ST JAMES CONSERVATION AREA: A PURCHASE FOR ECOSYSTEM SERVICES

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ABSTRACT: The New Zealand Government purchased the lease of St James in 2008 as public conservation land for ecosystem services, public recreation, and biodiversity protection purposes. In this chapter, the ecosystem services and biodiversity provided by St James are reviewed. In the future, climate regulation, erosion control, clean water provision, and recreation services are all likely to increase. Habitat provision, food provision, and biodiversity are likely to be maintained. Water yield is the one service which is likely to decrease. We discuss how an ecosystem services framework can best benefit conservation.

Key words: biodiversity benefit, carbon sequestration, clean water provision, climate regulation, ecological integrity, erosion control, native dominance, species occupancy.

INTRODUCTION

'Land under conservation management is crucial to the delivery of ecosystem services that fuel the economy and support society' (Morrison 2008). St James Station in North Canterbury was purchased on behalf of New Zealanders by the Nature Heritage Fund (administered by the Department of Conservation) in 2008. This purchase signalled the transition of this property from New Zealand's largest privately owned farm (78 000 ha) to St James Conservation Area for the benefit of ecosystem services, public recreation, and biodiversity protection. Land use on the former high-country pastoral leasehold property is changing from light cattle grazing to conservation/recreation including natural regeneration of indigenous forest, although light grazing by horses is still a feature of some restricted areas. Adoption of a new management plan (DOC 2009) for the St James Conservation Area (hereafter 'St James') will affect biodiversity and change the provision of ecosystem services.

Here, we examine some of the ecosystem services provided by St James and identify the services most likely to trade off against one another. Knowledge of the magnitude of these services and, more importantly, the potential trade-offs between them as influenced by management will be required in order to optimise the provision of multiple ecosystem services by St James. While St James represents one large block of land in single ownership, it can be viewed as a model system; the principles developed in this chapter are relevant to the large areas of 'marginal' lands in New Zealand, including those having gone through tenure review. High country tenure review is a voluntary process between the Crown and pastoral leaseholders run by Land Information New Zealand (LINZ). The process allows for the Crown and a leaseholder to review an area under lease with a view to the lease being cancelled and significant inherent values being given long-term protection under Crown ownership and management. The leaseholder has the opportunity to freehold the remaining parts of the lease. The Department of Conservation (DOC) is one of the agencies that has a role to identify areas with significant inherent values in a pastoral lease after it has entered the tenure review process. More information is available at LINZ (2013).

Our designation of ecosystem services at St James has been primarily informed by the Millennium Ecosystem Assessment (MEA) (2005). The MEA classified ecosystem services into provisioning (e.g. provision of food and fibre), regulating (e.g. regulation of climate through carbon storage), cultural (e.g. recreation values), and supporting services (e.g. nutrient cycling and soil formation). Further, it showed that over the last 50 years there were net gains in human well-being and economic development, but that these have come at the cost of 'degradation of many ecosystem services, increased risks of nonlinear changes, and exacerbation of poverty for some groups of people' (MEA 2005). The United Kingdom National Ecosystem Assessment (UK NEA 2011) states that biodiversity underpins all ecosystem services and also acknowledges that relating changes in biodiversity to changes in ecosystem services can be problematic due to a lack of data on associated values and benefits. In the UK NEA, biodiversity was credited with the provision of ecosystem processes and intermediate services such as primary production and nutrient cycling, which in turn lead to the ecosystem services of food production and clean water provision. This assessment also acknowledges very strong linkages between biodiversity and cultural services that are notoriously difficult to quantify. Biodiversity can also be thought of as part of 'natural capital' (sensu Hawken et al. 1999) whereby it acts more as a 'stock' than a 'service' in itself.

Recent literature on ecosystem service measurement has emphasised the provision of services at landscape scale – as is appropriate for policy formulation (Nelson et al. 2009). Given the importance of governance for ecosystem service enhancement, quantification of service provision across sectors, catchments, and even countries is necessary (e.g. Maes et al. 2012; Pittock et al. 2012; Primmer and Furman 2012). Nonetheless, there are other studies that examine property-scale service provision, usually of a restricted range of services (e.g. Ricketts et al. 2004; Kremen and Miles 2012). St James is unusual in that although it is a single property its large size and geographical placement allow for assessment of some services that are usually more appropriately studied at catchment scale, for example clean water provision. Although payments for ecosystem services are usually divested at national or sub-national scale to groups of landowners in exchange for their management of specific ecosystem services (e.g. Farley et al. 2010), land purchase for ecosystem services has

 Carswell FE, Easdale TA, McC. Overton J, Ausseil AE et al. 2013. *In* Dymond JR ed. Ecosystem services in New Zealand – conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand.

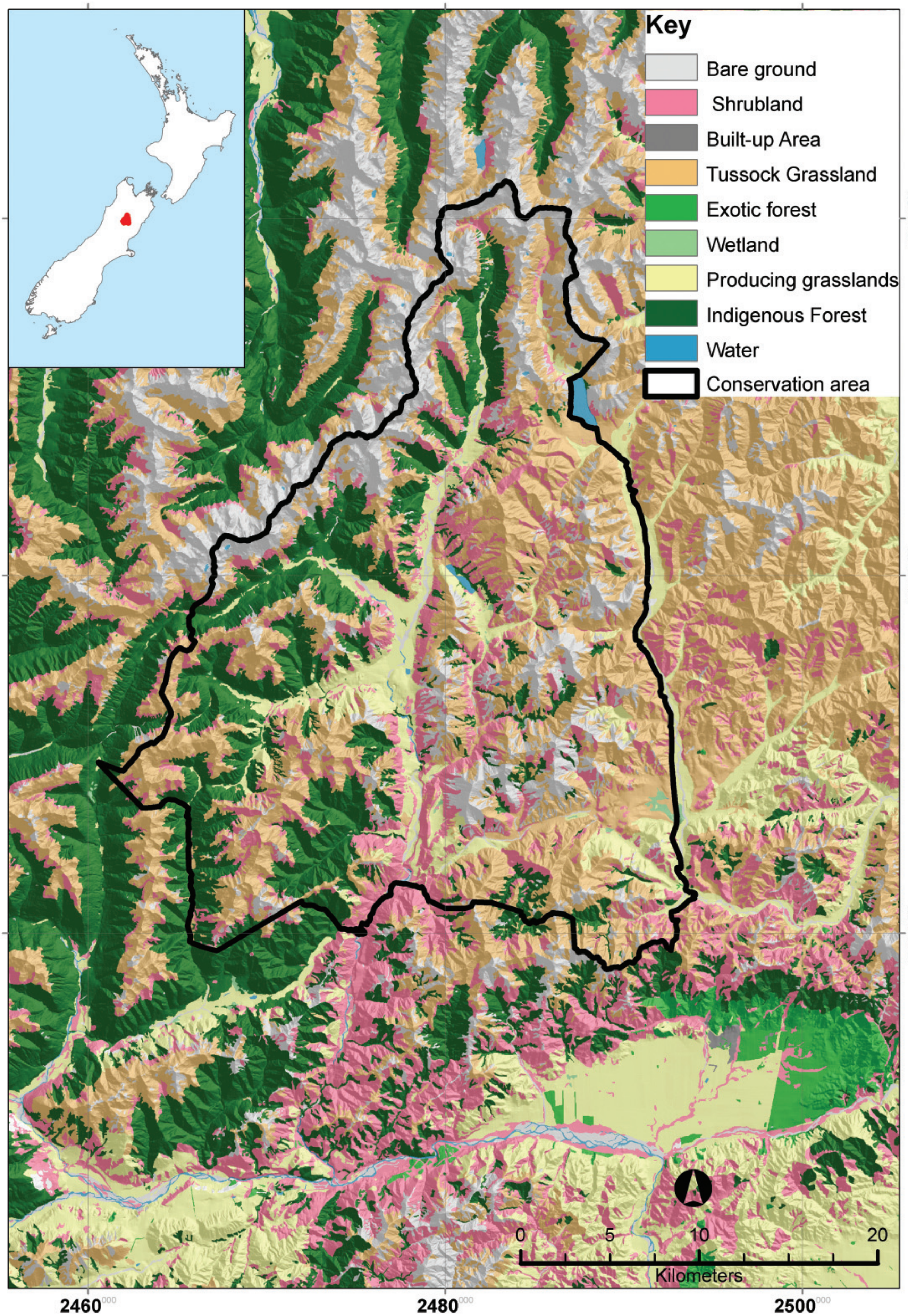

FIGURE 1 St James Conservation Area and its location in the South Island. Land cover categories are from the Land Cover Database. The major river running from North to South through the middle of St James is the Waiau River. The Clarence River sits in the north-east flowing south into Lake Tennyson and beyond. To the west of the Waiau are the Ada (northern) and Henry rivers.

occurred elsewhere, such as the Vittel payment for ecosystem services that included both land purchase and payments to landowners to preserve water quality in rural France (Perrot-Maître 2006). In the Vittel payment for ecosystem services, it was a private company that made the payments in order to preserve the quality of its product. The St James purchase, however, was on behalf of all New Zealanders.

In this chapter, we review the regulating and provisioning services that St James provides. The majority of the services have been estimated spatially, and have been produced in a GIS environment by Landcare Research and DOC. A series of maps shows the spatial distribution of various services within St James, for example surface water supply, erosion control (sensu Ausseil et al. 2013), carbon sequestration and the underpinning biodiversity benefit as assessed through 'ecological integrity'. We then apply a quantitative framework for assessing biodiversity benefit through management intervention (Vital Sites and Actions (VSA) Model; Overton et al. 2010). The VSA Model is used to quantify the current ecological integrity of St James. Our discussion synthesises the changes in ecosystem services likely to occur in the future and explores how an ecosystem services framework can best benefit conservation.

ST JAMES CONSERVATION AREA

The New Zealand Government purchased the lease of St James in October 2008 as public conservation land for ecosystem services, public recreation and biodiversity protection purposes (DOC 2009). St James includes the headwaters of two major Canterbury rivers – the Waiau and Clarence (Figure 1) – and four mountain ranges – Spenser, St James, Opera, and part of the Hanmer Range. The height above sea level ranges from 540 m in the lower Waiau to 2300 m on Mt Una in the Spenser Mountains. Expansive drylands are situated within the boundaries of this area. Historically, Māori trading and 'greenstone' trails ran though the Clarence and Waiau valleys, connecting the east coast of the South Island with the west. Before becoming public conservation land, St James Station had a long history of high-country pastoral-lease farming. The station was made up of a number of smaller pastoral leases that had been amalgamated over time.

DOC (2009) states that before government purchase of the lease, St James had been noted as an area with 'very high conservation values, including a wide variety of vegetation types, forming continuous unmodified vegetation sequences in excellent condition, a range of wetland types and habitats for birdlife, good quality dense short tussock land and highly natural riverbed vegetation in the upper Clarence'. There is also mention of the alluvial terraces and fans that support possibly the best population of tall dense matagouri (*Discaria toumatou*) in Canterbury.

Vegetation

St James comprises a mosaic of ecosystems with contrasting biodiversity values including extensive tussock grasslands, high-alpine ecosystems, and forest remnants. Interrogation of the National Vegetation Survey Databank (NVS) and LUCAS forest and shrubland vegetation plots indicates that nine vegetation types from the recent quantitative classification (Wiser et al. 2011; Wiser and De Cáceres 2013) are located within St James or its immediate surroundings (Table 1). Broom is also rapidly invading many alluvial flats and is currently only controlled in some parts of St James. Some wilding pines are present in the lower Clarence catchment but these are not considered to be a problem (DOC 2009).

WATER-FLOW REGULATION

Water-flow regulation is defined by the timing and magnitude of runoff, flooding, and aquifer recharge (MEA 2005). These attributes can be strongly influenced by changes in land cover, and in particular by alterations that change the water storage potential of the system. The WATYIELD [water yield] model (Fahey et al. 2010) was used to predict the hydrological effects of land cover in St James, where the surface-water-flow regulation service was defined as the net water remaining after evapotranspiration losses. WATYIELD models daily water transfers of rainfall, interception, evapotranspiration, and drainage associated with a soil profile. The daily surface water drainage Q (mm) at a point (x,y)

TABLE 1 List of vegetation alliances (plant communities) identified within the St James Conservation Area with abbreviated names for each class. Alliances in the original classification of Wiser et al (2011) are coded 'O' and recent updates by Wiser and De Cáceres (2013) are identified with an 'N'. Also shown is the estimated sequestration rate (with one std error) estimated for each vegetation alliance by Holdaway et al. (2010) – note that associations labelled N in identification code have sequestration rate estimated from other categories as these categories have been defined later than the Holdaway et al. (2010) sequestration rates.

Location	Identification Code	Carbon sequestration (tCO_2 ha yr^{-1})	Vegetation alliances
East, lower elevation	O2 (Matagouri shrubland)	1.4 ± 0	*Discaria toumatou – Coprosma propinqua* / *Anthoxanthum odoratum – Dactylis glomerata* shrubland
Toe-slopes to faces	O5 (Manuka shrubland)	3.3 ± 0.3	*Leptospermum scoparium – (Leptecophylla juniperina)*
West higher elevation	N2 (*Ozothamnus-Dracophyllum* montane shrubland)	2.3 ± 1	*Dracophyllum uniflorum* / *Gaultheria crassa – Poa colensoi – Festuca novae-zelandiae* montane shrubland
Montane areas	N3 (Beech)	1.2 ± 0.3	*Nothofagus menziesii* / *Hoheria glabrata – Myrsine divaricata – Coprosma ciliata* / *Polystichum vestitum* montane forest
Gullies in western tributaries nearby	O10 (Beech)	2.6 ± 0.4	*Nothofagus menziesii – Nothofagus fusca – Nothofagus solandri* forest
Gullies in western tributaries nearby	O15 (Beech)	1.8 ± 0.3	*Nothofagus menziesii – Weinmannia racemosa – Nothofagus fusca* / *Blechnum discolor* forest
Montane areas	O8 (Beech)	1.8 ± 0.5	*Nothofagus solandri* (*Peraxilla tetrapetala*) / (*Coprosma pseudocuneata*) subalpine forest
Montane areas	O11 (Beech)	1.8 ± 0.4	*Nothofagus solandri* – (*Nothofagus fusca*) / *Coprosma microcarpa – Leucopogon fasciculatus* forest
Montane areas nearby	O9 (Beech)	1.8 ± 0.3	*Nothofagus solandri – Nothofagus menziesii* / *Coprosma pseudocuneata – Hymenophyllum multifidum* forest

is expressed as:

$$Q(x,y) = P(x,y) - E(x,y) - \Delta Z(x,y),$$

where $P(x,y)$ is daily rainfall (mm), $E(x,y)$ is daily evaporation (mm), and ΔZ is change in water storage in the root zone (mm). Evaporation has two main components, an interception component of rainfall stopped by the vegetation before it reaches the ground and a transpiration component by which water is transferred as vapour from the land into the atmosphere. Interception is calculated from the daily rainfall; transpiration is derived from a climatological potential evapotranspiration that takes account of the vegetation type (pasture, scrub, forest, tussock). Other parameters required for the model include the waterholding capacity of total and readily available water for the whole soil profile. WATYIELD is data-intensive as it runs on a daily basis instead of an annual basis. The model was run for soil/climate units previously identified at Level II of the Land Environments of New Zealand (LENZ) classification (Leathwick et al. 2002). This was run over all of New Zealand (Ausseil et al. 2013) using mean soil properties from the Fundamental Soil Layers database (Landcare Research 2011) and 10-year records of daily rainfall and potential evapotranspiration from the nearest meteorological site (NIWA 2010). The entire run was subsequently sub-sampled for St James.

The resulting water-flow regulation service provided by the ecosystem in St James is mapped in Figure 2 as annual water yield (mm year^{-1}). The figure reveals the significance of topography, partly mediated by vegetation cover, on water drainage. In WATYIELD, tussock gives the highest yields, followed by pasture, scrub, and then forest. Forest cover lowers the water yield because of its high rate of interception. Therefore increasing levels of forest, even when achieved by natural regeneration, will decrease water provision – a considerable trade-off with management for conservation (i.e. increasing natural capital).

CLEAN WATER PROVISION

St James was formerly used for extensive pastoralism but stocking rates of cattle were low (< 0.5 stock unit ha^{-1}) and farming effects on water quality were expected to be minor. Laboratory tests were carried out for 10 water samples taken from throughout the Waiau and Clarence river catchments (Figure 3) in May 2010. Results for nitrates were not greater than 0.01 g m^{-3} and for nitrites were less than 0.002 g m^{-3} for all samples; these are well below the maximum acceptable values of 50 g m^{-3} (nitrates) and 0.2 g m^{-3} (nitrites) in the New Zealand drinking-water standard (Ministry of Health 2008). However, faecal coliform bacteria (comprising any of the genera *Erwinia, Klebsiella, Escherichia, Citrobacter* or *Enterobacter*) in some samples exceeded the maximum acceptable value of less than one *E. coli* unit per 100 ml of sample, especially those from the outlet of Lake Guyon and towards the lower end of the Clarence catchment (samples 8, 9 and 10 in Figure 3). It is unknown whether these readings are typical for similar catchments elsewhere that have been set aside for recreational purposes. At the time of testing, water for drinking would have had to be treated to remove coliform bacteria. Repeat sampling would determine whether stock removal has been effective in lowering coliform counts.

NITROGEN LEACHING

A by-product of livestock farming can be nitrogen leaching whereby N is mobilised from the soil and has potential to enter water bodies. Nitrogen leaching is estimated for each type of livestock and land cover on the basis of stocking values and rates of leaching. St James has been destocked since DOC took possession but because estimated original stocking at 2003 was very low – according to the area covered by each farm type indicated by the Agribase™ land use map (AgriQuality New Zealand 2003) – destocking is expected to have made no material difference to N leaching. The majority of land is under tussock or shrubland and there was previously only a very small area of sheep and beef farming (note that 'sheep and beef farming' is the land use required to run the OVERSEER® model even though St James was only stocked with cattle recently).

Figure 3 presents results based on (1) a model of nitrogen leaching (OVERSEER®; Wheeler et al. 2006) for average sheep and beef farming enterprises in the Waiau catchment, (2) current land use maps for St James (Agribase and LCDB – AgriQuality New Zealand 2003; Ministry for the Environment 2009), (3) Soil depth classifications from Trevor Webb, Landcare Research soil scientist, and (4) N leaching rates for pine plantations, native forest and tussock based on the literature and expert advice from Dr Roger Parfitt (Table 2). Overall, the model indicates that current levels of nitrogen leaching are very low.

Nitrogen leaching from soil can also result from nitrogen-fixing plants. The most widespread nitrogen-fixing plants in these catchments are matagouri and invading Scotch broom (*Cytisus scoparius*). Both occur most commonly along alluvial terraces and lower slopes, which co-occur with the topography most used by domestic stock. Broom has been shown to increase nitrogen leaching levels (Drake 2011), so it is likely these levels will increase as broom cover increases.

TABLE 2 Assumed average nitrogen (N) leaching and phosphorus (P) loss rates (kg ha^{-1}) for the St James Conservation Area, used in the OVERSEER® model to produce Figure 3. BAL: Balmoral Soil; LIS: Lismore Soil. See Figure 1 for the estimated cover of various land uses.

Enterprise or land cover	Soil type	N leaching (kgN ha^{-1})	P loss (kgP ha^{-1})
Deer	BAL	12.6	0.037
Deer	LIS	11.4	0.076
Sheep and Beef	BAL	4.0	0.50
Sheep and Beef	LIS	4.0	0.60
Pine plantation	BAL	4.0	0.00
Pine plantation	LIS	4.0	0.00
Scrub	BAL	1.0	0.00
Scrub	LIS	1.0	0.00
Native bush	BAL	1.0	0.00
Native bush	LIS	1.0	0.00
Tussock	BAL	1.0	0.00
Tussock	LIS	1.0	0.00

EROSION CONTROL

Soil erosion rates for St James were calculated for the current land use in the catchment (Figure 4), using the NZeem® erosion model of Dymond et al. (2010). The model estimates the long-term mean erosion rate from all sources of erosion, both mass-movement and surficial. The mean annual rate of sediment loss through erosion, e, (expressed in tonnes km^{-2} year^{-1})

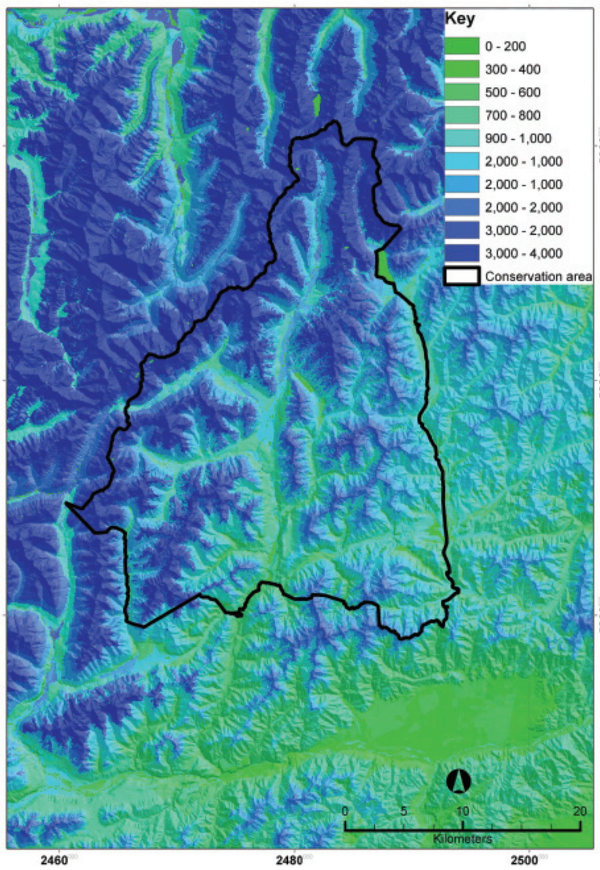

FIGURE 2 Water yield in mm year^{-1}, based on land cover information from the Land Cover Database. Increasing intensity of blue represents increasing yield – higher-elevation areas in this instance.

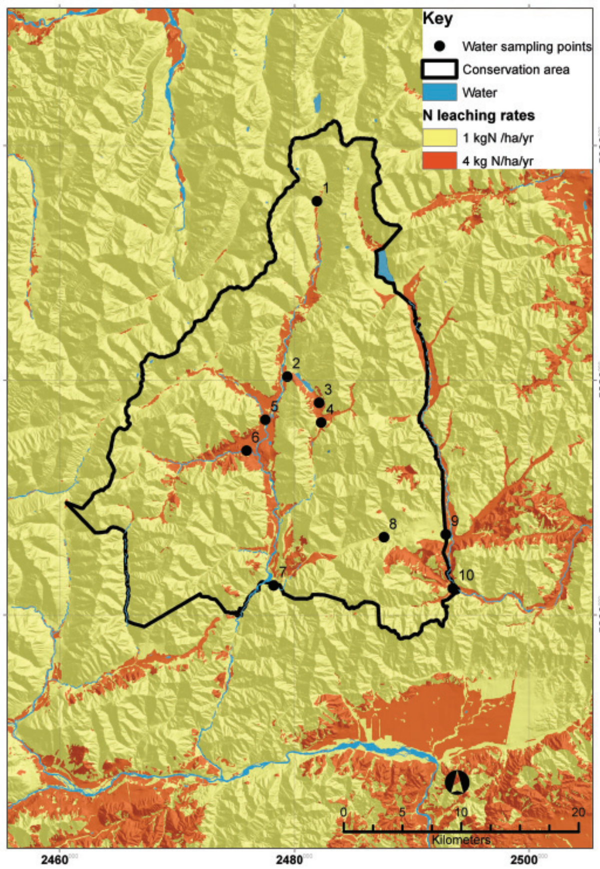

FIGURE 3 Nitrogen leaching in kg of nitrate-N ha^{-1} year^{1}. Note that leaching is very low overall but that slight increases are shown near the major rivers (where cattle grazing previously occurred). Also shown in black dots are the locations where water samples were taken within the St James Conservation Area in May 2010. Water sampling points 3 and 4 lie beyond Lake Guyon on the Stanley River.

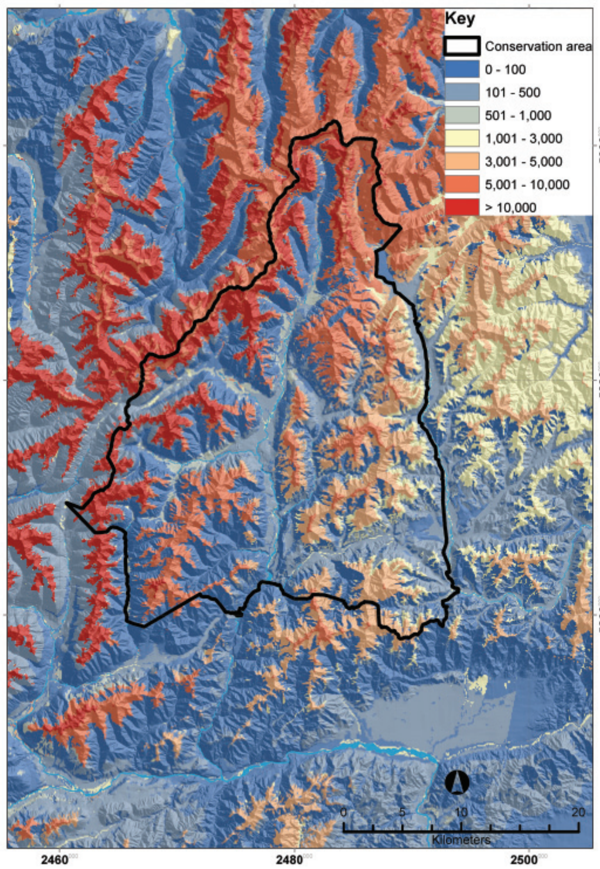

FIGURE 4 Soil erosion in tonnes of soil km^{-2} year^{-1}. Areas of high erosion correspond well with scree slopes and other non-forested high-elevation areas.

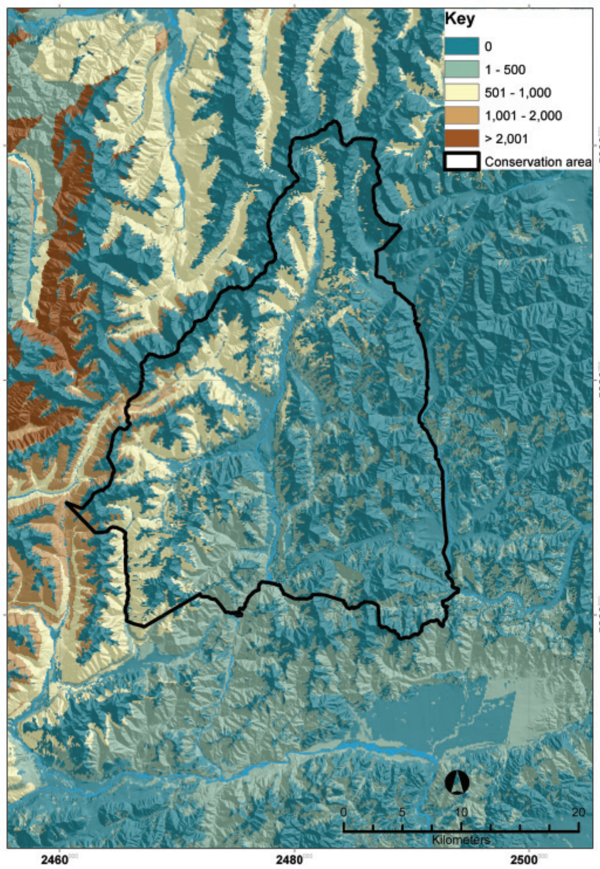

FIGURE 5 Sediment retained in tonnes of soil km^{-2} year^{-1}.

for geographic coordinates x and y, is a function of mean annual rainfall, land cover, landform, slope, and rock type:

$$e(x,y) = \kappa(x,y) \times C(x,y) \times R^2(x,y),$$

where $\kappa(x,y)$ is an erosion coefficient which depends on erosion terrain, $R^2(x,y)$ is mean annual rainfall squared, and $C(x,y)$ is a land cover factor which gives soil loss relative to erosion under forest cover. Previous research indicates notable reductions in sediment from erosion-prone land under afforestation compared with pasture, thus $C(x,y) = 1$ if land cover is woody vegetation or 10 if it is herbaceous vegetation or bare ground.

Erosion 'terrains' are areas of similar rock type and landform which will experience similar erosion processes. They were derived from land-use capability units of the New Zealand Land Resource Inventory (Eyles 1983). Rainfall at different locations was derived from data compiled by Leathwick et al. (2002). The inclusion of an explicit land cover term in the equation makes it possible to assess the erosion impacts likely to result from a change in land use or land cover.

The erosion control service is defined as the ability of an ecosystem to prevent soil loss (i.e. 'sediment retained'). It can therefore be calculated as the difference between the rate of sediment loss if the whole landscape had no trees (i.e. was all in grass) and that under current land use (i.e. mixed grass, forest, regenerating shrubland) (Figure 5).

CLIMATE REGULATION

Agricultural greenhouse gas emissions

Livestock are a major contributor to the emission of greenhouse gases into the atmosphere, by releasing nitrous oxide and methane – which, according to the latest IPCC assessment report (IPCC 2007), have respective warming potentials of 310 and 21 times that of CO_2 equivalents. Greenhouse gas emissions from agriculture are based on per-head emission rates per year and per-hectare stocking rates for different types of livestock (i.e. dairy, sheep, beef or deer). As indicated above, original stocking at St James before 2003 was very low and destocking of livestock since St James became public conservation land is expected to have made no material difference to agricultural greenhouse gas emissions. Nitrous oxide and methane emissions are assumed to be negligible for non-pastoral land uses.

CARBON SEQUESTRATION

Mapping of forest cover classes

Given the dominance of the Kyoto Protocol in setting the parameters for developed nations to participate in global carbon markets and the ongoing reporting requirements of developed nations within UNFCCC (United Nations Framework Convention on Climate Change), we distinguished areas of St James that were already in forest from those in the process of reversion or that could revert in future and consequently gain credit for post-1989 carbon sequestration. This was achieved using a time series of multi-spectral aerial imagery from 2002 to 2009, in combination with site visits and sample plots (Burrows et al. 2011). Land was assessed at a per-hectare scale and classified into three cover classes: existing forest (including beech and manuka), regenerating, and permanent non-forest.

Existing forest — All areas described as 'existing forest' are expected to be treated as 'forest land as at 31 December 1989' under the New Zealand Emissions Trading Scheme. Aerial images supported by retrospective ground-based assessments were used to define land that was already forest at 31 December 1989 – that is, by 31 December 1989 they already had at least 30% canopy cover in any one hectare of tree species capable of reaching 5 metres in height at maturity. From Table 1 it is clear that most of the existing forest (primarily mountain beech mixtures = c. 15,000 ha) is currently sequestering carbon at c. 1.8 ± 0.3 tCO_2-eq ha^{-1} $year^{-1}$. The sequestration service from beech alone is therefore 27,000 tCO_2-eq $year^{-1}$.

Regenerating forest (c. 4,700 ha) — land that was not forested at 31 December 1989 but has the potential to revert to forest by natural succession. This was based on: land use post-1989 that is consistent with natural forest reversion (e.g. lack of intensive grazing, lack of land clearance practices); presence of some tree species (but less than 30% cover or 5-m height) at 1 January 1990 as estimated from aerial imagery or ground assessment; and biotic and abiotic conditions conducive to reversion (i.e. available seed sources, suitable temperature, rainfall).

Permanent non-forest (c. 59,000 ha) — land that will either not revert to forest naturally within the foreseeable future (i.e. next 50–100 years) or, if so, only very slowly. Areas unlikely to revert to forest include recent landslide scars, scree slopes, rocks and bluffs, shingle riverbeds and areas with environmental constraints such as cold or moisture limitations. We used a general elevational upper-limit of 900 metres above sea level. We acknowledge that this is relatively severe as existing beech forest on the western side of the Waiau River forms a treeline at c. 1300 metres elevation. However, high-elevation woody cover may never reach the height definition of 'forest' (in New Zealand carbon trading parlance) and/or sequestration rates will be very slow (well below 3 t CO_2-eq ha^{-1} $year^{-1}$). For example, there are continuous slopes covered in mānuka (*Leptospermum scoparium*) at St James where trees at c. 800 metres elevation are > 5 metres tall, while at c. 1000 metres on the same face mānuka is stunted and barely reaches 3 metres. Further, hill slopes recovering from a pastoral legacy will be severely limited by available seed – beech being notoriously slow to spread. Areas of valley-bottom land on alluvial terraces with a slope of < 5 degrees were considered unsuitable for natural reversion due to the likely presence of 'frost flats', that is, areas where extreme frosts or a high frost frequency was likely to prevent or impede the establishment or growth of forest species. In some cases those flat lands remain in short tussock grassland (*Festuca* spp., *Poa* spp.); in other cases short shrubs are common (Figure 6).

The estimation of potential sequestration rates relied on the recent national classification of vegetation by Wiser et al. (2011) and Wiser and De Cáceres (2013). The classification is based on a quantitative and nationally representative network of permanent vegetation plots collected as part of the Ministry for the Environment's Land Use and Carbon Analysis System (LUCAS) (Lawton and Barton 2002). The classification comprises 24 woody vegetation communities and is based on species composition and population structure, and recognises successional shrubland communities.

Only limited quantitative sampling to estimate biomass C stocks or sequestration rate in regenerating shrublands has been carried out at St James. A set of 16 permanent plots (20 × 20 m) were established by Landcare Research during 2010 and a further five LUCAS plots of the same size were established between 2002 and 2006. The St James plots are randomly located in reverting shrublands, while three of the LUCAS plots are in mature forest and two are in alpine shrubland. These plots have been used to help interpret vegetation cover classes and species

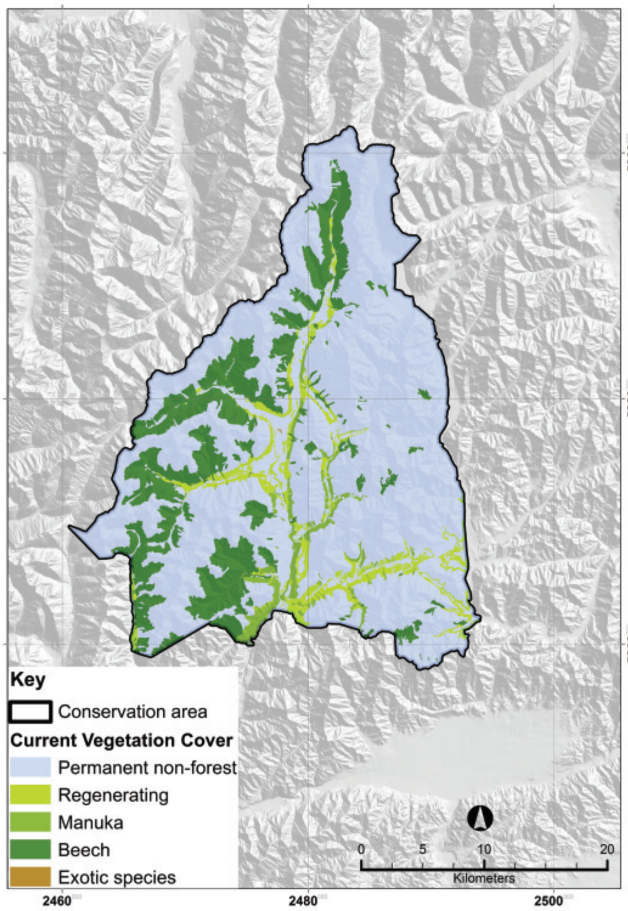

FIGURE 6 Current vegetation within the St James Conservation Area. Note that the manuka depicted lies predominantly above 900 m a.s.l. and is therefore not considered to be 'regenerating' to tall forest.

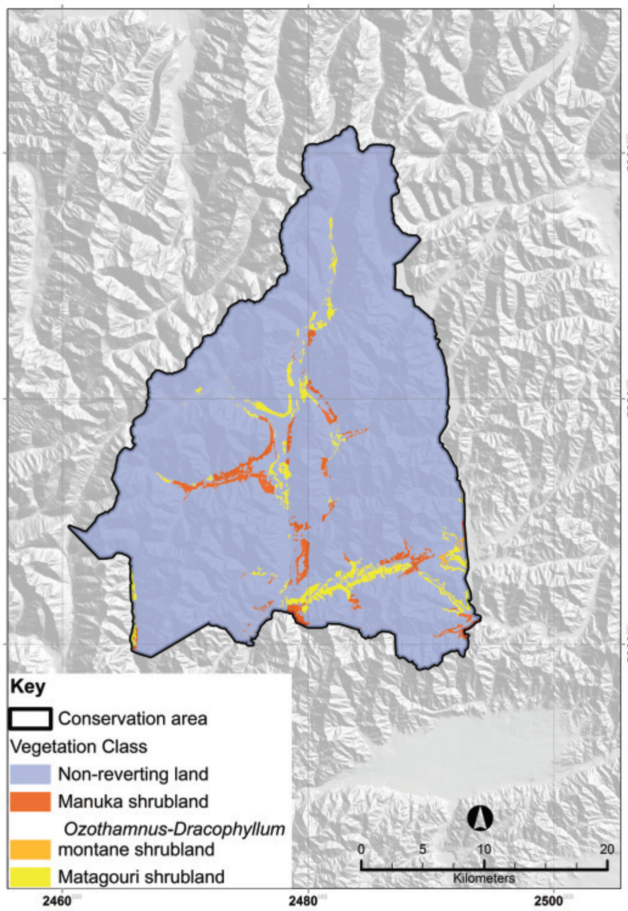

FIGURE 7 Vegetative communities for the areas classed as 'regenerating' within the St James Conservation Area, i.e., those below 900 m elevation. Note that the Wiser et al. (Wiser et al. 2011; Wiser and De Cáceres 2013) vegetation classes have been used to classify the regenerating areas.

present, but cannot be used to estimate sequestration as they have not yet been remeasured.

A map of current vegetation cover is presented in Figure 6. Much of the wide grass-covered alluvial terraces at St James have little or no woody component and can extend for several hundred metres from any forest margin or seed source. The most extensive of these grassy flats fall into the 'frost flat' category and so were excluded as potential forest land. A unique feature of St James is the matagouri forest or woodland. On lower hill slopes and alluvial fans in the Waiau River catchment matagouri forms extensive woodlands that can exceed 5 metres in height. This matagouri shrubland was observed to succeed into both mānuka forest and beech forest and has been included here as a vegetation class with associated sequestration estimates.

Sequestration rates of communities reverting to forest

Few data are available for quantifying sequestration rates across a range of reverting shrubland types, both at national and regional scale (Carswell et al. 2009). But modelling approaches can be used to provide estimates. For this purpose, the modelled sequestration rates from Holdaway et al. (2010) were applied to each of the Wiser et al. (2011) vegetation types identified as reverting to forest. Those sequestration rates are based on plot-level estimates of current carbon stock (derived from LUCAS data) and modelled estimates of potential carbon stock in the absence of anthropogenic disturbance (Holdaway et al. 2010; Mason et al. 2012). Notable assumptions that underlie these estimates are that (1) it takes an average of 400 years for mature forests to develop from bare land, (2) there will be no ongoing effects of anthropogenic disturbance, and (3) there is no dispersal limitation on seedling establishment.

These sequestration-rate estimates are based on an unbiased sample of natural communities with varied tree densities and successional stages and so are thought to reflect the average sequestration rate for each community type under 'optimal' conditions (Holdaway et al. 2010). Thus some areas within each community will be experiencing higher or lower sequestration rates depending on site quality, plant species composition and successional stage.

Land that was not forest at 1990 but had the potential to revert to forest cover ('Regenerating') was divided into:

- Land regenerating to forest that has potential to sequester ≥ 3 t CO_2-eq ha^{-1} year^{1} = Manuka shrubland (c. 2,200 ha)
- Land regenerating to forest that will sequester < 3 t CO_2-eq ha^{-1} year^{-1} (*Ozothamnus-Dracophyllum* montane shrubland and Matagouri shrubland).

Sequestration estimates were based on current or potential vegetation supported across St James. We mapped the vegetation present, or potentially present based on adjacent vegetation types, at each site and used modelled estimates of potential sequestration rates for each vegetation type, as described below, to identify areas likely to sequester ≥ 3 t CO_2-eq ha^{-1} year^{-1}.

Figure 7 depicts each regenerating community type, but in effect, many of the communities will develop into later-successional vegetation types over time (Wiser and Hurst 2010). For example, mānuka forest at St James may eventually become beech forest. Due to the shape of the sequestration curves, rates of sequestration are likely to increase during the early stages of succession (as trees become established and tree density increases), remain high for a number of years (e.g. 50–100 years), and then gradually decline as the forest reaches maturity. Much of the cover in St James is within the early stages of the sequestration curve.

CULTURAL AND RECREATIONAL SERVICES

Studies across ecology, biology, psychology and psychiatry have empirically examined the human relationship with the natural world, some concluding that as well as being totally dependent on nature for material needs (food, water, shelter, etc.) humans also need nature for psychological, emotional and spiritual needs (St Leger 2003). In a review of research about organised wilderness experiences Barton et al. (2009) found that both mental and physical health benefits were accrued from wilderness areas, improving personal and interpersonal skills and overall quality of life for the participants who had experienced camping, tramping or outdoor survival courses.

St James provides a range of recreational opportunities including tramping (huts are provided), mountain biking, horse riding, mountaineering, some four-wheel driving and motor biking, kayaking/rafting, hunting, fishing, and skiing (DOC 2009). These opportunitites together with the heritage, spiritual, aesthetic, inspirational and knowledge creation values of this area can be understood as the cultural and recreation services provided by places such as St James (Tengberg et al. 2012). Most efforts internationally to value and protect ecosystem services have concluded that more research is needed on developing non-monetary methods for valuing cultural ecosystem services (Daily et al 2009). To date little work has been done to assess the value of these services for St James. Given that public access to St James has increased since the purchase of St James and that much work has been done to improve recreational facilities such as the mountain bike tracks, it can be reasonably expected that recreational and cultural services will have increased.

VITAL SITES AND ACTIONS MODEL

The Vital Sites and Actions (VSA) Model has been developed and demonstrated for regional and national prioritisation of conservation action, and reporting on conservation achievement (Overton et al. 2010). A recent study provides an example of how the 'Environmental Representation and Native Dominance' strand of the VSA Model can be used to assess biodiversity gain from afforestation in the Manawatu River catchment (Mason et al. 2012).

The framework operationalises the concept of 'ecological integrity', defined by Lee et al. (2005) as 'the full potential of indigenous biotic and abiotic factors, and natural processes, functioning in sustainable communities, habitats, and landscapes', which was adopted by the New Zealand Department of Conservation as its primary biodiversity outcome (DOC 2011). Lee et al. (2005) suggested ecological integrity is demonstrated through long-term indigenous dominance (high influence of indigenous species on ecosystem processes compared with non-native species), occupancy by all appropriate biota, and full representation of ecosystems (environmental representation). Here we use the VSA framework to quantify the current ecological integrity of St James. This framework could be used to assess a variety of management actions and the difference made by those actions to biodiversity. Future research using VSA could concentrate on whether weed invasion should be actively managed, versus more intensive pest control, etc. Conservation actions such as natural regeneration of tall forest, and the services that might be enhanced as a result, would need to be considered alongside the potential trade-offs to other ecosystem services, if St James is truly to be managed for 'ecosystem services' in general.

VSA measures conservation actions by their contribution to national (or regional) ecological integrity. As defined by Lee et al. (2005), 'ecological integrity' has three components:

1. Species occupancy, or the extent to which species inhabit their natural ranges
2. Environmental representation, or the extent to which all ecosystems remain
3. Indigenous dominance, reflecting the extent to which species composition, biomass and ecosystem processes are dominated by native species.

VSA uses two computational strands to address these three components. Several parallel outputs are produced for each strand, including *naturalness*, *significance* and *priority*. The definitions of each have slight differences under the two strands and are discussed below.

The **species occupancy (SO) strand** of VSA addresses the first component of ecological integrity, and looks at conservation actions relative to their contribution to the maintenance of national species occupancy. A number of outputs from this strand include:

- *Naturalness*: The naturalness of species occupancy is presented as a map that shows, for each pixel, the proportion of original species that remain in that pixel.
- *Significance*: This map gives the rank of each pixel for its contribution to national ecological integrity in the SO strand.
- *Priority sites* for species conservation management. This output combines significance and vulnerability to identify pixels for which urgent conservation action will avert the most loss of species' ecological integrity.

The **environmental representation and native dominance (ERND)** strand of VSA addresses the second two components of ecological integrity together, and results in a number of outputs that accord with those from the SO strand:

- *Naturalness*: Estimated native dominance of vegetation. High values indicate undisturbed native vegetation cover.
- *Significance*: This map ranks each pixel for its contribution to regional or national environmental representation and native dominance.
- *Priority*: Priority sites for protection or conservation action. This output combines significance and vulnerability to identify pixels for which urgent conservation action will avert the most loss of ERND ecological integrity.

The two strands are reported separately below, although VSA does provide combined outputs.

In viewing these outputs, it is important to note that VSA is designed primarily for national- or regional-scale – rather than property-scale – analyses. The major strengths of VSA are the ability to consider the mix of conservation actions across a large area, and to estimate the regional or national contribution to ecological integrity of different actions. Still, it is of interest to consider the application of VSA to a smaller scale, as is done here. Finally, outputs should be considered relative to the current input data. Species or environments that are not represented in the input data will not be able to influence the outputs. Ongoing improvement of the input data will enhance the predictions of VSA.

The VSA model holds a wide range of inventory information on the current and past biodiversity of St James, and the pressures (e.g. plant and animal pests) on biodiversity. This can form the basis for any conservation assessment, and can be supplemented with more taxonomically or geographically specific surveys. Below we provide a range of high level outputs from VSA.

Species Occupancy (SO) strand

The current underlying data for the SO strand in VSA include almost 100 native taxa (species or subspecies) and 33 species of animal pests and 20 species of weeds. The input data do not include a number of species present at St James that would be expected to contribute to the significance of sites within the conservation area. Of particular importance to national species occupancy are those species that are of limited or greatly reduced distributions, especially those for which St James comprises a significant portion of their range. First, we consider the results of the current species in the model. Species that might be expected to have high contribution to regional or national ecological integrity are then discussed.

The **estimated species naturalness** for St James is shown in Figure 8. In general, forested areas on the western side have greater naturalness. **Species significance** for St James and the surrounding areas is shown in Figure 9. Species significance is relatively low (less than 80th national percentile) for all of St James. Species priority for St James and the surrounding areas is shown in Figure 10. Species priority is even lower than species significance (less than 70th national percentile) for St James. Since species priority includes both significance and vulnerability this suggests that St James has lower vulnerabilities than the national average, at least for the native species that contribute most to significance. Figure 11 shows the **highest priority taxa** for each part of St James. Note that this map shows the highest priority taxa, but these priorities are quite low overall, as seen in Figure 10. For upper elevational areas, the most important species is rock wren. Mistletoes and a range of other plant species are the highest priority species in lower elevational areas. The importance of morepork is interesting. This results from the high predicted vulnerability of moreporks nationally (and at St James), as predicted by VSA.

In addition to the species included in the VSA data and represented in the outputs above, other species of particular importance identified by the St James tenure review report (DOC 1998) and information from a DOC botanist (N. Head, pers. comm.) are discussed below. While these species could be added to the VSA data, this would give a skewed representation of the national importance of St James to national ecological integrity.

DOC (1998) indicate the presence of the long-toed skink, which in this area will be *Oligosoma longipes* (R. Hitchmough, pers. comm.), which was first recognised in the upper Clarence Valley and is still resident in the mid-Clarence Valley. The species is listed as nationally vulnerable (Hitchmough et al. 2013) and is largely limited to South Marlborough.

There are three threatened plant species listed by DOC (1998), revised here to species and threat categories listed by de Lange et al. (2009). One (*Peraxilla tetrapetala*) (declining) is included in the VSA data. *Leonohebe cupressoides* (nationally endangered) has been found in the Henry River near the walkway swingbridge and in the Boyle midway between the Boyle and Rokeby huts and has a very patchy eastern South Island high country distribution from Marlborough to Otago. *Pittosporum patulum* (nationally critical) has been recorded from four sites in St James (Horrible Stream, Lake Guyon, the base of Malings Pass and the Williams Valley) and is very patchily distributed in North Canterbury; most occurrences are only juveniles.

Environmental Representation and Native Dominance strand

The current data for the Environmental Representation and Native Dominance (ERND) strand use LENZ (Land Environments of New Zealand; Leathwick et al. 2002) as an environmental (ecosystem) classification, and LCDB2 (Land Cover Database version 2 Ministry for the Environment 2009) and a potential vegetation map of New Zealand to interpret current vegetation. See Overton et al. (2010) for details.

The **ERND naturalness** for St James (Figure 12) shows largely natural areas at upper elevations, but much lower naturalness at lower elevations. ERND naturalness is overall higher for St James than is SO naturalness (Figure 8).

ERND naturalness (Figure 12) shows considerable areas above the 80th national percentile, and some areas in the top 0.5% nationally, which contrasts to species significance in St James (Figure 13). But some high values of ERND significance in St James are not surprising, given the low levels of representation in dryland areas of New Zealand.

The **ERND priorities** show a strong effect of the boundary of St James. This is because the input data to VSA do not include St James in the conservation protected areas. Therefore, St James is shown to be at relatively high vulnerability to biodiversity loss. A rough estimate of the benefits of protecting St James can be achieved by overlaying Figures 13 and 14.

Figure 15 shows details of the areas indicated as being of the **highest ERND significance nationally.** It is noteworthy that areas of high ERND significance are concentrated around riparian habitats, especially given that most riparian vegetation (especially east of the Main Divide in both islands) has been removed.

Special habitats

DOC (1998) lists a number of specific types of forest, shrubland, tussockland and wetland, but does not provide an assessment of the national significance of each type. Since these vegetation types are not contained in the Vital Sites information, the current data does not allow for assessment of their significance. However, if a nationally consistent classification of ecosystems (such as that used for the DOC ecosystem prioritisation work), was mapped for all of New Zealand, then a Vital Sites approach could incorporate that information to assess the national significance of areas within St James.

DISCUSSION

We summarise the likely impacts of tenure change (from farming to recreation and conservation) on ecosystem services provision in St James in Table 3. St James spans relatively large environmental gradients of elevation and rainfall, driving huge variation in water yield and soil erosion or sediment retained (Figures 2, 4 and 5). Past land use was extensive pastoralism on c. 1–2% of the land, and as a result, nitrogen leaching is very low and water quality generally high (Figure 3); the sole exception to this was elevated faecal coliform counts at the outlet of Lake Guyon and in lower reaches of the Clarence River. Provision of clean water is particularly relevant in the context of intensive land management within the plains downstream from the property. We note, however, that the superior water yield of pasture cover compared with shrubland or forest may represent a major trade-off between biodiversity and water provision, should natural regeneration be favoured/encouraged. It should also be noted that although the removal of light grazing makes little difference to greenhouse gas emission or nitrate leaching, we cannot be certain

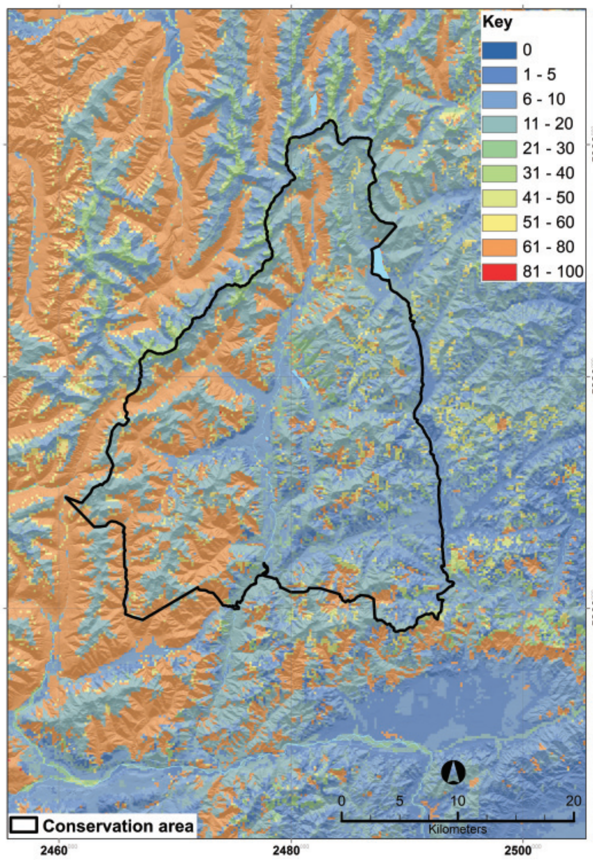

FIGURE 8 Species naturalness as predicted by the Vital Sites and Actions model. Note that the higher the number, the greater the proportion of original species in a given pixel.

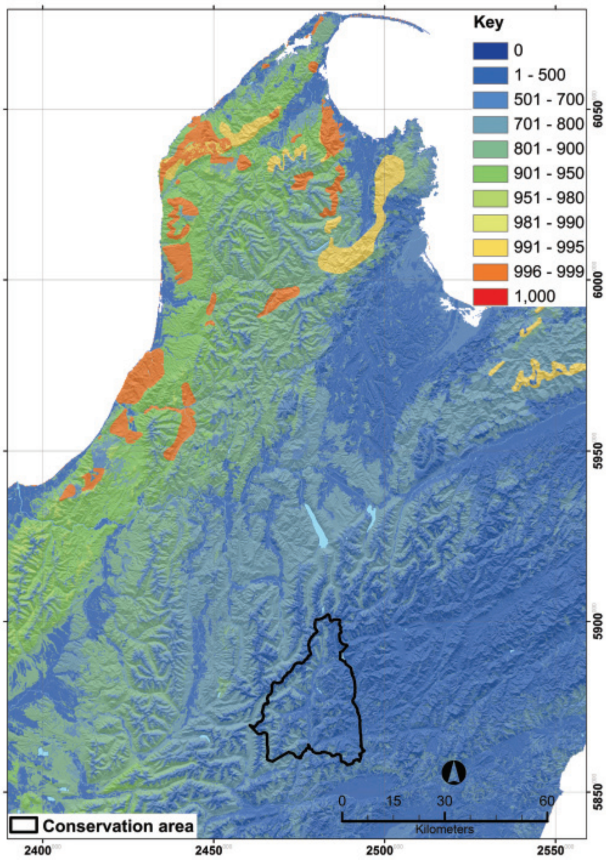

FIGURE 9 Species significance for St James Conservation Area and surrounding areas. Note that the colour ramp is non-linear. This figure places St James within the context of the species signficance for the rest of the upper South Island. The higher the number, the greater the species' contribution to environmental representation and native dominance.

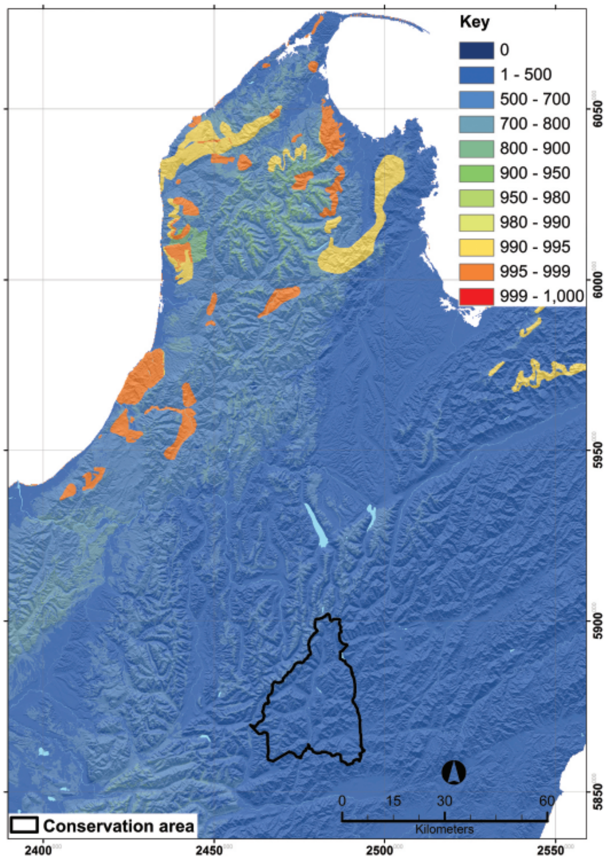

FIGURE 10 Species priorities for St James Conservation Area and surrounding areas. The St James area has low overall national ranking for species priority. This figure places St James within the context of the species priorities within the rest of the upper South Island. Areas of high national priority ranking resulting from endangered birds and snails are visible to the north and west.

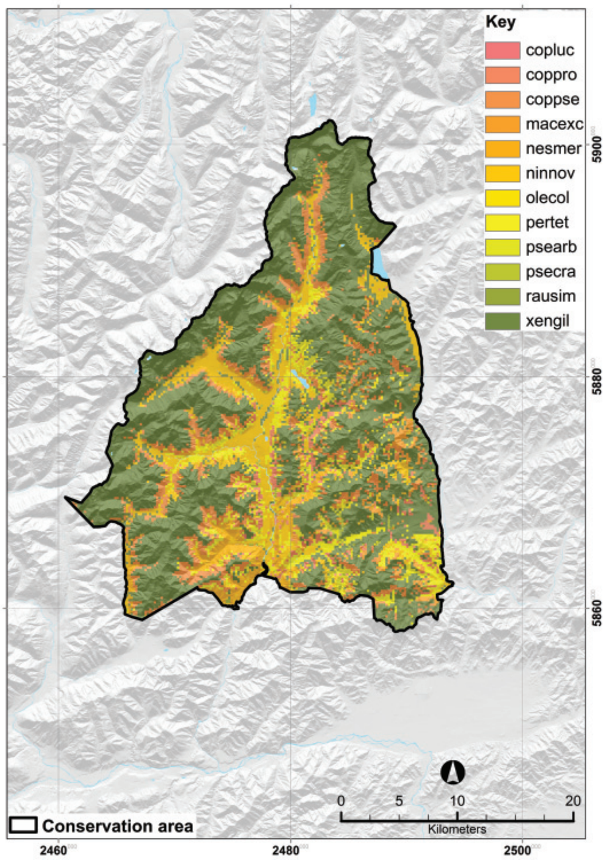

FIGURE 11 Highest priority taxa. A full list of species abbreviations is given in Appendix 1 but the highest priority taxa are *Coprosma lucida* (copluc), *Coprosma propinqua* (coppro), *Coprosma pseudocuneata* (coppse) and *Macropiper excelsum* (macexc).

TABLE 3 Ecosystem services provided by St James Conservation Area and their likely direction of change with conservation management.

Type of service	Service (or Stock)	Impact of becoming conservation land	Comments
Regulating	Water flow	↘	Natural regeneration will decrease water yield
	Climate	↗	Increase in carbon sequestration
	Erosion control	↗	Increase in sediment retention with tree cover
Provisioning	Clean water	↗	Water quality is already high but coliforms likely to disappear
	Habitat provision	→	Naturalness reasonably high and likely to stay the same
	Food	→	Increase in wild food but decrease in dairy and sheep and beef
Cultural	Recreation	↗	Increase in recreation value
Natural capital	Biodiversity (stock not service)	→	Good representation of indigenous biodiversity already

that habitat provision and biodiversity were in a steady state – tenure change should at least ensure that these values are not declining (Table 3). Carbon sequestration is possible in central and eastern areas of St James, but the total area that is eligible for claiming carbon credits and is sequestering carbon during succession at a rate > 3 t CO_2-eq ha^{-1} year^{-1} is relatively small (Figure 7). Thus, the potential for carbon sequestration (using indigenous vegetation) is relatively limited in St James. Some tools for quantifying the spatial trade-offs among carbon, diversity and water quality and quantity have recently been developed by Mason et al. (2012) and Dymond et al. (2012), and these methods could be applied to St James when planning conservation actions.

Despite the large environmental gradients found within St. James, there are relatively few areas of high, unique plant diversity, and these comprise primarily the wetlands south of Lake Tennyson. The estimated species naturalness is high (Figure 8) and the vulnerability of native species is relatively low (Figures 9 and 10). What this suggests is that much of the indigenous biodiversity at St James is in relatively good shape, but is generally well represented elsewhere in New Zealand. The most distinct, or nationally significant, environments on St James comprise riparian areas along the Clarence and Waiau rivers (top 1% of ERND nationally; Figure 15). This is because little intact riparian vegetation remains east of the Main Divide.

In this context, how can 'ecosystem services' best serve St James? It is clear that significant ecosystem services are provided, but the evidence suggests that additional conservation management can do little to enhance the level of service provision. Rather, trade-offs will occur between the natural process of natural forest regeneration and water yield as required for provisioning services such as dairy and sheep farming downstream. While some authors fear that the 'market environmentalism' associated with ecosystem 'services' may be counterproductive for biodiversity conservation (especially longer term) and equity of access to ecosystem services benefits, they also acknowledge that traditional conservation practices have not halted the decline in natural ecosystems (Gómez-Baggethun and Luis-Pérez 2011). The appeal of an ecosystem services approach is the pragmatic development of integrated solutions to the problem of understanding the nature and scale of ecosystem degradation plus an underpinning belief in the value of the maintenance and enhancement of ecosystem services (Potschin and Haines-Young 2011).

For an ecosystem services framework to achieve its full potential, further research is required on both monetary and non-monetary valuation methods. Current theoretical and empirical research on economic valuation suggests that preferences for environmental goods and services depend on a variety of cultural and psychological characteristics that vary from individual to individual, and from culture to culture (Parks and Gowdy 2013). These authors suggest that environmental valuation now requires the recognition of the social nature of preferences, and acceptance that individuals seldom act in accordance with the 'rational actor' predictions required by the current methods of economic valuation. Possible approaches for assessing monetary value of the St James recreation and cultural services would be to undertake contingent valuation or deliberative monetary valuation (Portney 1995; O'Hara 2006; Parks and Gowdy 2013). Contingent valuation, also known as 'willingness to pay' surveys, requires strict adherence to best practice guidelines to overcome inherent difficulties in eliciting accurate economic values through survey methods (Arrow et al. 1993). Deliberative monetary evaluation has arisen in response to this criticism.

Deliberative evaluation discusses an issue (such as the value of biodiversity) in focus groups before the group attempts monetary valuation (Szabo 2011). Deliberative evaluation goes beyond contingent valuation in that it can additionally include participants who believe landscapes should be maintained/enhanced because of intrinsic values and not direct utility value (Szabo 2011). Other researchers suggest that the ascription of value to biodiversity conservation is in itself anthropocentric. Humans derive pleasure from knowing that biodiversity is being conserved, but this act may create social inequities especially where the benefits are derived globally, while the costs (of exclusion/lack of use) occur at local scale, and often in poor communities (Adams et al. 2010; Kari and Korhonen-Kurki 2013). One potential solution is to broaden the debate from the economic valuation of ecosystem outputs to conservation governance and place-based or contextual knowledge in order to aid application, and increase the social legitimacy, of the ecosystem services paradigm (Potschin and Haines-Young, 2011). Parks and Gowdy (2013) agree that improved structures for communal resource governance should sit alongside improved methods of monetary and non-monetary valuation.

The Ministry of Business, Innovation and Employment has taken some steps in this direction. The Ministry conducted a recent online survey and called for public opinion on the nation's largest science challenges (http://www.thegreatnzscienceproject.co.nz/). The public ranked Protecting New Zealand's Biodiversity second only to Fighting Disease. The Director-General of the Department of Conservation also signals the importance of conservation in delivering the full set of values for sustainability, namely economic and social as well as environmental (Morrison 2008). He describes how conservation protects the natural capital that is critical to sustainable development and economic growth.

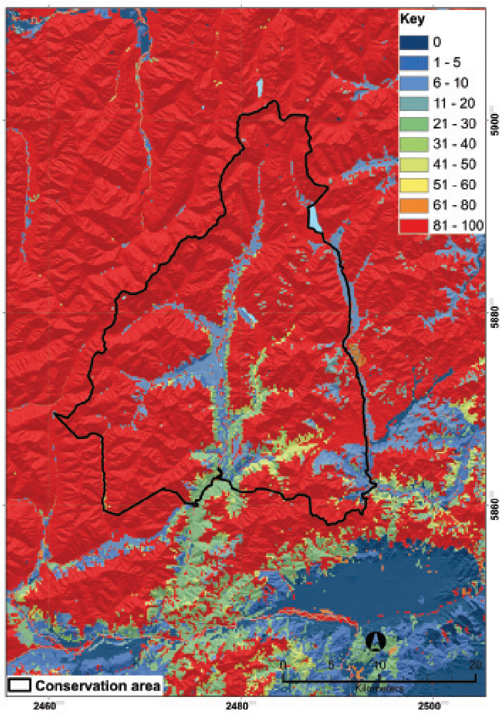

FIGURE 12 Environmental-Representation-and-Native-Dominance (ERND) naturalness for the St James Conservation Area and surrounding areas. The ERND naturalness scale is unit-less (Overton et al. 2010), but red areas indicate a high degree of naturalness.

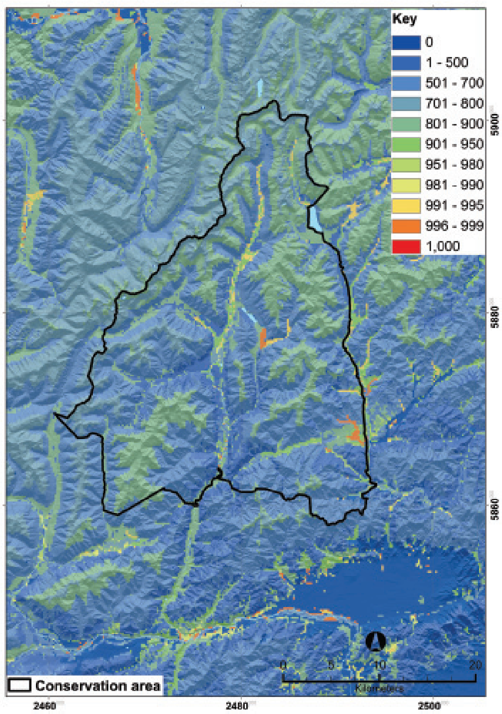

FIGURE 13 Environmental-Representation-and-Native-Dominance (ERND) significance for St James Conservation Area and surrounding areas. The more significant areas are at higher elevation and near Lake Guyon and Stanley River. This figure specifically places St James within the context of the ERND signficance for the rest of the upper South Island.

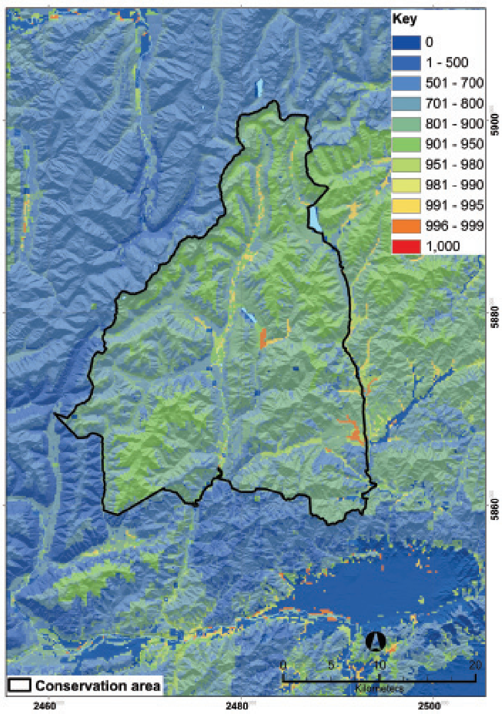

FIGURE 14 Environmental-Representation-and-Native-Dominance (ERND) priorities for St James Conservation Area and surrounding areas. The ERND priorities scale is unit-less (Overton et al. 2010).

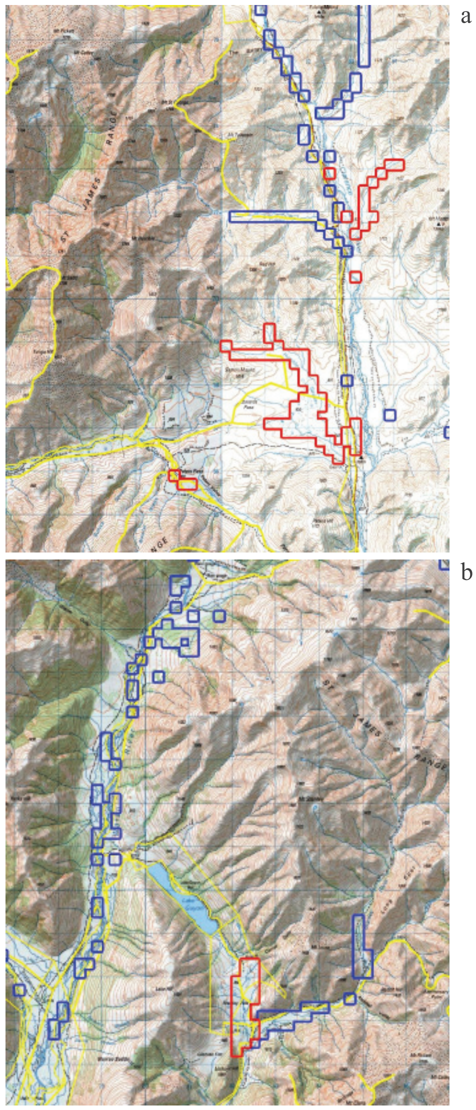

FIGURE 15 (right) Details of areas of very high national Environmental-Representation-and-Native-Dominance (ERND) significance. Area bounded in blue or red includes the top 1% ERND significance nationally, while the red shows the area of the top 0.5%. St James Conservation Area internal and external boundaries are shown in yellow. (a) Area along Clarence River and Horrible Stream; (b) areas along Waiau and Clarence rivers.

It appears as if the New Zealand public are ready to participate in the debate and that the thousands of users of St James would already support its value in providing a broad range of benefits from biodiversity to natural space and reinforcement of a sense of identity. Intrinsic benefit accrued from a particular place has been described by Sale (2001) as 'love of home', using the spanish word 'querencia' which means:

> "the deep sense of inner well-being that comes from knowing a particular place on the Earth; its daily and seasonal patterns, its fruits and scents, its soils and bird-songs. A place where, whenever you return to it, your soul releases an inner sigh of recognition and realisation" (Sale 2001, p. 44).

The majority of these values cannot be priced, but we argue that New Zealanders are nonetheless extracting a considerable degree of 'service' from their provision.

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APPENDIX – NATIVE SPECIES LIST

List of native species in the input data for the species occupancy strand of VSA.

Scientific name	Acronym	Common name
Anarhynchus frontalis	ANAFRO	Wrybill
Anas chlorotis	ANACHL	Brown teal
Apteryx australis 'Haast'	APTAUS	Haast tokoeka
Apteryx australis 'North Fiordland'	APTAUS	Southern tokoeka – North Fiordland
Apteryx australis 'South Fiordland'	APTAUS	Southern tokoeka – South Fiordland
Apteryx australis 'Stewart Island'	APTAUS	Southern tokoeka – Stewart Island
Apteryx haastii	APTHAA	Greater spotted kiwi
Apteryx mantelli	APTMAN	North Island brown kiwi
Apteryx mantelli 'Okarito'	APTMAN	Rowi or little brown, Okarito kiwi
Apteryx owenii	APTOWE	Little spotted kiwi
Aristotelia serrata	ARISER	Wineberry
Austrofestuca littoralis	AUSLIT	Sand tussock
Brachyglottis repanda	BRAREP	Rangiora
Callaeas cinerea	CALCIN	Kōkako
Carpodetus serratus	CARSER	Marble leaf/putaputaweta
Coprosma foetidissima	COPFOE	Hūpiro/stinkwood
Coprosma grandifolia	COPGRA	Kanono
Coprosma lucida	COPLUC	Shining coprosma
Coprosma propinqua	COPPRO	Mingimingi
Coprosma pseudocuneata	COPPSE	
Coprosma rotundifolia	COPROT	
Coprosma tenuifolia	COPTEN	
Cyclodina aenea	CYCAEN	Copper skink
Cyclodina ornata	CYCORN	Ornate skink
Dactylanthus taylorii	DACTAY	Dactylanthus
Desmoschoenus spiralis	DESSPI	Pingao
Dysoxylum spectabile	DYSSPE	Kohekohe
Elaeocarpus dentatus	ELADEN	Hīnau
Fuchsia excorticata	FUCEXC	Tree fuchsia
Griselinea litoralis	GRILIT	Broadleaf
Griselinea lucida	GRILUC	Shining broadleaf
Hedycarya arborea	HEDARB	Pigeonwood/porakaiwihiri
Kunzea ericoides	KUNERI	Kānuka/tea tree
Latrodectus katipo	LATKAT	Katipō
Leiopelma hochstetteri	LEIHOC	Hochstetter's frog
Leptospermum scoparium	LEPSCO	Mānuka/tea tree
Macropiper excelsum	MACEXC	Kawakawa
Melicope simplex	MELSIM	Poataniwha
Melicytus ramiflorus	MELRAM	Māhoe/whiteywood
Metrosideros umbellata	METUMB	Southern rātā/ironwood
Mohoua ochrocephala	MOHOCH	Mohua
Muehlenbeckia astonii	MUEAST	Shrubby toraro
Myrsine australis	MYRAUS	Māpau/matipou
Myrsine divaricata	MYRDIV	
Myrsine salicina	MYRSAL	Toro
Mystacina tuberculata	MYSTUB	Short-tailed bat
Neomyrtus pedunculata	NEOPED	Rōhutu

Scientific name	Acronym	Common name
Nestor meridionalis	NESMER	Kākā
Ninox novaeseelandiae	NINNOV	Morepork
Olearia arborescens	OLEARB	
Olearia avicenniifolia ‘White Confusion’	OLEAVI	
Olearia colensoi	OLECOL	Tupare
Olearia ilicifolia	OLEILI	Mountain holly
Peraxilla tetrapetala	PERTET	Mistletoe
Podocarpus nivalis	PODNIV	Mountain tōtara
Powelliphanta ‘Parapara’	POW’PA	
Powelliphanta annectens	POWANN	
Powelliphanta gilliesi aurea		
Powelliphanta gilliesi compta		
Powelliphanta gilliesi fallax		
Powelliphanta gilliesi gilliesi		
Powelliphanta gilliesi jamesoni		
Powelliphanta gilliesi kahurangica		
Powelliphanta gilliesi montana		
Powelliphanta gilliesi subfusca		
Powelliphanta hochstetteri anatokiensis		
Powelliphanta hochstetteri bicolor		
Powelliphanta hochstetteri consobrina		
Powelliphanta hochstetteri hochstetteri		
Powelliphanta hochstetteri obscura		
Powelliphanta lignaria johnstoni		
Powelliphanta lignaria lignaria		
Powelliphanta lignaria lusca		
Powelliphanta lignaria oconnori		
Powelliphanta lignaria rotella		
Powelliphanta lignaria ruforadiata		
Powelliphanta lignaria unicolorata		
Powelliphanta patrickensis	POWPAT	
Powelliphanta superba ‘Gunner River’	POWSUP	
Powelliphanta superba harveyi		
Powelliphanta superba mouatae		
Powelliphanta superba prouseorum		
Powelliphanta superba richardsoni		
Powelliphanta superba superba		
Pseudopanax arborea	PSEARB	Five-finger
Pseudopanax crassifolius	PSECRA	Lancewood
Pseudopanax linearis	PSELIN	
Pseudowintera colorata	PSECOL	Pepper tree/horopito
Raukaua simplex	RAUSIM	
Schefflera digitata	SCHDIG	Seven-finger
Sphenodon species	SPHSPE	Tuatara
Weinmannia racemosa	WEIRAC	Kāmahi
Xenicus gilviventris	XENGIL	Rockwren