystem Services in Australia's Desert Uplands

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Abstract

This study conducts an assessment of ecosystem services of the Desert Uplands Bioregion in Queensland, Australia with high priority value as potential national park locations. This study proposes a framework for estimating the value of ecosystem services provided by natural areas within the Desert Uplands Bioregion. Ecosystem services valuation of natural areas is a policy tool to justify the costs of acquiring and managing national parks. A record of the services that this environment provides can be examined in future decision-making to determine the value that would be gained from protecting lands in this region.

Keywords: Ecosystem Services; National Parks; Ecosystem Service Valuation.

1. Introduction

The future of Australia's protected areas is at a crossroads, particularly in its most biodiverse state, Queensland. Queensland's biodiverse ecosystems and natural landscapes provide value in a variety of ways to a range of stakeholders. Queensland's Department of Environment and Science [1] outlines the principal threats to the state's natural landscape and wildlife to be 'land clearing, inappropriate livestock grazing and fire regimes, invasive plants and animals, and climate change'. Mitigating these threats, along with other services, are values that natural landscapes provide people. Conserving these natural areas under perpetual and expanding legislation acts as a crucial tool to promote healthy, resilient environments.

Queensland has the lowest percentage of protected area out of all Australia's states and territories at 8.24%, which is less than half of the national average [2]. The variety of benefits that healthy ecosystems provide people, both directly and indirectly, should provide significant motivation for increasing the protected area estate. National parks provide ecosystem services and therefore have economic value.

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It is essential to determine the economic value of natural areas when considering and developing plans for national park acquisition and management.

This study aims to determine what ecosystem services are provided by the natural landscape in Queensland's Desert Uplands Bioregion and present the most effective methods for valuing them. There are very few published studies that evaluate the economic impact of national parks in Queensland. The arguably favoured services that national parks and other protected areas provide are the opportunities for tourism and recreation and their subsequent value. Interest in nature-based tourism is currently prevalent throughout government and publications [3-5]. Ballantyne and his colleagues [6] designed and carried out a study to gain insight into the economic contributions made by visitors to Queensland's national parks. The researchers proclaim the 2008 project, "constitutes the first stage of a national assessment of the value of national park visitor expenditure" [6:vi]. Ballantyne and his colleagues [6] contribution to research facilitated a growing interest in tourism spending, commencing a series of efforts to develop methodologies to measure the economic value of tourism [7-9]. Tourism and recreation only represent one aspect of National parks' value, with there being a wide range of additional benefits offered known as ecosystem services. Kutt and his colleagues [10] is likely the only study to explicitly outline ecosystem services provided by the Desert Uplands bioregion. Other surveillance studies of the area such as the Biodiversity Planning Assessments carried out by the Department of Environment and Resource Management [DERM] [11-13] highlight ecosystem services, albeit not explicitly. This study collates available information on the biophysical characteristics of the Desert Uplands, and the ecosystem services they provide. It attempts to provide a framework to evaluate the Total Economic Value (TEV) of any particular parcel of land under examination in the Desert Uplands bioregion. While this study focuses on one bioregion within Queensland, Australia, it provides a framework for ecosystem valuation that can be applied elsewhere.

1.1. Theoretical foundations

1.1.1. Defining ecosystem services

Ecosystem services, simply put, are the "benefits people obtain from ecosystems" [14:5]. Ecosystem services is a concept that has been defined in a variety of ways with a corresponding range of interpretations and practical applications. Ecosystem services can be understood as the processes, outputs, and conditions of natural systems that directly or indirectly benefit humans or enhance social welfare [15-18]. They can also be regarded from an anthropogenic-centred perspective as the benefits acquired by humankind from surrounding ecosystems [19]. These services include water purification, climate stabilization, and food provision, among others [20]. For the purpose of this report, ecosystem services are defined and viewed from the perspective of the benefits that these natural systems produce and not the natural processes themselves. Ecosystems services and the benefits that they give humans are the result of ecosystem structures, processes, and functions [18,21]. The dynamics between these processes can be complex, and subsequently ecosystem services can be difficult to quantify.

Ecosystem services have historically not been adequately quantified in terms compatible with economic services and manufactured capital and are therefore not thoroughly captured in commercial markets. There are many conceptual and empirical problems inherent in producing any estimate of ecosystem services and the natural capital that they produce. Determining the benefits of ecosystem services and quantifying their value can be controversial as they are fraught with uncertainties. While some people believe that value cannot accurately be placed on intangibles, others believe an economic valuation should not even be attempted as ecosystems should be protected for moral and aesthetic purposes, not for financial gain [22]. It wasn't until 2013 that the first Common International Classification of Ecosystem Services (CICES) for Integrated Environmental and Economic Accounting was published [23]. Fisher and his colleagues argue that there are too many contexts that ecosystem service research operates within and thus attempts at classifying them "should be based on both the characteristics of the ecosystems of interest and a decision context for which the concept of ecosystem services is being mobilized" [17:1]. Although these services arise from public goods or common-pool resources and are largely provided free-of-charge to the public, they must nonetheless be valued, as they significantly contribute to wealth, well-being, and sustainability [24].

1.1.2. Valuing ecosystem services

Ecosystem services represent a range of benefits offered by the natural environment and should be valued accordingly. Ecosystem services can either be measured directly or indirectly via proxies, and can be transformed into monetary values via environmental valuation methods [21]. An understanding of these values is required to account for these values when considering potential protected area acquisition. Haines-Young and Potschin-Young [23] draw attention to the reality that one cannot manage what cannot be measured and this requires an understanding of precisely what is being measured. Valuing areas that are under consideration to be protected as national parks inevitably requires a valuation of ecosystem services. Utilizing and defining an appropriate and comprehensive valuation strategy for ecosystem services in locations where new national park allocation may be considered is the most-likely way of achieving an optimal protection strategy. National parks can be preserved and sustainably managed if they have optimal protection strategies safeguarding them from environmental degradation. This study provides a list of key ecosystem services related to each natural ecosystem (bioregion) so that they may be counted, assessed, and valued separately to assess the economic valuation of ecosystem services in a particular area.

The benefits that ecosystem services provide to humans can be organised under the Total Economic Value [TEV] framework used in environmental economics [25-27]. The TEV is an all-encompassing measure of the economic value of any environmental asset or place [28]. It breaks down benefits into use values and non-use values and further classifies these depending on how they are used [28]. Detailed explanations of the components of TEV can be found in Appendix A. Figure 1 outlines the categories of TEV of natural environments to humans with examples of benefits that protected areas provide. Conservation efforts for national parks and other protected areas have been met with reluctance due to a lack of understanding about the value that protected areas provide [21]. By presenting an overview of the various benefits that natural areas provide, the TEV framework allows for a greater comprehension of value that protected areas yield.

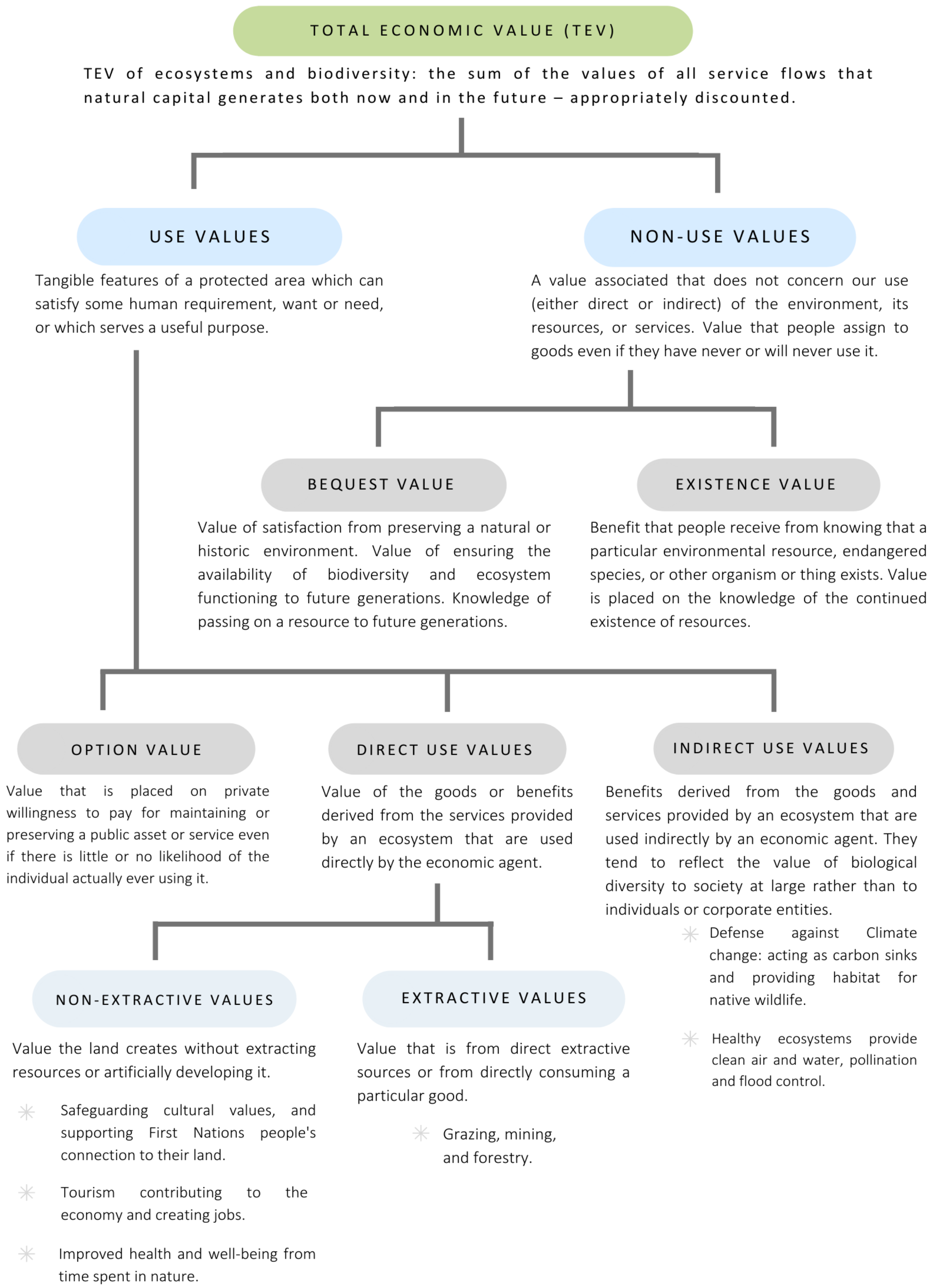

Figure 1: Total Economic Value (TEV) of Protected Areas

Sources: [18, 25-27, 29]

2. Study area: Queensland, Australia

This study takes place in the state of Queensland in Australia, located on the northeast portion of the continent. Queensland is the second largest state in Australia, with an area of 1,727,000 square kilometres [30]. As of June 2021, the estimated resident population was just over 5 million, or 20% of Australia's population [31]. Queensland's ecological conditions have allowed for the creation of highly biodiverse ecosystems and the state holds the title of being the most biodiverse in the country [2].

Australia's landscape is classified into bioregions, 13 of which are located in Queensland [32]. These regions, known as bioregions, categorise the landscape in terms of similar soils, climate, geology and vegetation communities [10]. The national and regional planning framework for the systematic development of a comprehensive, adequate and representative 'CAR' National Reserve System is provided by the Interim Biogeographic Regionalisation for Australia (IBRA) [32]. IBRA was developed in 1993-94 and is endorsed by all levels of government as a key tool for identifying land for conservation under Australia's Strategy for the National Reserve System 2009-2030 [32]. The nationally agreed regionalisation was published in An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves [33]. The Desert Uplands Bioregion is the bioregion at the focus of this report.

2.1. Site description: Desert Uplands Bioregion

The Desert Uplands Bioregion is a semi-arid bioregion on the Great Dividing Range in Central Queensland [13]. It makes up approximately 4% of Queensland at 6.89 million hectares [13]. The bioregion consists of deeply weathered plateaus and sandstone ranges and is dominated by large areas of sand plains [13, 34]. The Desert Uplands is a diverse region with 72 regional ecosystems identified, this is reflected in its variety of flora and fauna [10:35]. Approximately 2500 plant species and 430 vertebrate species have been recorded in the Desert Uplands [10:35]. This diversity is driven by the unique location as well as different geologies present that contribute to different soil formations [10]. Due to the Desert Upland's positioning on the boundary of the wetter east coast, and drier interior, it contains fauna that would typically be found in both arid regions and in coastal regions [10]. Much of the bioregion's biodiversity remains relatively intact as much of the bioregion is in a relatively natural condition [13]. This study focuses on the benefits that would be generated by preserving these biodiverse areas as protected areas under the Nature Conservation Act 1992 (Qld) [35].

Parts of the Desert Uplands' natural areas have been preserved in the form of legally-binding protected areas. Areas within Queensland that possess biological diversity, outstanding natural and cultural features, and wilderness can be declared protected areas under the Nature Conservation Act 1992 (Qld) [35]. Protected areas under the Nature Conservation Act 1992 (Qld) [35] are classified according to the level of protection offered and whether they are public or private. National parks, conservation parks and resources reserves are classified as public areas, while special wildlife reserves, nature refuges, and coordinated conservation areas are classified as private, with level of protection ranging from high to low respectively. The following National Parks are located in the Desert Uplands Bioregion: Cudmore National Park, Forest Den National Park, Great Basalt Wall National Park, Moorrinya National Park, and White Mountains National Park [36]. Currently, no conservation parks exist in the Desert Uplands [36]. Under the Nature Conservation Act 1992 (Qld) [35], resource reserves are state government-owned land that can be used for controlled levels of resource extraction such as mining or quarrying. Cudmore resources Reserve and White Mountains Resources Reserve are the two Resources Reserves in the bioregion [36]. Since special wildlife reserves are the newest class of protected areas under the Nature Conservation Act (Qld) [35], none exist in the Desert Uplands Bioregion yet. Under the Nature Conservation Act 1992 (Qld) [35], nature refuges are privately owned land that are established through a perpetual and binding agreement between the landholder and the state government for the conservation of the land. The following areas exist as nature refuges in the Desert Uplands: Bellview nature refuge, Bimblebox Nature Refuge, Bygana West nature Refuge, Doongmabulla Mound Springs Nature Refuge, Edgbaston Nature Refuge, Strathtay Nature Refuge, Toomba Nature Refuge, and Ulcanbah Nature Refuge [36]. Coordinated conservation areas are a class of protected area offering a low level of protection that were grandfathered into the act. The capacity to declare more has been removed, there are none in the Desert Uplands Bioregion [36]. National parks and special wildlife reserves are the classes of protected areas awarding the highest level of protection and thus should be the primary options considered as a tool for preserving biodiversity.

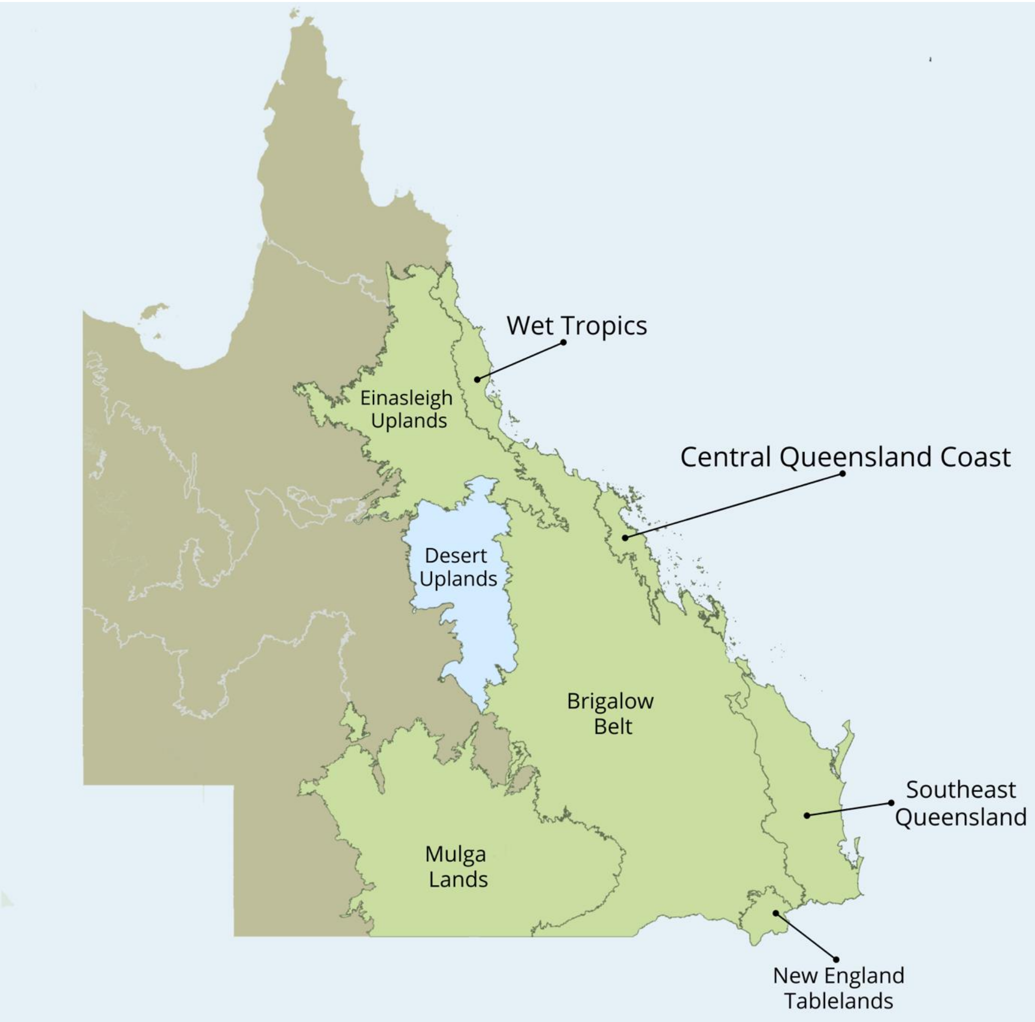

Figure 2: Map of Queensland’s Under-protected Bioregions with the Desert Uplands Bioregion highlighted. Adapted from [2]

3. Background and drivers of change

Institutional, economic, cultural, and technological drivers of change have played a key role in shaping the composition of protected areas and natural areas as a whole in Queensland.

3.1. Promise for 17% land area protected

There has been an international movement to advocate for the increase in protected areas worldwide to cover a larger percentage of land. The Convention on Biological Diversity [CBD] is an international legal instrument for "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources", governed by the Conference of the Parties [COP] and ratified by 196 nations [37]. The COP put forth the Aichi Biodiversity Targets for the 2011-2020 period; with Strategic Goal C being to “improve the status of biodiversity by safeguarding ecosystems, species, and genetic diversity,” and accompanying Target 11: "by 2020, at least 17% of terrestrial and inland water, and 10% of coastal and marine areas…are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures…” [37]. Participating countries, including Australia, translate this international framework into specific action plans to carry out themselves [37].

The Queensland government has stated that its conservation goals are in line with the Aichi Targets, but current protected area expansion rates do not reflect this. Following the recommendations put forth in the 2010 Aichi Biodiversity Targets, the Queensland Government first adopted a long-term target of 17% of the state's land mass being protected in 2015 [3]. Since the initial pledge to increase Queensland’s protected estate to cover 17% of the state’s land area, the percentage of protected area has only increased modestly and has stabilized at just above 8% of the state’s land [3]. The recently published Queensland Protected Area Strategy 2020-2030 [3] is a plan put forth by the Queensland government for building an extensive network of protected areas. The Queensland Protected Area Strategy 2020-2030 [3], reiterates and reinstates the 17% target, bringing promise for an enhanced system of world-class protected areas within the state.

3.2. Lost opportunities from properties sold

Opportunities to expand and acquire new national parks and other protected areas come in the form of private properties becoming available for purchase. A report by the NPAQ [2] highlighted missed opportunities to purchase available land to be converted to national parks. The report, Lost opportunities for new national parks in Queensland [2], identified around 2,000 properties across Queensland that would have very high priority for acquisition as national parks. These properties were highlighted due to their status as climate resilient properties as previously identified by the Queensland Government under their former Climate Resilience Strategy [2]. An additional 1850 lots were identified as World Wildlife Fund [WWF] High Priority Properties and were regarded as very high priority for acquisition [2]. It should be noted that areas where some form of government-binding protection of nature already existed over them such as existing nature refuges and environmental offsets were excluded from these identified properties [2]. The NPAQ (2020) used Queensland’s property sales data from

June 2015 to October 2018 to determine if any of these identified high priority properties had sold in that period and for what price [2]. Of the 2,000 priority properties, 175 very high priority properties covering about 241,000 ha of land were sold on the private market between 2015 and 2018 for a combined price of $198 million [2]. Most of these properties were sold for ongoing agricultural use [2]. NPAQ then quantified the biodiversity value of properties that sold based on whether they were home to species in the Species of National Environmental Significance database, if they processed state significant biodiversity corridors, and were home to regional ecosystems that are endangered or have low to no protection [2]. The majority of the high priority properties sold (94.3%) were located in just four under-protected bioregions: Brigalow Belt (2.9% protected), South East Queensland (14.4% protected), Desert Uplands (3.2% protected) and Einasleigh Uplands (6.9% protected) [2]. Available properties for sale in these regions present an opportunity to expand the state's protected areas network.

Acquiring these biodiverse properties and awarding them national park status would be a significant step in enhancing the national park system within Queensland. NPAQ quantified the biodiversity value of these properties that sold based on their intersection with the following three criteria: the Species of National Environmental Significance database, current to Jan 2016, State significance biodiversity corridors, and regional ecosystems that are endangered or low/no protection [2]. According to the NPAQ, "acquiring these properties into the national park system would have closed major gaps in ecosystem and species protection, greatly progressed the government's 17% protection target and added significant value to the state's tourism industry" [2:10]. In regards to biodiversity in the Desert Uplands, Kutt and his colleagues point out that "on a smaller scale, the diversity of animals found on each property is usually also high," [10:40] highlighting the importance of managing biodiversity at a property scale. Properties for sale within the Desert Uplands should undergo valuation assessments based on their ecosystem services to determine their suitability as a prosperous national park.

4. Methods

This study presents a framework for integrated economic valuation of ecosystem services provided by the Desert Uplands Bioregion in Queensland. This assessment of ecosystem services provided by the Desert Upland's natural areas is assembled from secondary data. This involves a comparative review of related literature and collating the information to produce an integrated framework/approach. This can be used by the Queensland Government and relevant stakeholders in order to assess the suitability of available parcels of land in the Desert Uplands to be purchased and protected as national parks.

4.1. Classification and categorisation of ecosystem services

A classification system is important in helping to define benefits from natural areas and communicate findings about their value. The Millennium Ecosystem Assessment [MA] [14] was called for the by the United Nations Secretary General in 2001 with the objective of assessing the ecosystems and the impact of their changes. It aimed to form the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being [14]. The findings provide a scientific appraisal of the conditions and trends in the world's ecosystems and the services they provide [14]. Building on the MA, The Economics of Ecosystems and Biodiversity [TEEB] is a global initiative focused on "making nature's values visible" with a principal objective being to mainstream the values of biodiversity and ecosystem services into decision-making at all levels [18]. The MA identified four classes of ecosystem services: provisioning services, regulating services, cultural services, and supporting services [14]. This report adopts MA's classification system and refers to these four classes of ecosystem services.

Four Classes of ecosystem services

1. *Provisioning Services*

Provisioning services can be thought of as the physical goods or products obtained from nature [38]. These services provide raw materials extracted or collected and commonly include food, water, timber, fibre, agricultural products, and genetic resources [14].

2. *Regulating Services*

These services are those associated with maintaining the desirable environmental conditions for human communities [14]. These services are provided by regulating ecosystem processes such as climate regulation, flood regulation, disease regulation, and water purification [14]. These services include regulation of gases in the atmosphere, local and global climate, water, and disturbances; erosion, flood, and biological control; as well as waste treatment and water purification [39].

3. *Cultural Services*

These are non-material benefits that people receive from nature and ecosystems [14, 38]. Cultural services include cultural heritage, spiritual, scientific, aesthetic, educational, and recreational benefits [14, 39]. They include the things in nature that help people identify with the history or culture of where they live or come from [40]. Balzan and his colleagues describe these services to be "the biophysical characteristics or qualities of species or ecosystems (settings/cultural spaces) that contribute to cultural heritage or historical knowledge" [40:e6].

4. *Supporting Services*

These services are involved in preserving the integrity, functioning, and resilience of the ecosystem [39]. These provide what is necessary for the production of the other classes of ecosystem services [14, 39]. These include soil formation, primary production, nutrient cycling, water cycle, and habitat provision [14, 18].

4.2. Identification of Ecosystem Valuation Methods

Depending on the ecosystem service being assessed, there are different approaches to approximate its value. The value of ecosystem services can be considered for policy decisions when there are conflicting potential uses of the environment, which give rise to a trade-off between outcomes [29]. This is the case for assessing areas of land for potential national park allocation in the Desert Uplands Bioregion. There are several techniques used to value ecosystem services, based on what information is available to utilize. Individuals' behaviour and their market transactions in direct relation to an ecosystem service can determine the value of that ecosystem service [18]. If this information does not exist, price information must be derived from parallel market transactions that are associated indirectly with the good being valued [18]. If there is neither direct nor indirect price information on the ecosystem service, hypothetical markets may be created in order to elicit values [18]. Different valuation methods should also be used depending on whether an ecosystem service fell under the categories of direct use or indirect use [18]. Four approaches are identified for ecosystem valuation, within which exist varying methods, as outlined below [18, 26, 39].

The environment provides value in the form of market values and non-market values [29]. Market values are associated with the value that the ecosystem provide that are traded on the market in the form of goods and services with quantifiable prices [29]. Other ecosystem services provide value but cannot be traded on the market and have non-market value [29]. Both market and non-market ecosystem service values are relevant in many policy matters.

Types of Valuation Approaches

1. Direct Market-Based Approaches

A. Market Price Method

This method is used to approximate the value of environmental goods that are bought and sold on a market [41]. This method examines the maximum willingness to pay for an item as a measure of value for that ecosystem service. Measuring values this way is typically done by measuring consumer and producer surplus. Consumer surplus is the difference in the benefits that people get from an item and what they pay (or give up) in order to get that item, this is the value that people get from that item [41]. The producer surplus is the difference between (the revenue they earn from the sale of the good) and the cost of bringing the good to market, this is the value of bringing the good to market [41].

B. Cost-Based Approaches

i. Avoided Cost Method

The avoided cost method estimates the costs incurred in the absence of ecosystem services. The avoided cost is the cost people incur to avoid the negative consequences of an environmental change [42].

ii. Replacement Cost Method

The replacement cost method estimates the costs incurred by replacing ecosystem services with artificial technologies [18]. The replacement cost is what it would cost to replace a certain ecosystem service if it went away or were to be destroyed [43].

iii. *Restoration Cost Method*

The restoration cost method looks at how much money is spent or would be spent repairing environmental damage between a situation with and a situation without the ecosystem service [18]. The difference is an estimate of the amount of value the service provides to people.

C. Productivity Method

The productivity method is used to estimate the economic value of ecosystem products or services that contribute to the production of commercially marketed goods [44]. When natural resources are a component of production, any changes in their quality or quantity will change production costs [39]. This method should be applied for instances where an ecosystem service is used to produce a marketed good [44].

2. Revealed Preference Approaches

In these approaches, value is determined based on the observation of individual choices in existing markets that are related to the ecosystem service being valued [29]. Preferences are revealed through real-life choices, actions, and conditions.

A. Travel Cost Method

This method is based on the rationale that there are costs associated with recreational experiences, including direct expenses of attending the location and the opportunity costs of time. Looking at the demand function for site visitation can help estimate the value of a change in quality or quantity of a recreational site (resulting from changes in biodiversity).

B. Hedonic Pricing Method

This environmental valuation method tries to quantify the value of the ecosystem services by examining the demand for an environmental attribute of marketed commodities. Hedonic pricing suggests people value an environmental good because they value the characteristics of the good rather than the good itself. It estimates the impact of environmental attributes, such as scenic views, reduced noise, and reduced air pollution, on market goods' prices [39]. This method is mostly used to analyse the changes in land or housing prices as a reflection of adjacent environmental attributes [39]. A change in property value due to changes in biodiversity or ecosystem services serves as an indicator of that ecosystem service's value.

3. Stated Preference Approaches

These approaches involve asking people to respond to hypothetical questions in order to simulate a market and demand for ecosystem services [29]. The following two methods can be used to estimate both use and non-use values of ecosystems and/or when a surrogate market does not exist to deduce a value of ecosystems from.

A. Contingent Valuation Method (CVM)

This method uses questionnaires to ask people how much they would be willing to pay to increase or enhance the provision of an ecosystem service or how much they would be willing to accept for its loss or degradation. Willingness to pay is based on the selection from among the various hypothetical scenarios of ecosystem status [39].

B. Choice Modelling (CM)

In this method, people are surveyed and asked to make choice between policy options or ecosystem status. Unlike with the CVM, choice modelling (CM) does not require survey respondents to place a direct monetary value of a particular market good or service [18]. Rather, respondents are asked to indicate their preference among two or more policy options or alternative states of the world [45].

4. Benefit Transfer Method

The benefit transfer method takes values from studies that have already been completed in other areas and applying them to the area in focus [29]. The benefit transfer method should be used in instances where there are limitations in resources preventing other methods to be utilized.

4.3. Literature Review to Identify Ecosystem Services for Desert Uplands Bioregion

Step 1: Literature Review to identify important flora, fauna, and landscape features pertaining to the Desert Uplands Bioregion.

To identify the ecosystem services provided by the Desert Uplands Bioregion, a literature review was conducted of scientific papers, government websites, news articles, webpages of Australian public institutions and organisations associated with national parks, and media documents.

Step 2: Identify and classify the types of ecosystem goods and services related to ecosystem features in the Desert Uplands Bioregion.

Ecosystem services were selected and identified based on information found in the above-mentioned sources and categorised as either regulating, cultural, and supporting services in accordance with the ecosystem services categories of the MA [14]. This study is looking at ecosystem services that are provided by the environment that would be preserved by protecting the land under national park status. For this reason, only ecosystem services that would be provided under national park status are considered. This distinction is most pertinent when considering provisioning services. Provisioning services essentially involve extracting something from the environment, which is generally against the principles of national parks. Provisioning services are therefore carefully considered to ensure they match national park principles and thus are not as plentiful as other categories of ecosystem services.

Step 3: Selection of appropriate valuation methods to estimate the economic value for each of the ecosystem goods and services identified and quantified.

For the economic valuation of any service, the most appropriate method should be identified and used. These are selected based off of relevant literature that describe the various approaches to environmental valuation such as TEEB [18]. This research mirrors similar studies such as one conducted by Badamfirooz and his colleagues [39] which examines ecosystem services for wetlands in Iran and suggested various valuation methods in accordance with each ecosystem service. For each ecosystem service offered, a selection of appropriate valuation methods is presented. Stakeholders using this framework to perform ecosystem service valuation should select among the appropriate methods presented in Table 1.

5. Results

Table 1: Ecosystem services classification, description, and proposed valuation methods for areas within Queensland's Desert Uplands Bioregion. Own elaboration of categories and descriptions based on [14, 18, 38-9]. Ecosystem service examples compiled from [10-13, 46-7]. Proposed valuation methods compiled from [18]

ECOSYSTEM SERVICE CATEGORY	ECOSYSTEM SERVICES	DESCRIPTION	EXAMPLES/ INDICATORS	PROPOSED VALUATION METHODS
PROVISIONING *Physical goods obtained from nature*	Water storage, Supply of drinking water	Precipitation collected and stored in rivers, lakes, and basins for water supply	Burdekin Basin Cooper Creek Great Artesian Basin and Other regional Aquifers Gulf water resource planning area	• Market Price Method • Replacement Cost Method • Productivity method
PROVISIONING	Medicinal resources	Resources providing medicinal benefits to human health	Blue Devil plant (*Eryngium fontanum*)	• Market Price Method • Productivity Method
REGULATING *Services provided from ecological regulation processes; maintain the desirable environmental conditions for human communities*	Climate Regulation	Regulation of Greenhouse Gases	Carbon sequestered and stored in vegetation and Oxygen emitted from vegetation	• Replacement Cost Method • Avoided Cost Method • Productivity Method • Market Price Method
REGULATING	Climate Regulation	Regulation of temperature, precipitation, and other climatic processes	Overstorey vegetation Mid-storey vegetation	• Hedonic Pricing Method • Avoided Cost Method
REGULATING	Water flow regulation (flood control)	Water infiltration	Tussock Grasses Burrowing frogs Burrowing invertebrates Termites Ground-dwelling birds	• Avoided Cost Method • Replacement Cost Method • Productivity Method
REGULATING	Water flow regulation (flood control)	Inundated Areas: Lakebeds and periodically inundated depressions and plains/ areas subject to flooding	Webb Lake Lake Buchanan Thirlestone Lakes Cauckingburra Swamp Lake Galilee Lake Huffer Lake Barcoorah Lake Moocha Lake Mueller Lake Dunn	
REGULATING	Biological control	Native species that naturally control and regulate pest species	Snakes Small mammals Carnivores Insect-eating bats Wolf spiders	• Replacement Cost Method • Productivity Method • Market Price Approach
REGULATING	Erosion prevention	Prevention of wind or water eroding landscapes	Termites Vegetation	• Avoided Cost Method • Replacement Cost Method • Restoration Cost Method • Productivity Method

CULTURAL *Non-material services that people receive from interacting with nature and ecosystems*	Opportunities for recreation and tourism	Spending time in nature in one's leisure time; visiting certain sites in nature	'The Palace' National park associated spending and national park generated spending in local areas	• Travel Cost Method • Contingent Valuation Method • Hedonic Pricing Method • Choice Modelling • Market Price Method • Productivity Method
	Scientific, research, and educational activities	Learn from observation and derive benefit from the land from this knowledge.	Mapping conducted by the Queensland Government and affiliated groups such as the Biodiversity Assessment and Mapping Methodology (BAMM) and Statewide Landcover and Trees Study (SLATS) Biodiversity Planning Assessments (BPAs) Studies conducted in the Desert Uplands Bioregion	• Travel Cost Method • Market Price Method • Contingent Valuation Method • Productivity Method
	Aesthetic value	Aesthetic features of natural areas	Appreciation of natural features.	• Hedonic Pricing Method • Contingent Valuation Method • Choice Modelling
	Sense of place and Identity	Strengthening social cohesion through identifying oneself in relation to a place and community	Cultural Heritage: Traditional beliefs, customs, and stories of Indigenous communities Monuments with historical value Ecosystems renowned for their cultural significance such as arid and semi-arid lakes	• Travel Cost Method • Contingent Valuation Method • Choice Modelling • Hedonic Pricing Method
	Existence and Bequest Values	Benefits received by those who may not even have direct engagement with the landscape.	Endangered species or habitat	• Choice Modelling • Contingent Valuation Method • Hedonic Pricing Method

SUPPORTING AND HABITAT *Preserving the integrity, functioning, and resilience of the ecosystem as well as providing what is necessary for the production of all ecosystem services*	Habitat provision	Provision and preservation of habitat for flora and fauna	Complex, well-formed woodlands with many hollow-bearing trees of high fertility Roosting and feeding sites Dense foliage of the mid-layer (usually acacias) Dense, extensive spinifex groundcover Centres of endemism Sub-tropical woodlands Areas of disjunct populations Habitat for species at the limits of their range Areas with high species richness Areas with relictual populations Areas of high species composition Hummock grasslands and related low-shrubby habitats occurring in the saline discharge zones Caves and escarpment	• Replacement Cost Method • Contingent Choice Method
	Wildlife Corridors and connectivity enabling species movement	Maintain long term evolutionary/genetic processes that allow natural change in distributions of species and connectivity between populations of species	Stepping-stone Corridors Riparian Corridors	• Contingent Valuation Method • Replacement Cost Method
	Soil Formation	Creation of new soil through accumulation and storage of organic matter and sediment retention	Ground-dwelling birds Termites Woodland birds Bettongs Large mammals Ground layer vegetation	• Production Function Based Approach • Restoration Cost Method • Replacement Cost Method
	Nutrient Cycling	Storage, retrieval, processing, and acquisition of nutrients	Soil macro-organisms and soil micro-organisms Burrowing frogs Termites Acacias Tussock grasses	• Replacement Cost Method • Avoided Cost Method • Productivity Method

6. Discussion

Any particular parcel of land that is being considered for conversion to national park should be evaluated to determine which ecosystem services are being provided in that area. The list of indicators of ecosystem services provided in the results section should be cross-examined with the parcel of land to determine which indicators are present. These indicators have been compiled from previous studies on the Desert Uplands bioregion. The presence of these indicators in an area of land being appraised determines which ecosystem services are likely provided. Valuation of ecosystem services in an area should be tailored to each individual service provided by that area. Stakeholders using this framework should perform ecosystem services valuation (ESV) in current and future situations using the selected approaches presented in Table 1 for each ecosystem service. These valuation methods should be combined to estimate the total value of all ecosystem services provided by the land that would be safeguarded by keeping the land in its natural and preserved state. Valuation should be regularly performed to ensure the data is relevant and a reflection of the ecosystem status. Undoubtedly, it would be costly and time-intensive to undergo such a practice each year, so valuation should be estimated for a period of time until the next study can be completed. Researchers Badamfirooz and his colleagues suggest that the values should be estimated for a reasonable period such as a 5-to-10-year period from the time of valuation [39:14]. An accurate ecosystem service valuation will help reveal the benefits that a location would yield if preserved as a protected area.

Acquiring a natural area and converting it to a new national park is an investment and should thus be considered in terms of benefits and costs. In order to acquire and maintain national parks, the Queensland Government has to invest in purchasing the land and continuously spend money to look after the park. These acquisition costs as well as ongoing management costs represent the total costs in forming new national parks. These costs should be weighed up against the benefits of setting aside that land to be protected as a national park. In order to measure the full benefits that would be provided, the range of ecosystem services must be considered. By pledging to expand protected areas to 17% of the state, the Queensland Government has inherently committed itself to increase funding to national parks to achieve this goal and recognises that, “growing the protected area system requires a significant investment” [3:21]. The framework presented in the report should be used to evaluate land parcels in terms of the ecosystem services they provide that would be ensured under national park status. Using this framework, the Queensland Government should determine what the return on investment would be of purchasing available parcels of land to convert to national parks.

Any study, including this one, of ecosystem services has its limitations. While effort has been made to provide a comprehensive look at ecosystem services, this is not an extensive list of all ecosystem services in the Desert Uplands Bioregion. It could be argued that it would be nearly impossible to ever provide a complete and thorough estimation of all ecosystem services as they are ever evolving and newly being discovered and understood. TEEB highlights that, “information gaps will be rife throughout ecosystem service research and should always acknowledge the current uncertainty about how the system ‘works’” [18:12]. Some ecosystem services are nearly impossible to quantitatively measure, especially those linked to cultural services. One notable example is the cultural significance of arid and semi-arid lakes, a staple of the Desert Uplands landscape. While the Indigenous peoples of inland Queensland have strong cultural associations with arid and semi-arid lakes and over 80 cultural heritage sites recorded in association with these wetland ecosystems, "most arid and semi-arid zone lakes have not been systematically surveyed or assessed for cultural heritage significance" [47:5]. Even in instances where studies have been conducted, quantitative metrics may not meaningfully capture ecosystem services such as 'sense of place' or 'spiritual experience' [38]. There is the risk of underrepresentation of ecosystem services and indicators in Table 1 for which relevant information is scarcer and/or difficult to acquire. Another constraint impacting this study that should be considered when interpreting the results is the lack of timely research on the Desert Uplands Bioregion to draw from. The majority of studies on the Desert Uplands referenced in this report were published on average 10 years prior to the time of this study's publication. The indicators of ecosystem services provided by the Desert Uplands should be interpreted with care and cross-checked to ensure relevance. This framework should be updated and expanded upon in the future to reflect any new understandings of ecosystem services and new assessments of the Desert Uplands bioregion.

7. Conclusion

The benefits that can be obtained from ecosystem services provided by Australia's national parks are a product of ecological, socio-cultural and economic factors. Ecosystem services are a result of the biophysical elements that make up each national park and of the ecological functions they sustain, but also of the interaction between nature and anthropogenic assets within each area [48]. These anthropogenic influences include history, culture, governance, knowledge, infrastructure, financial capital, technology, and institutions [38, 48]. Institutional, technological, and cultural changes are key drivers shaping the composition of ecosystem services provided by natural areas in the Desert Uplands and Australia as a whole [38].

Many of nature's contributions to people are essential for human health and well-being and so any decline in the quality of nature threatens a good quality of life [48:22]. DERM identify the land use activities of mining and grazing as the most prominent and immediate threats contributing to the "loss and degradation of biodiversity values in the Desert Uplands bioregion" [13:14]. Safeguarding biodiversity in the form of national parks protects against potential declines in the quality of nature. National parks contribute to the livelihoods of the local communities that surround them, so these stakeholders are directly impacted by the findings of any studies on the valuation of national parks. Valuation of national parks' ecosystem services is used to showcase the seemingly intangible value provided by these natural areas. Ecosystem services valuation provides the Australian government and stakeholders with the information needed to make decisions on how to best allocate and manage natural areas. Knowledge-based decisions related to national park allocation and subsequent utilisation maximises the range of benefits these areas provide. Decisions related to natural area preservation include setting price points for visitation, including camping and entrance fees; implementing management strategies; and conservation efforts [39]. The more an ecosystem is intact, the greater their capacity to provide ecosystem services. The value that natural ecosystems provide cannot be substituted with man-made inventions as "most of nature's contributions are not fully replaceable, yet some contributions of nature are irreplaceable" [48:22]. Ignoring the value that is generated by ecosystem services that would be preserved under national park protection can lead to reduced allocation of national parks followed by a decreased supply of ecosystem goods and services offered from national parks that people benefit from.

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Appendices

Appendix A Total Economic Valuation

1. Use values

The category of 'use' values can be understood to represent tangible and quantifiable ecosystem services. Use Values are the tangible features of a protected area which can satisfy some human requirement, want or need, or which serve a useful purpose [A1]. This form of value refers to the tangible features of a natural resource that serves a useful purpose for human use. The value is determined by its utility to the people who benefit from that resource. Within Use Values exists direct use value and indirect use values as well as option value.

1.1. Option Value

Option value is the value that is placed on private willingness to pay for maintaining or preserving a public asset or service even if there is little or no likelihood of the individual actually ever using it. Option value represents the importance that people place on ecosystem services remaining available in the future for their own personal benefit [A2]. Some interpretations of TEV, including Driml and his colleagues [A3] are that 'option' values exist as a component independent of 'use' values and 'non-use' values. For the considerations of value of national parks in this report, option values are considered to be a component of 'use' values. This is especially relevant when considering the value that can be achieved through better management practices of existing protected areas.

1.2. Direct-Use values

Direct use values represent the value of the goods or benefits derived from the services provided by an ecosystem that are used directly by an economic agent [A4]. The value is determined by its utility to the people who directly use that resource. Direct use values are sometimes categorised as 'non-consumptive' and 'consumptive' values [A2, A3]. In the context of protected areas, 'non-extractive' and 'extractive' values are the more appropriate classification. The term 'consumption' can be too open to interpretation and too all-encompassing to distinguish between activities done in protected areas, as most could be considered to be consuming goods or services. Extractive, on the other hand, refers to the acts of physically removing an aspect of the ecosystem.

1.2.1 Non-Extractive Values

Non-extractive values represent the value that the land creates as is without extracting resources or artificially developing it. Examples of non-extractive values include safeguarding cultural values, and supporting First Nations peoples' connection to their land.

1.2.2 Extractive Values

Extractive values represent the value that can be gained from direct extractive sources or from directly consuming a particular good [A5]. Examples of extractive values include the benefits received by activities such as mining, harvesting wood, taking water, as well as using the land for livestock grazing.

1.3. Indirect Use values

Indirect Use values are the benefits derived from the goods and services provided by an ecosystem that are used indirectly by an economic agent. Ecosystem services that provide indirect value are the processes that are part of the normal functioning of healthy, biodiverse ecosystems that end up benefitting humans [A2]. Indirect values tend to reflect the value of biological diversity to society at large rather than to individuals. Healthy ecosystems provide clean air and water as well as provide habitat for native wildlife. Other examples of indirect benefits include certain vegetations and soils protecting against storm surges and erosion or landscapes providing flood control [A6, A7].

2. Non-Use Values

Non-use values represent value that people place on natural features despite not using them. Non-use values almost always represent non-market values; therefore, they are generally not included in market valuation as they effectively have a price of zero [A1]. This inability to effectively capture non-use values is a shortcoming in environmental valuation as it does not reflect their value. While these values are not captured in the market, they do fuel monetary exchanges [A5]. People give money to charities that serve to protect landscapes and species that people value existing, despite not using them.

2.1 Bequest Value

Bequest value is the value of satisfaction from preserving a natural or historic environment. It represents the value placed on ensuring the availability of biodiversity and ecosystem functioning to future generations [A2]. People place value on having the knowledge that they are enabling a resource to be passed on to future generations. Importance isn't placed on the current present value of the land, but on what type of landscape feels best to leave to your children [A5]. An example would be how a local community may place a high cultural value on the life that they have formed around their use of a natural landscape. The way that community members interact with and use a particular natural resource would be imbedded in their culture and they would likely want future generations to be able to continue these activities. Activities could consist of camping, hunting, or farming that a person may want the future generation to be able to experience in the same way that they were able to. Bequest value can come from passing on any aspect of the ecosystem, depending on what the community values [A5].

2.2 Existence Value

Existence value represents the benefit that people receive from knowing that a particular environmental resource, endangered species, or other organism exists. Satisfaction is derived from the knowledge of the continued existence of resources [A2]. This is often the case with notorious ecosystems that are revered such as the Amazon Rainforest and iconic species like whales and koalas. People do not place value on the rainforest, for example, because of a hope that they may be able to vacation there or use its resources, but because they simply value a world in which the rainforest exists [A5].

Appendix B Description of Ecosystem Services in Desert Uplands Bioregion

1. Provisioning Services

1.1 Water storage, Supply of Drinking Water

Precipitation is collected and stored in rivers, lakes, and basins for water supply. Water resource planning areas in the Desert Uplands Bioregion include the Burdekin Basin, Cooper Creek, the Great Artesian Basin and other regional aquifers, and the Gulf water resource planning area [A8]. The town of Barcaldine, who's water comes from the Great Artesian, holds the title for 'best tasting water' in Queensland and New South Wales [A9]. This is a title that "the local townsfolk are all too happy to share with any visitors passing through" [A9].

1.2 Medicinal Resources

Many plants contain medicinal benefits to humans. Eryngium fontanum (Blue Devil plant) is one example of a plant that has medicinal benefits. Eryngium species are a rich source of flavonoids, tannins, saponins, and triterpenoids [A10]. Eryngial is one the most important and major compounds of Eryngium plants' essential oil, possesses a significant antibacterial effect [A10]. Eryngium fontanum (Blue Devil plant) is listed by the NCA and EBPC as endangered and is only known from two spring wetland complexes: Doongmabulla Springs and Edgbaston/Myrros Springs complex [A11]. Eucalyptus trees are found throughout the Desert Uplands Bioregion and also have medicinal benefits. The tree's leaves can be used to make eucalyptus oil which is used to help relieve coughing, as an insect repellent, to treat minor burns, to treat respiratory conditions like asthma and sinusitis [A12].

2. Regulating Services

2.1 Climate Regulation

The regulation of greenhouse gases reduces the progression of global warming [A13]. Plants regulate greenhouse gases through carbon sequestration and oxygen emission. Carbon is sequestered by vegetation that binds carbon dioxide in photosynthesis [A14]. In addition to gas regulation is the regulation of (local, regional, and probably global) temperature, precipitation, and other climatic processes. One process this is done through is evapotranspiration. Evapotranspiration is the process where water evaporates from the pores on the leaf surface. [A15]. Through evapotranspiration as well as direct shading, the canopy cools and stabilises the ambient air temperatures and influences the surrounding environmental conditions [A15]. This cooling effect is beneficial to understorey plants as well as animals - both wild and livestock [A15]. Eucalypt trees make up the majority of the uppermost layer of vegetation – the over storey or canopy [A15]. An overview of canopy layer vegetation found in the Desert Uplands Bioregion are outlined in Appendix C. Mid-story vegetation, which consists of smaller species, sapling trees, acacias, and softwood species, reduces environmental extremes of heat and cold [A15]. Mid-layer vegetation found in the Desert Uplands Bioregion can be found in Appendix C [A11].

2.2 Water flow regulation (flood control)

2.2.1 Water Infiltration

Water infiltration is the downward movement of water through the land surface [A16]. Water infiltration allows water to be absorbed and reduces the likelihood of water sitting on the surface of the earth, leading to flooding. The ground layer of vegetation such as Tussock grasses control the way that water and nutrients infiltrate or evaporate from the soil [A15]. These grasses provide shade on the soil surface and reduce evaporation, which promotes water infiltration and increases soil moisture [A15]. Tussock grasses have extensive root systems which penetrate deep into the soil and make them efficient at harvesting moisture [A15]. Tussock grasses and other perennial grasses are particularly valuable as they are resilient meaning they can absorb a degree of disturbance and bounce back and continue to do their job of water infiltration [A15]. Termites consume live and dead grasses and bury organic material, which enhances water infiltration [A15]. The sheer number of burrows creates by burrowing invertebrates significantly helps soil water infiltration [A15]. Burrowing frogs also create burrows which are important for nutrient flow and water infiltration [A15]. Ground-dwelling birds turn over top soil and leaf litter, which helps water infiltration [A15].

2.2.2 Inundated Areas

DERM [E6] highlights several lake beds and periodically inundated depressions and plains of state significance. These areas subject to flooding can also be referred to as floodplains. A floodplain is a generally flat or gently sloping area of land beside a river channel which is inundated during periods of high water [A17]. Intact and restored floodplains generate major environmental benefits that provide significant support for local and regional economies, mostly through the management of flood-risk [A18]. The inundated areas of state significance outlined by DERM [A6] are Webb Lake, Lake Buchanan, Thirlestone Lakes, Cauckingburra Swamp, Lake Galilee, Lake Huffer, Lake Barcoorah, Lake Moocha, Lake Mueller, and Lake Dunn.

2.3 Biological Control

The Desert Uplands Bioregion provides the right habitat and conditions for species that naturally control and regulate pest species. Controlling pests and animals is a key component of QPWS's management focus and fall under the department's Pest Management System [A19]. Proper management of these sectors is extremely important. Invasive plants and animals jeopardize natural ecosystems as well as human and animal health. Pest species also have significant impacts on industries and cost the state an estimated $710 million annually [A19]. There are key species in the Desert Uplands Bioregion that provide biological control via their predatory habits. Snakes eat pest animals as well as other carnivores who control feral cat, fox, and pig numbers [A15]. Mulga snakes (Pseudechis australis) have the widest distribution of any snake species found in Australia [A20]. Mulga snakes are identified by Kutt and his colleagues [A15] to be very important in maintaining ecological balance.

Other snakes identified by DERM [A21] in the Desert Uplands Bioregion are the near-threatened Yellow-naped snake (Furina barnardi), Collett's snake (Pseudechis colletti), Robust burrowing snake (Simoselaps warro); vulnerable Ornamental Snake (Denisonia maculate); endangered Grey Snake (Hemiaspis damelii); and the King brown snake (Pseudechis australis). Marsupial mice such as dunnarts help to control plague insects such as locusts [A15]. DERM identify the Common dunnart (Sminthopsis murina) to occur across the Desert Uplands Bioregion [A21]. The Common Dunnart is an insectivore whose diet consists mainly of beetles, cricket larvae, cockroaches and spiders [A22]. DERM list the Julia Creek dunnart (Sminthopsis douglasi) as an endangered species [A21]. The Julia Creek Dunnart feeds on insects such as silverfish, cockroaches, crickets, and slaters; as well as spiders, centipedes, scorpions, and skinks [A23]. DERM identifies the Common rock-rat (Zyzomys argurus) as a priority fauna taxa [A21]. The common rock-rat lives in the rocky areas of woodlands, grasslands, low open forests, and bases of cliff slopes and feeds on insects as well as plant matter, grasses, seeds, fungi and insects [A24]. Lizards feed on insects like grasshoppers that eat pasture grasses and crops [A15]. Insect-eating bats eat crop and fodder insects and wolf spiders consume large quantities of pest insects [A15]. Bats are the most numerous mammals in savanna woodlands, causing them to have a very large role in insect regulation [A15]. The Yellow-bellied Sheathtail Bat (Saccolaimus flaviventris) feeds on flying insects, including pest species such as mosquitos and cop and fodder pests [A15]. The Yellow-bellied Sheathtail Bat roosts in old tee hollows and occasionally in the abandoned nests of sugar gliders [A25]. DERM (2012a) identify the Little Pied Bat (Chalinolobus picatus) as a near-threatened species [A21] and its distribution across the Desert Uplands Bioregion is significantly less than the Yellow-bellied Sheathtail Bat [A22, A26]. The natural habitat of the Little Pied Bat includes caves and tree-hollows but with the onset of human development, they have been known to live in mines and disused houses [A26]. The Little Pied Bat is vulnerable to disturbance from human visitors to cave roosts and other threats include destruction of caves by mining, and loss of feeding habitat by clearing and land degradation from agriculture [A26]. Bats are the least observed mammal [A15] and arguably face difficulties in their ability to be studied. Animals can assist in biological control from an indirect and passive standpoint as well, contributing to a chain of events that keep the biological control in check. Native mice provide biological control by being prey for a variety of other animals, especially snakes and nocturnal birds [A15]. This allows these predators to exist and feed on invasive rodents that have been introduced into the environment by humans and have the potential to occur in plague proportions if left unchecked [A15]. Native mice found in the Desert Uplands Bioregion include the desert mouse and the eastern pebble mouse [A21].

2.4 Erosion Prevention

Erosion is the process of soil particles, particularly those in the top layer, being removed from their original location and transported elsewhere. Soils within the Desert Uplands are susceptible to wind and water erosion [A15]. Water erosion is caused by water detaching and transporting soil and eroded matter away from the point of removal [A27]. Rain can cause erosive activities in the soils surrounding gullies, rivers, and streams, which can lead to the downstream effects of flooding and sedimentation [A27]. Factors like slope, soil type, soil water storage capacity, the underlying rock, vegetation cover, as well as rainfall intensity and period all influence the severity of water erosion [A27]. Wind erosion is the process by which fine soil particles are carried away by the action of the wind on the soil surface [A27]. Factors like wind speed, the condition of the soil surface, and the amount of vegetation cover present all influence wind erosion [A27]. Wind and water erosion are significantly influenced by the amount of vegetation cover; therefore, any activity that removes vegetation, such as agriculture, deforestation, or other land degradation processes, can increase erosion [A27]. Land use changes from human activities are the primary causes of increased and accelerated soil erosion [A28]. Soils can become compacted from overgrazing, causing them to become relatively non-porous, absorbing less water, leading to increased water runoff [A15]. Soils across the Desert Uplands are fragile by nature, highly susceptible to compaction and are extremely sensitive to both wind and water erosion, especially once disturbed [A15]. Erosion negatively impacts both the natural environment and anthropogenic industries. Erosion can have negative impacts on the agriculture industry, costing people money and resources to rectify the damage [A29]. The top layer of soil contains essential nutrients for crops, which if eroded away decreases soil fertility and negatively impacts crop yields [A29]. Erosion can also send water laden with soil downstream, this creates heavier layers of sediment that can prevent rivers and streams from flowing smoothly, eventually leading to flooding [A29]. Wind erosion can create problems outside of the initial erosion site such as dust storms that reduce air quality in nearby areas populated by people [A27]. Soil erosion has substantial economic socio-implications as it has dramatic implications for nutrient and carbon cycling and land productivity [A28]. DERM highlights soil erosion as being one of the predominant threatening processes on the condition of the remnant vegetation in the Desert Uplands Bioregion [A6].

2.4.1 Termites

Termites help reduce soil erosion by consuming live and dead grasses and burying organic material [A15].

2.4.2 Vegetation

Overstorey vegetation reduces the effect of both wind and water erosion by “acting as wind-break and shielding the ground from rain drop impact” [10:20]. The overstorey is commonly composed of Eucalypt trees [A15]. Overstorey layer vegetation found in the Desert Uplands Bioregion is described in Appendix C. The mid-layer vegetation produces leaf litter and protects the soil surface from wind and water erosion [A15]. The mid-layer consists of smaller species and sapling trees and is often composed of Acacias and softwood species [A15]. Mid-layer vegetation found in the Desert Uplands Bioregion are described in Appendix C. The ground layer also protects the soil from wind and water erosion. This layer consists of grasses, forbs, and smaller woody species [E15]. Ground layer vegetation found in the Desert Uplands Bioregion are described in Appendix C.

3. Cultural Services

Cultural and social values derived from national parks are experienced across a range of people including Traditional Owners, tourists, tourism operators and even people who don’t use or visit the national parks or other protected areas. The Queensland Conservation Council [QCC] regards national parks as places that provide the opportunity for people to reconnect with friends and family but also experience freedom [A30]. Value is held by those who may not even visit national parks, known as the non-use values held by people outside of those regularly recreating in the parks. These include bequest value (satisfaction felt of preserving a resource for future generations) as well as existence value (the benefit felt from knowing an area exists).

Blackwell and Asafu-Adjaye found in a study of one of Queensland's National Parks, Noosa, that a significant proportion of park users hold non-use values for the park [A31]. A tactic for conservation groups to highlight national parks is to appeal to peoples' shared experiences and sentimentality. QCC [A30] does this by describing national parks as "nature's playground and a treasure to pass on to our children and grandchildren" (para. 2). Social value can be experienced beyond individual uses or perceptions of the environment; it can be felt in the form of cultural value. Ties with the land is a concept experienced by people across the world for generations and has been expressed in cultural outlets such as philosophy, poetry, and religion [A32].

3.1 Opportunities for Recreation and Tourism

Nature-based recreation and tourism includes spending time in nature in one's leisure time. It can include visiting specific places in nature in order to see certain sites. In the report, *Estimating the Value of National Parks to the Queensland Economy*, the economic value of Queensland's national parks as a tourism and recreation asset is presented in terms of the benefits to the Queensland economy through spending by tourists [A3]. Driml and his colleagues [A3] examine the spending in the regional economy by tourists who visit national parks in the area. Driml and his colleagues [A3] combine data collected through surveys of national park users with secondary tourism data to present information on expenditure within Queensland. This is used to estimate the economic contribution of expenditure by visitors attracted by the natural environment, specifically national parks. Visitors to national parks not only spend money on any entry costs and in-park accommodation costs, such as camping, they also spend money in the surrounding region on accommodation, transport, tours, food, and beverages, among other things [A7]. The researchers identify three categories of national park visitor spending: National Park Associated Spending (all expenditure in a tourism region by people who visit a national park in that region over the time spent in that region), National Park Generated Spending (expenditure by those visitors who stated that national parks were very important to their travel and spending), and National Park Generated Spending with an Unambiguous Component (visitor spending that unambiguously accrues to Queensland only because national parks are accessible by visitors). The substantial values presented in the Driml and his colleagues study of tourism value set the precedent for tourism spending to be acknowledged as a sizable contributor to the state's economy [A3].

The Palace is an Aboriginal Rock Art site located around 60 km south of the town of Jericho, and is the largest complex of art sites known to exist in Central Queensland [A33]. According to the Bidjara people, the site known as The Palace is around 4,000 years old [A34]. The site was declared a Scientific and Recreational Reserve in 1933 [A33]. There are approximately 10,000 recorded rock art paintings set on around 1000 square metres of sandstone cliff faces [A33]. A Palace Scoping Study [A35] was conducted to provide Regional Development Australia Fitzroy and Central West [RDAFCW] with a level of detailed information on the cultural significance, protocols and required statutory and legislative process that is necessary to assess the level of legal and cultural appropriateness of future development applications regarding The Palace. RDAFCW acknowledge the iconic significance of the Aboriginal Rock Art located within the Central Queensland sandstone belt [A35]. An article published by ABC News [A34] highlighted the Traditional Owners' eagerness to see The Palace open for tourists. RDAFCW state that the Palace is an important tourism and recreational resource [A35].

3.2 Scientific Research and Educational activities

Scientific research and educational activities involve learning from observations of natural areas and ecosystems. By trying to understand this information and from this knowledge, benefits can be derived from the land [A15]. Biophysical characteristics of ecosystems and cultural places provide opportunities to observe, experience, and experiment in the outdoors, increasing ecological knowledge and connectedness to nature [A36]. For example, the site known as ‘The Palace’ has substantial scientific value for the wealth of information it contains. Analysis of the artistic styles and the material culture such as the tools, weapons and dilly-bags depicted, can reveal much about traditional Aboriginal culture in the region [A35]. RDAFCW state that the Palace is an important educational resource [A35]. Landscapes provide us with information about wildlife, ecology, ecosystems, managing cattle, using fire, climate variation, and vegetation patterns [A15].

3.3 Aesthetic Value

There is value in the opportunities for aesthetic enjoyment of nature and for the scenic views natural landscapes can provide [A36]. Aesthetic value is the appreciation of the biophysical characteristics or qualities of species or ecosystems for their inherent beauty [A36]. A couple who own a Desert Uplands property next to a large saline lake enjoy taking friends to view the peaceful scene. At times there are hundreds of brolgas performing their mating dances, and pelicans, black swans, seagulls, avocets, egrets and ducks come there to breed. When interviewed the couple were emphatic that ‘we really appreciate the lake for what it is and our appreciation is not only commercially driven’ [A37:19].

3.4 Sense of Place and Identity

Cultural Heritage can be understood to be the tangible and intangible components of a society or group’s heritage passed down through generations. A community’s customs, practices, places, objects, artistic expressions, and values are all expressions of their ways of living and form their cultural heritage [A38]. This can also be experienced as the cumulation of traditional beliefs, customs, and stories. Identifying oneself in relation to a place and community contributes to strengthening social cohesion [A39]. Indigenous peoples place spiritual values on ecosystems within the Desert Uplands and have specific religious practices associated with certain areas and natural features. The Indigenous peoples of inland Queensland have strong cultural associations with arid and semi-arid lakes - a prevalent ecosystem feature in the Desert Uplands [A37]. Arid and semi-arid lakes have provided seasonal water, food and other material resources for thousands of years and also have ceremonial and spiritual values [A37]. Old sites, artifacts, and practices that society regards as important and worthy of conservation are all encompassed in cultural heritage [A40]. Monuments with historical value can serve as a physical grounding point for people to feel a sense of place and identity [A33-35]. The Aboriginal cave art, ‘The Palace’ has been written about in terms of its appeal as an attraction and potential source of income but is arguably most importantly and primarily a monument of historical value for the Bidjara People.

3.5 Existence and Bequest Values

Existence and Bequest Values are non-use values that do not concern peoples’ use of the environment, but instead provide a feel-good or warm glow effect. Existence and Bequest values are benefits received by those who may not even have direct engagement with the landscape. Existence value refers to "the benefits from simply knowing the landscape is there and in good health, even though there is no intention of ever using it" [A15:56]. Bequest value refers to "the benefit derived from being able to pass on healthy landscapes to future generations – landscapes that do not suffer from salinity, soil erosion or lack of water, or weeds and ferals" [A15:56]. The most common examples are people's desire to protect endangered species or habitat [A36].

4. Supporting/Habitat Services

Supporting services are those that maintain processes and conditions that are needed for species' survival.

4.1 Habitat Provision

The provision and preservation of habitat for flora and fauna forms the basis of a healthy ecosystem and associated ecosystem services. There are several ways in which the natural landscape is specialised to provide the best habitat for the species that live in the region. Complex, well-formed woodlands with many hollow-bearing trees of high fertility provide habitat for [A21]. Dense foliage of the mid-layer (usually acacias) provides nesting habitat for small birds [A15]. Dense, extensive spinifex groundcover is a significant feature that provides important habitat for a range of priority terrestrial species [A21]. Sub-tropical woodlands represent a substantial area of species turnover, refuge, and disjunction [A21]. Hummock grasslands and related low-shrubby habitats occurring in the saline discharge zone are particularly significant for specialized fauna [A21]. Caves and escarpment provide significant roosting habitat for many bat species including many significant species as well as roosts for owls in environments that may not otherwise have tall hollow-bearing trees [A21]. Roosting and feeding sites are found throughout the Desert Uplands and provide habitat for tree-dwelling species such as bats and birds [A6]. Other significant habitat locations are those that provide habitat for specialised populations. These include centres of endemism, areas of disjunct populations, areas with high species richness, areas with high species composition and areas with relictual populations [A6].

4.2 Corridors and Connectivity

Wildlife corridors maintain long term evolutionary and genetic processes that allow natural change in distributions of species and connectivity between populations of species. Wildlife corridors are sections of the landscape that allow wildlife to move between differing areas of the environment [A41]. This movement of species allows species to travel to new locations to find resources like food and water [A41]. A 'riparian corridor' refers to land that adjoins or exists nearby a body of water such as a: river, creek, gully, lake or wetland [A42]. There are several locations of intact riparian corridors that allow inland incursions of south-east and east coast species into the semi-arid zone [A21]. The Fauna Expert Panel declares these habitats to be biogeographically significant. Corridors can also be in the form of 'stepping stone' trees which link larger patches of forest or woodlands [A41]. Corridors are extremely important as natural landscapes become increasingly fragmented in the age of urbanisation and agricultural expansion.

4.3 Soil Formation

Soil is formed through the accumulation and storage of organic matter as well as sediment retention [A43]. Various flora and fauna contribute to the formation of healthy soil. Ground-dwelling birds turn over top-soil and leaf litter [A15]. Termites create soil by consuming live and dead grasses as well as burying organic material; these processes also increase soil fertility [A15]. Woodland birds forage and turn over leaf mulch, assisting with the incorporation of organic matter into the soil [A15]. There are a total of 360 bird species found in the Desert Uplands Bioregion [A44]. Bettongs digging in the soil for fungi and plant roots helps spread fungal spores, which are crucial to soil health [A15]. Large mammals' shallow digging captures grass seeds and litter, helping to recycle them into the soil [A15]. The ground layer (grasses, forbes, and smaller woody species) increases soil organic matter [A15].

4.4 Nutrient Cycling

The nutrient cycle is the movement of particular nutrients and elements from the environment, through one or more organisms, and then back into the environment [A45]. The presence of soil macro-organisms such as ants, beetles, termites, snails, and earthworms as well as micro-organisms such as soil bacteria and fungi indicate soil activity. Termites are particularly important for nutrient cycling in arid Australian soils [A15]. Soil macro-organisms consume organic matter and their waste becomes food for soil micro-organisms. The mineral waste from soil bacteria and fungi then serves as food for trees and grasses [A15]. Other larger creatures contribute at various stages of the nutrient cycle. Burrowing frogs return nutrients back to the soil and woodland birds forage and turn over leaf mulch, assisting with the incorporation of nutrients into the soil [A15]. Particular vegetation also has a strong influence on the nutrient cycle. Acacias improve soil quality by fixing nitrogen in the soil, making it available for the uptake by other plants and grasses [A15]. Tussock grasses have deep, extensive root systems that allow them to reach nutrients from greater depths, making them efficient at harvesting nutrients [A15]. The nutrient cycle is critical to the success of maintaining the natural environment as well as grazing systems in the Desert Uplands [A15].

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