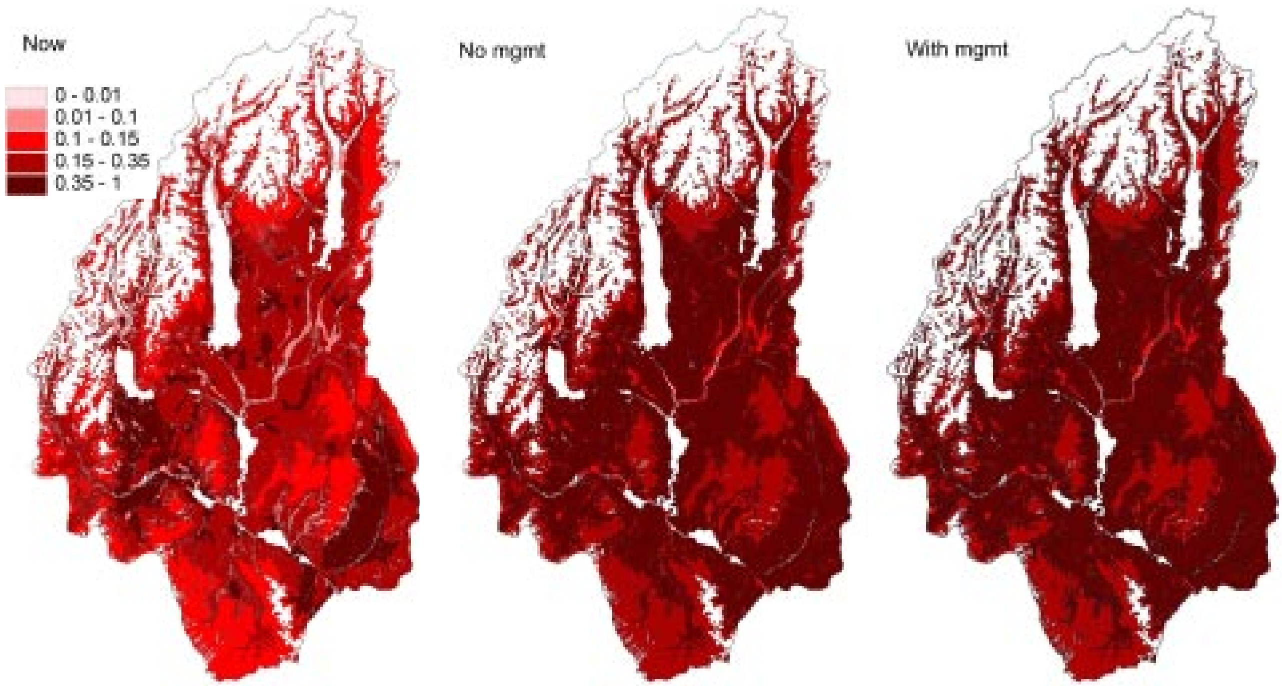


Figure 40. Pasture grass cover index.

8.4.1 Infestation pressure

The infestation pressure index is based on explicit definition of the amount of space left for natural native biota after the cover of each plant pest has been accounted for. The index assumes that much of the space made vacant by the control of only one of several competing weeds will tend to be occupied by the other weeds, not native biota. Major gains for native biota occur when all the weeds competing for space in a particular environment are controlled, thereby allowing less aggressive native species to occupy this space. The index allows for overlapping weed cover in several tiers to total more than 100%:

Space left = $(1 - \text{cover}_{\text{weed 1}}) \times (1 - \text{Cover}_{\text{weed 2}}) \times (1 - \text{Cover}_{\text{weed 3}})$

Competition pressure = 1 – Space left

The model states that the greatest gains will be made with removal of the last weed.

Infestation pressure (Fig. 41) is currently least in lakes and mountain ranges and most where agriculture is intensive on private land and Crown land not managed for conservation (Table 2). Without weed control, infestation pressure will increase everywhere except above 2000 m, in the lakes and on land primarily used for pastoral grazing. Much of this increase can be attributed to the spread of wilding pines over tussock, scrub and bare ground. Average infestation pressure over the Twizel study area will rise from 0.310 to 0.794 without any weed control. With planned and currently funded weed control projects (wilding pines not included in the RPMS), the low level of infestation pressure will be maintained in the mountains but not in the vicinity of the McKenzie Basin, Ahuriri River and Omarama Basin. Average infestation pressure for the whole area will rise to 0.691, suggesting that the current weed control programme is nowhere near sufficient to halt the losses caused by weed

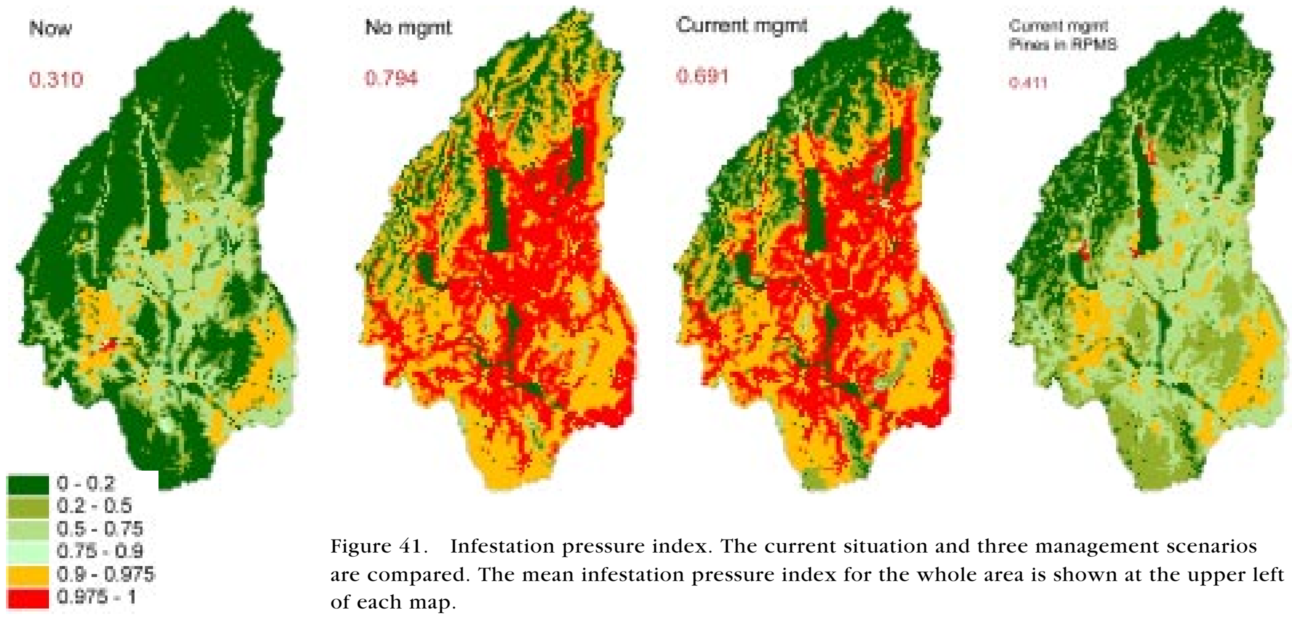


Figure 41. Infestation pressure index. The current situation and three management scenarios are compared. The mean infestation pressure index for the whole area is shown at the upper left of each map.

TABLE 2. AVERAGE INFESTATION PRESSURE BY LAND TENURE FOR FOUR MANAGEMENT SCENARIOS.

MANAGEMENT SCENARIOS	CONSERVATION LAND	OTHER CROWN LAND	PRIVATE LAND	WHOLE AREA
Current situation	0.083	0.180	0.463	0.310
No management	0.571	0.812	0.879	0.794
Current projects (no RPMS)	0.130	0.809	0.874	0.691
Current projects with pines in RPMS	0.130	0.279	0.588	0.411

invasion. If wilding pines become a RPMS weed, the average infestation pressure for the area will be 0.411, still a significant increase on the present situation.

8.5 HUMAN-INDUCED DISTURBANCE PRESSURE

Pressure is defined here by the multiplicative combination of the four indices for biota removal: resource modification, consumption and infestation pressure. It does not include fragmentation (i.e. connectivity and edge effects). Ideally, the pressure index would include fragmentation pressure. However, while we were able to develop a model to account for the effects of fragmentation (Section 8.5.1 below), we had no basis for scaling its parameters and we were unable to devise a sufficiently rapid calculation process for practical estimation of the impacts of different projects and project combinations on fragmentation.

The level of pressure is influenced by the current management regime. Several management regimes (including no management) are discussed. The various

TABLE 3. PROJECTS AND SCENARIOS. These project codes are used from this point onwards to refer to the project or scenario (i.e. a combination of projects) under discussion. 'Years to Outcome' is the number of years until the 'with management situation' is attained. Two values are given where alternative project designs (with different cost and risk profiles) have been defined to deliver the same outcome over a different timeframe. Project codes and Years to Outcome values in bold indicate those that are currently underway and collectively constitute 'current management'.

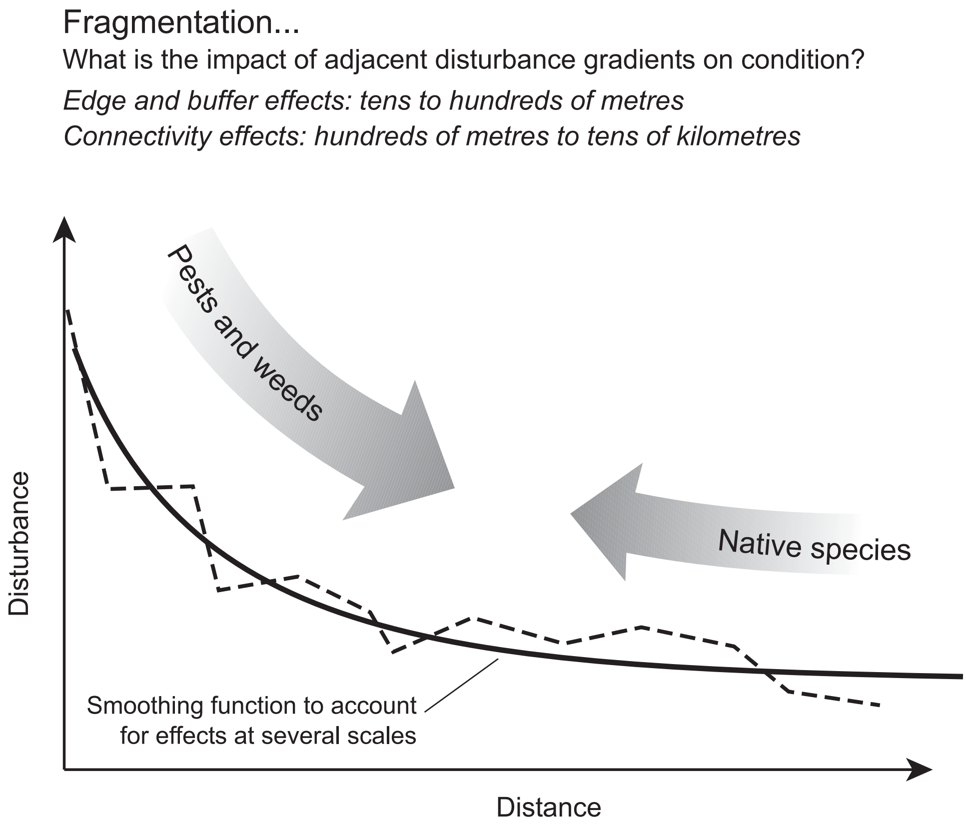
PROJECT CODE	PROJECT DESCRIPTION AND SCENARIO COMPOSITION	YEARS TO OUTCOME
Bennetts	Bennetts wallaby control	**1**
Broom50	Broom control (a component of PRR)	10/**50**
Cat	Cat control (a component of BStilt)	**1**
Cat1	Cat control (a component of BStilt1)	1
Ferret	Ferret control (a component of BStilt)	**1**
Ferret1	Ferret control (a component of BStilt1)	1
Gorse	Gorse control (a component of PRR)	10/**50**
Hedge	Hedgehog control (a component of BStilt)	**1**
Hedge1	Hedgehog control (a component of BStilt1)	1
Pig	Pig control	**1**
PineDOC	Pine control on Conservation land only	7/**50**
PineRPMS	Get wilding pines in RPMS; control on conservation land	7/50
Rabbit	Rabbit control	**1**
Rlupin	Russell lupin control (a component of PRR)	10/**50**
Stoat	Stoat control (a component of Bstilt)	**1**
Stoat1	Stoat control (a component of Bstilt1)	1
StockCL	Stock fencing on all conservation land	5
StockSQ	Maintain existing stock fences	**1**
StockTR	Stock fencing on all Crown land	5
Thar	Thar control	**1**
Willow	Willow control (a component of PRR)	10/**50**
Ylupin	Yellow tree lupin control (a component of PRR)	**2**
PRR	Project River Recovery: Broom, Gorse, Rlupin, Ylupin & Willow	9.7/**48**
BStilt	Black Stilt protection: Cat, Ferret, Hedge & Stoat	**1**
BStilt1	Extended Black Stilt protection: Cat1, Ferret1, Hedge1 & Stoat1	1
PRRBS	PRR & BStilt	38
PRRBS1	PRR & BStilt1	38
CMan	Bennetts, PRR, BStilt, Pig, PineDoC, Rabbit, StockSQ, Thar	5.4/**35**
MoreMan	Bennetts, PRR, BStilt1, Pig, PineRPMS, Rabbit, StockCL, Thar	5.4/35

projects considered in this study are listed in Table 3. Current management comprises:

- thar control
- Bennett's wallaby control
- pig control
- stock fence maintenance
- riverbed predator control (i.e. stoats, ferrets, cats and hedgehogs)
- Project River Recovery (control of willows, gorse, broom, Russell and yellow tree lupin)
- wilding pine control.

Pressure over the Twizel study area is described in Sections 13.3 and 13.4.

Figure 42. Modelling fragmentation. Pests and weeds flow freely down the disturbance gradient while the native biota struggles against it. Edge, buffer and connectivity effects smoothen local variations in the disturbance surface – but by how much and over what scales?



This completes the natural heritage information required for conservation measurement. Other information (e.g. distinctiveness and importance) is derived from information already assembled, or specified in project design information (e.g. size of control areas, project timeframes, costs and risks). The capture of essential project design information needed for conservation measurement is described in Sections 10.1 to 10.3.

8.5.1 Fragmentation: connectivity and edge effects

Disturbance caused by biota removal, physico-chemical resource alteration, consumption and infestation pressure, cannot be expected to fully account for the pressures on native biota because fragmentation effects further reduce the sustainability of native biodiversity. Fragmentation both reduces connectivity and hence exchange of native biota, and increases edge effects such as invasion opportunity for introduced species. Pests and weeds are conceived to flow down disturbance gradients (edge effects) while the native biota struggle against them (connectivity effects). This model implies that a locally steep disturbance gradient is not a persistent feature; and that edge, buffer and connectivity effects will, over time, smoothen peaks and hollows in the disturbance surface (Fig. 42). Accordingly, connectivity and edge effects could be accounted for by adjusting the disturbance value of each pixel according to the difference in the mean disturbance of adjacent pixels. However, to scale the adjustment appropriately, it is necessary to know something of the impact of adjacent disturbance gradients on point (or pixel) condition. It seems reasonable to assume that the effects of high pressure would penetrate a greater distance than the effects of low pressure, because introduced species are generally more able to invade natural areas than native species are able to invade exotic communities. Thus the impact of the disturbance gradient can be expected to vary with its direction. Some estimate of the impact of adjacent disturbance gradients is needed to appropriately scale the smoothing function, and this is needed if the model is to address trade-offs between few large areas under conservation management versus many small areas.

A 1 km buffer is large in relation to the spatial scale of edge effects. Edge effects are probably better represented by a 50 to 200 m buffer, but this is not possible with 1 km pixel data. Connectivity effects could be accounted for by some larger buffers, perhaps around 2 to 10 km. Thus at least two different buffers with different scaling for effects are required to model the impact of connectivity and edge effects on condition. However, since:

- the calculation is very time consuming
- edge effects cannot be appropriately captured with 1 km^2 pixels
- there is insufficient understanding to scale edge and connectivity effects,

the analyses presented hereafter do not take into account the impact of adjacent disturbance gradients. A smoothing function to account for edge and connectivity effects on pressure (P) is proposed below and the issues associated are indicated.

Edge effects | **Connectivity effects**

$$\text{Corrected pressure} = P_{Pixel} - p_1(P_{Buffer1} - P_{Pixel}) + p_2(P_{Buffer2} - P_{Pixel}) + \ldots$$

How strong is the impact of surrounding pressure? How much (p) of the difference should be smoothed? Should p vary with the direction of the gradient?

How many buffers of what width are needed to account for connectivity effects?

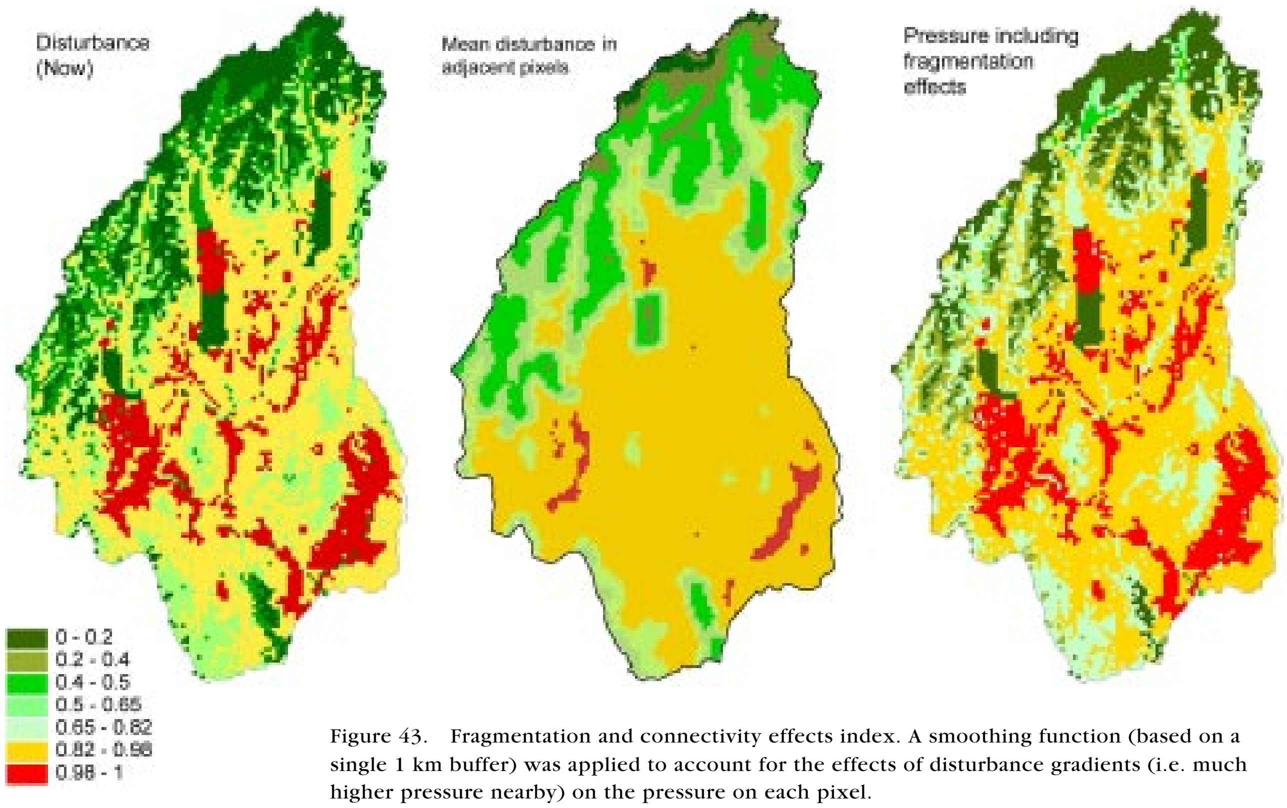


Figure 43. Fragmentation and connectivity effects index. A smoothing function (based on a single 1 km buffer) was applied to account for the effects of disturbance gradients (i.e. much higher pressure nearby) on the pressure on each pixel.

Its application is illustrated (Fig. 43) for a simple case where just a single (1 km) buffer was applied with p = 0.1 for positive gradients (native invasiveness from lower surrounding pressure) and p = 0.3 for negative gradients.

Buffering to account for connectivity and edge effects smoothens steep disturbance gradients. This is most obvious in the St Mary's Range (the southern-most green area) where areas of high pressure are close to areas of low pressure.

9. Importance

The importance index provides a measure of how well each pixel (or land unit) represents what remains of its environment type and so provides a way to identify the best examples of what remains over the whole landscape. Table 4 demonstrates calculation of the importance index for a single large site (Mt Cook National Park).

Conservation management affects site importance by altering pressure at both the site and in environments represented at the site, but management does not necessarily increase the importance of a site. Conservation management will increase a site's importance if pressure within the site is reduced more than in places in the same environments elsewhere. If the management reduces pressure outside the site more than within the site, then the importance of the site will be reduced. Similarly, if a site is more degraded than areas of the same environments outside the site, its importance will also be reduced.

TABLE 4. CALCULATION BY SPREADSHEET OF THE IMPORTANCE INDEX FOR A LARGE SITE IN WHICH NINE ENVIRONMENTAL DOMAINS OCCUR. The importance measure is weighted by the extent of each environment within the site. Env't identifies the environment. Column letters (D to K) identify the data used in calculations. Mean = mean pressure within site; D, Inside area remaining = number of grids in site with pressure ≤ mean pressure; E, Outside area remaining = number of grids outside site with pressure ≤ mean pressure; F, Env't area = number of grids for each Env't Code.

	INPUT DATA					CALCULATIONS				
	MEAN	D	E	F	G	H	I	J	K	
ENV'T CODE		INSIDE AREA REMAINING	OUTSIDE AREA REMAINING	ENV'T AREA	TOTAL AREA REMAINING	D/G	G/F	H^I	D/417	WEIGHTING J*K
5	0.523	59	550	2313	609	0.097	0.263	0.54	0.141	0.077
12	0.354	108	625	1044	733	0.147	0.702	0.26	0.259	0.068
15	0.536	15	0	41	15	1	0.366	1	0.036	0.036
31	0.597	5	4	48	9	0.556	0.188	0.9	0.012	0.011
37	0.75	4	13	228	17	0.235	0.075	0.9	0.01	0.009
45	0.196	162	7	333	169	0.959	0.508	0.98	0.388	0.38
71	0.413	2	0	8	2	1	0.25	1	0.005	0.005
74	0.014	47	0	53	47	1	0.887	1	0.113	0.113
76	0.482	15	11	37	26	0.577	0.703	0.68	0.036	0.024
Totals		**417**					**Importance measure:**			**0.722**

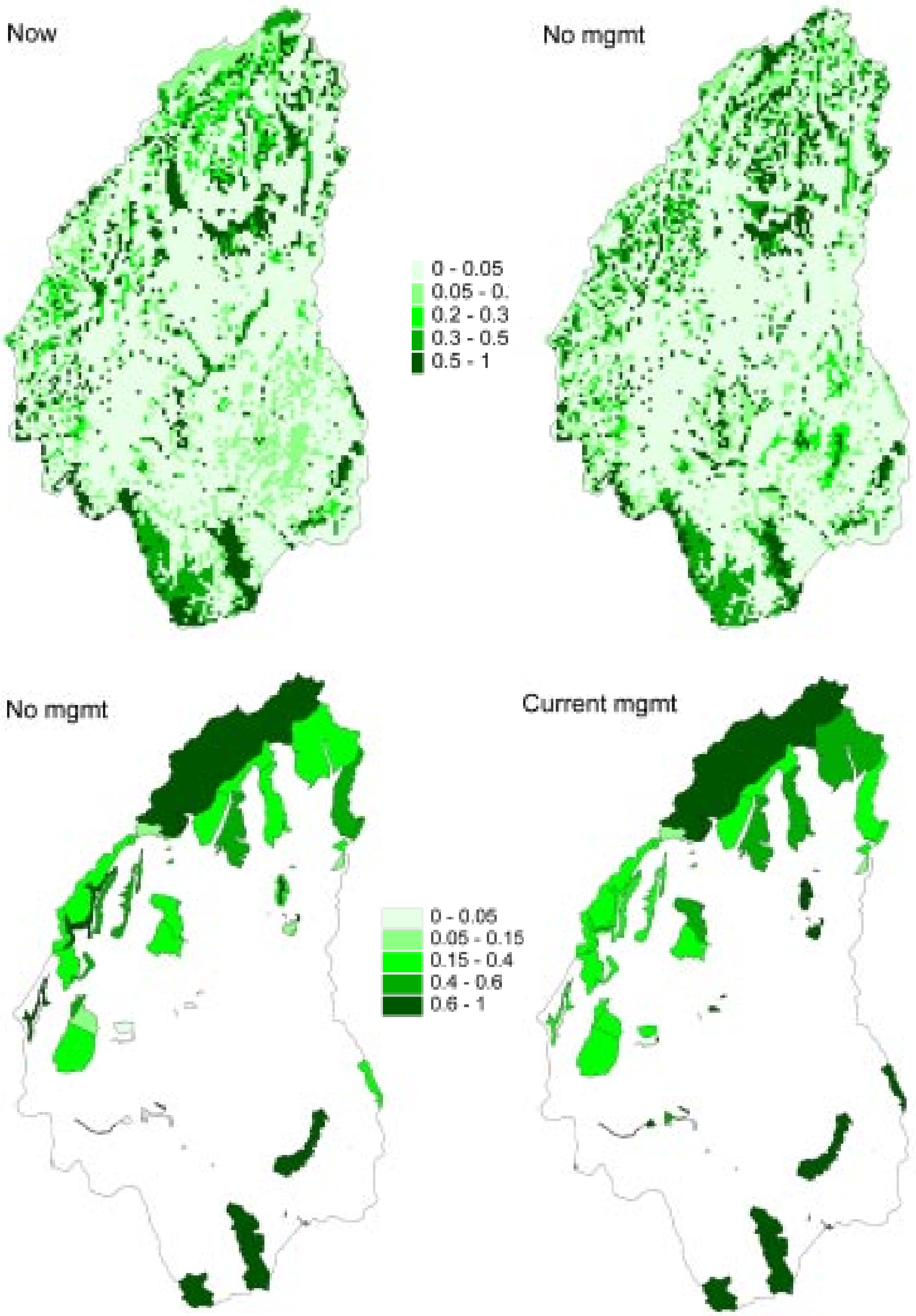


Figure 44. Importance index: the best of what remains of each environment type. Above: pixels that represent the best (i.e. least pressure) remaining in their environment type for two scenarios. Below: conservation land unit importance. These land units are the best remaining examples of their environment type.

Calculation of the importance of each pixel within the Twizel study area indicate that the best of what remains over the landscape is in the St Mary's ranges, the area around the Tekapo scientific reserve and the Tasman river bed (Fig. 44). The most important conservation land parcels are tiny fragments representing a large proportion of rare environments (e.g. Tekapo Domain around Lake Alexandrina; Waitaki River bed Crown Land). These sites are the best of what remains of environments that cover very small areas. Also important are larger parcels representing the best of what remains of extensive but highly degraded environments (e.g. St Mary's Range; Kirkliston Range and Mt Ida Conservation Area). The small size of some of the most important sites in relation to the 1 km^2 grid makes them difficult to identify spatially. Large important sites are more obvious (e.g. Mt Cook National Park, Kirkliston and St Mary Ranges).

10. Site value

The largest conservation areas tend to be among the most valuable (Tables 5 and 6). This is because of the major contribution that size makes to the value estimate. Conversely, small sites tend to be the most valuable on a per-unit area basis.

Site value is a context-dependent measure. Conservation work may reduce site pressure but it may not increase its value if there is a greater pressure reduction in other sites of the same environment type (Table 7). For example, with intensive management of the Huxley Forest, the average pressure index is reduced from 0.768 to 0.614 but its site value index *decreases* from 0.029 to 0.025. This is because there will be greater pressure reductions in the same environments outside Huxley Forest than within it, causing the site to become less important (0.688 declining with management to 0.384). The decrease in importance is greater than the pressure reduction, so the site becomes less valuable.

One consequence of this context-dependent feature of the site value measure is that conservation land unit value scores are not additive. It would be misleading to tally land unit value scores to index total portfolio worth or the added value achieved by conservation management. This issue is addressed in the following section by defining ‘project sites’.

10.1 PROJECT SITES

The definition of project sites is derived from pressure data with and without each conservation project (Fig. 45). Project sites are areas defined by the pixels where conservation management makes a difference: the set of pixels for which there is a decrease in pressure. That is, the set of pixels where:

$$\text{Pressure}_{\text{With Project}} < \text{Pressure}_{\text{Without Project}}$$

Project sites can cover a range of environments, land tenures and land cover classes. They can be non-contiguous areas and may contain holes. Conservation management may not necessarily occur within the project site (e.g. biosecurity at ports to prevent colonisation by invasive pests). Thus project site boundaries may or may not coincide with the location of management action, land tenure, land cover or environmental boundaries or even the current ranges of pests, weeds or other threats.

TABLE 5. COMPONENTS OF CURRENT SITE VALUE FOR CONSERVATION LAND UNITS IN THE TWIZEL AREA. Sites are ranked by site value and the scenario modelled is the current situation 'now'.

PLACE	AREA (km^2)	SIZE	MEAN DISTINCTIVENESS	MEAN PRESSURE	SITE IMPORTANCE	SITE VALUE	VALUE BY AREA
Mt Cook National Park	725.5	13.9	0.245	0.247	0.758	1.948	0.0027
Lake Alexandrina, Tekapo Dom.	6.2	2.1	0.550	0.107	1.000	1.020	0.1643
St Mary's Range (South)	90.0	6.0	0.108	0.465	0.971	0.338	0.0038
Godley Macauley Cons Area	248.8	9.1	0.107	0.314	0.424	0.282	0.0011
St Mary's Range (North)	44.7	4.6	0.132	0.553	0.935	0.253	0.0057
Ohau Cons Area Hopkins/Huxley	187.0	8.1	0.133	0.316	0.318	0.235	0.0013
Godley Peaks Retirement Area	90.7	6.1	0.089	0.401	0.490	0.159	0.0018
Liebig Ra /Upper Jollie /Cass	57.6	5.1	0.181	0.199	0.216	0.158	0.0028
Braemar Retirement Area	95.6	6.2	0.093	0.284	0.368	0.152	0.0016
Plantation	3.2	1.6	0.793	0.861	0.780	0.138	0.0426
Mt Ida Cons Area	59.1	5.1	0.111	0.706	0.810	0.135	0.0023
Lake Tekapo Scientific Reserve	10.3	2.5	0.729	0.861	0.493	0.127	0.0123
Mt Gerald Two Thumb Cons Area	104.8	6.4	0.102	0.562	0.279	0.080	0.0008
Fishing Purposes	15.9	3.0	0.643	0.855	0.276	0.078	0.0049
Ferintosh Retirement Area	53.2	4.9	0.086	0.369	0.258	0.068	0.0013
Mt Cook Stn Retirement Area	71.9	5.5	0.078	0.483	0.273	0.061	0.0008
Ohau (Freehold Creek)	105.4	6.4	0.079	0.540	0.212	0.050	0.0005
Kirkliston Range Cons Area	76.0	5.7	0.115	0.854	0.368	0.035	0.0005
Dusky Run Cons Area	54.6	5.0	0.102	0.555	0.155	0.035	0.0006
Two Thumb Ra Cons Area	7.1	2.2	0.120	0.487	0.211	0.028	0.0040
Ohau Range Cons Area	34.8	4.1	0.127	0.566	0.108	0.025	0.0007
Dobson Forest	41.2	4.4	0.113	0.740	0.184	0.024	0.0006
Upper Dobson Cons Area	20.7	3.4	0.242	0.359	0.031	0.016	0.0008
Huxley Forest	42.0	4.5	0.040	0.699	0.274	0.015	0.0004
Ahuriri Forest	20.6	3.4	0.075	0.713	0.195	0.014	0.0007
Hunters Hills Cons Area	24.5	3.6	0.046	0.780	0.348	0.013	0.0005
Hopkins Forest (Pt)	26.5	3.7	0.031	0.677	0.227	0.008	0.0003
Ohau Cons Area Temple Forest	13.1	2.8	0.034	0.668	0.206	0.007	0.0005
Two Thumb Cons A Richhmond Ra	7.5	2.2	0.116	0.509	0.048	0.006	0.0008
Ruataniwha Cons Area	13.0	2.8	0.173	0.782	0.053	0.006	0.0004
Ohau Cons Area Upper Maitland	11.7	2.7	0.045	0.759	0.072	0.002	0.0002
Round Hill Forest	2.6	1.5	0.077	0.742	0.067	0.002	0.0007
Plantation	5.1	1.9	0.910	0.976	0.011	0.000	0.0001
River Bank Protection	3.4	1.6	0.923	0.988	0.010	0.000	0.0001
Ben Omar Swamp	1.7	1.2	0.859	0.994	0.010	0.000	0.0001

TABLE 6. COMPONENTS OF CURRENT SITE VALUE FOR CROWN LAND UNITS NOT MANAGED FOR CONSERVATION. Sites are ranked by site value and the scenario modelled is the current situation 'now'.

PLACE	AREA (km^2)	SIZE	MEAN DISTINCTIVENESS	MEAN PRESSURE	SITE IMPORTANCE	SITE VALUE	VALUE BY AREA
Huxley/Glen Lyon	440.4	11.4	0.117	0.526	0.433	0.273	0.0006
Glen More	155.6	7.5	0.202	0.572	0.377	0.245	0.0016
Otematata	38.1	4.3	0.198	0.714	0.773	0.188	0.0049
Otamatapaio	47.2	4.7	0.184	0.752	0.685	0.146	0.0031
Mt Ida/Soldiers	97.7	6.3	0.176	0.791	0.530	0.122	0.0013

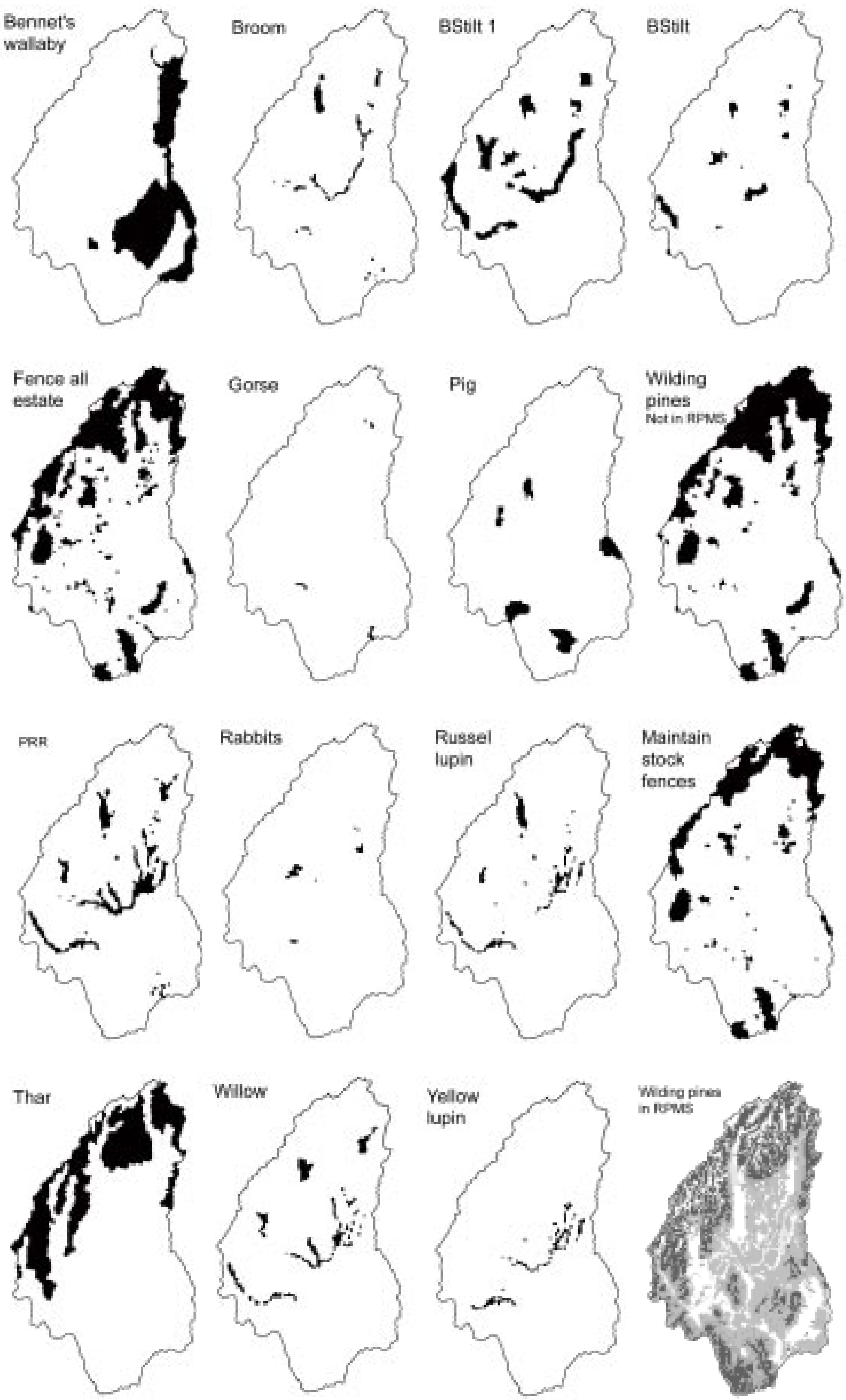
TABLE 6 (continued)

PLACE	AREA (km^2)	SIZE	MEAN DISTINCTIVENESS	MEAN PRESSURE	SITE IMPORTANCE	SITE VALUE	VALUE BY AREA
Simons Hill	18.7	3.2	0.891	0.911	0.441	0.113	0.0060
Birchwood	179.4	8.0	0.077	0.437	0.275	0.095	0.0005
Godley Peaks	118.8	6.8	0.144	0.627	0.218	0.079	0.0007
Two Mile	9.0	2.4	0.131	0.691	0.802	0.078	0.0086
Twin Peaks	10.1	2.5	0.133	0.703	0.781	0.078	0.0077
Braeside	19.6	3.3	0.117	0.733	0.743	0.076	0.0039
Ben More Range	126.7	6.9	0.176	0.824	0.354	0.076	0.0006
Shelton Downs	5.6	2.0	0.515	0.853	0.500	0.075	0.0134
Pukaki Downs	81.6	5.8	0.189	0.686	0.210	0.073	0.0009
Glenntanner	93.3	6.1	0.110	0.510	0.211	0.070	0.0007
Balmoral	20.9	3.4	0.520	0.880	0.316	0.066	0.0032
Richmond	31.0	4.0	0.353	0.853	0.305	0.063	0.0020
Lake Ohau	65.5	5.3	0.068	0.547	0.358	0.059	0.0009
Irishmans Creek	6.4	2.1	0.587	0.901	0.464	0.057	0.0089
Dunstan Peaks	26.0	3.7	0.194	0.785	0.361	0.056	0.0021
The Jollie	137.8	7.2	0.247	0.834	0.163	0.048	0.0003
Shelton Downs	2.3	1.4	0.704	0.896	0.464	0.048	0.0206
Aviemore	114.2	6.7	0.175	0.878	0.331	0.047	0.0004
Longslip	29.3	3.9	0.071	0.675	0.440	0.039	0.0013
Quailburn	33.9	4.1	0.153	0.807	0.302	0.037	0.0011
Blackstone Hill	14.9	2.9	0.156	0.787	0.348	0.034	0.0023
Omarama Station	32.3	4.0	0.209	0.857	0.275	0.033	0.0010
Dunstan Peaks	12.3	2.7	0.146	0.767	0.352	0.033	0.0027
Berwen	11.1	2.6	0.155	0.783	0.315	0.028	0.0025
Richmond	8.5	2.4	0.051	0.502	0.447	0.027	0.0032
Twinburn	9.6	2.5	0.216	0.815	0.231	0.023	0.0024
Mt Hay	62.6	5.2	0.075	0.648	0.156	0.022	0.0003
Grampians	60.0	5.1	0.141	0.866	0.215	0.021	0.0003
Dunstan Downs	18.0	3.2	0.140	0.745	0.174	0.020	0.0011
Ben Ohau	12.6	2.8	0.825	0.906	0.081	0.017	0.0014
Tara Hills	2.7	1.5	0.202	0.806	0.190	0.011	0.0041
Curraghmore	41.0	4.4	0.079	0.850	0.204	0.011	0.0003
Mt Dalgety	41.6	4.4	0.067	0.866	0.262	0.011	0.0003
Ben Avon	18.0	3.2	0.051	0.643	0.158	0.009	0.0005
Ben Drose	17.9	3.2	0.116	0.787	0.080	0.006	0.0004
Rhoboro Downs	33.8	4.1	0.145	0.719	0.026	0.004	0.00013
Ranui	12.5	2.7	0.043	0.856	0.214	0.004	0.0003
Mt Gerald	28.2	3.8	0.221	0.868	0.030	0.003	0.00012
Holbrook	28.9	3.8	0.045	0.743	0.076	0.003	0.00012
Maryburn	8.8	2.4	0.695	0.931	0.028	0.003	0.0004
Grampians	12.0	2.7	0.088	0.878	0.099	0.003	0.0002
Delrachney	5.5	2.0	0.111	0.885	0.104	0.003	0.0005
Rostriever	2.0	1.3	0.398	0.906	0.037	0.002	0.0009
Omahau	16.4	3.1	0.278	0.876	0.015	0.002	0.00009
Shelton Downs	12.1	2.7	0.505	0.952	0.016	0.0010	0.00008
Mt Cook	21.6	3.4	0.120	0.892	0.016	0.0007	0.00003
Lilybank	9.3	2.4	0.166	0.893	0.009	0.0004	0.00004
Ferintosh	1.5	1.2	0.263	0.880	0.010	0.0004	0.0003
Glen Rock	9.2	2.4	0.048	0.889	0.034	0.0004	0.00004
The Wolds	2.8	1.5	0.570	0.906	0.004	0.0003	0.00011
Ferintosh	3.5	1.7	0.305	0.920	0.002	0.0001	0.00003
Sawdon	6.5	2.1	0.107	0.927	0.004	0.0001	0.00002
Bog Roy	2.6	1.5	0.648	0.938	0.001	0.0001	0.00004

TABLE 7. SITE VALUE ESTIMATES FOR CONSERVATION LAND UNITS UNDER TWO MANAGEMENT SCENARIOS. The two management scenarios are no management and current management plus extended river bed predator control, wilding pines in RPMS and all land units stock fenced. Sites are ranked by 'with management' site value.

PLACE	PRESSURE		IMPORTANCE		SITE VALUE	
	NO MGMT	WITH MGMT	NO MGMT	WITH MGMT	NO MGMT	WITH MGMT
Mt Cook National Park	0.577	0.254	0.750	0.738	1.083	1.878
Lake Alexandrina, Tekapo Dom.	0.125	0.117	1.000	1.000	1.000	1.009
St Mary's Range (South)	0.866	0.486	0.983	0.973	0.086	0.325
Godley Macauley Cons Area	0.693	0.285	0.396	0.428	0.118	0.297
St Mary's Range (North)	0.900	0.583	0.941	0.938	0.057	0.237
Liebig Ra /Upper Jollie /Cass	0.423	0.118	0.291	0.292	0.154	0.236
Braemar Retiremnet Area	0.517	0.169	0.526	0.484	0.147	0.232
Cass River Delta Cons Area	0.998	0.334	0.567	0.979	0.001	0.227
Ohau Cons Area Hopkins/Huxley	0.722	0.291	0.261	0.250	0.078	0.191
Godley Peaks Retirement Area	0.718	0.292	0.376	0.408	0.058	0.157
Mt Ida Cons Area	0.989	0.696	0.814	0.897	0.005	0.155
Pt Ahuriri R M. Strip	0.989	0.398	0.923	0.976	0.002	0.133
Ohau Cons Area (Freehold Creek	0.850	0.463	0.209	0.362	0.016	0.100
Mt Gerald Two Thumb Cons Area	0.788	0.476	0.409	0.286	0.057	0.099
Dusky Run Cons Area	0.810	0.447	0.249	0.348	0.024	0.097
Lake Tekapo Scientific Reserve	0.999	0.911	0.072	0.574	0.000	0.094
Mt Cook Stn Retirement Area	0.760	0.346	0.274	0.304	0.029	0.086
Lower Waitaki Riverbed Cons Area	0.999	0.821	0.217	0.800	0.000	0.068
Ferintosh Retirement Area	0.725	0.364	0.240	0.251	0.028	0.067
Fishing Purposes	0.998	0.945	0.152	0.619	0.001	0.066
Upper Dobson Cons Area	0.674	0.186	0.051	0.095	0.014	0.063
Ahuriri Forest	0.780	0.424	0.623	0.405	0.034	0.058
Crown Land	0.595	0.214	0.986	0.986	0.026	0.051
Kirkliston Range Cons Area	0.987	0.839	0.853	0.443	0.007	0.046
Dobson Forest	0.890	0.694	0.510	0.268	0.028	0.041
Two Thumb Cons A Two Thumb Ra	0.705	0.415	0.215	0.238	0.017	0.037
Ohau Range Cons Area	0.865	0.510	0.084	0.115	0.006	0.030
Plantation	0.998	0.954	0.043	0.487	0.000	0.029
Huxley Forest	0.768	0.614	0.688	0.364	0.029	0.025
Hopkins Forest (Pt)	0.792	0.589	0.577	0.280	0.014	0.013
Waitaki River Bed Crown Land	0.995	0.821	0.144	0.186	0.000	0.012
Hunters Hills Cons Area	0.994	0.817	0.315	0.347	0.000	0.011
Ohau Cons Area Temple Forest	0.772	0.596	0.544	0.236	0.012	0.009
Ohau Cons Area Upper Maitland	0.842	0.680	0.534	0.232	0.010	0.009
Two Thumb Cons A Richhmond Ra	0.765	0.484	0.109	0.055	0.007	0.007
Round Hill Forest	0.851	0.670	0.260	0.068	0.004	0.003
Birch Hill Flat	0.998	0.938	0.225	0.121	0.000	0.002
Ben Omar Swamp	0.996	0.990	0.868	0.013	0.004	0.000
Soil Conservation	0.996	0.989	0.844	0.013	0.002	0.000
Lake Tekapo Recreation Reserve	0.996	0.994	0.677	0.034	0.001	0.000

Figure 45. Project sites and pressure reduction. Project sites are the set of pixels for which the project makes a difference.



11. Measuring conservation output

Measuring conservation output requires estimation of project outcome size, integrated with consideration of how long it will take to achieve it and the risks of non-achievement. Other things being equal, an outcome that is achieved sooner is more valuable than one that occurs later. Similarly, a highly feasible outcome is more valuable than one for which there is significant risk of non-achievement. This means that it is necessary to discount project outcome size according to how long it will take for the outcome to occur, and to weight it according to the risks associated with its achievement. We define 'project merit' as the time discounted and risk-weighted measure of conservation output. Thus project merit is a fully weighted measure of the contribution made by a project (or programme of projects) to the flow of benefits supplied by the natural heritage asset portfolio. It is therefore a measure of conservation output.

11.1 MEASURING PROJECT OUTCOME SIZE

Project outcome size was defined as the difference in project site value with and without management (Table 8):

$\text{Project Site Value}_{\text{With Management}} - \text{Project Site Value}_{\text{Without Management}}$

Measurement of project outcomes requires estimation of site value twice: with and without project implementation. The estimation procedure is the same as for conservation unit site value except that the spatial unit for analysis—the project site—is quite different and has to be defined for each project or combination of projects.

11.2 DISCOUNTING FOR OUTCOME DELIVERY TIME

The discount rate (related to interest rates) expresses the value that society gives to an outcome occurring sooner rather than later. Within government departments, the capital charge rate (currently 10%) provides an indication of the value government puts on immediate outcomes. This was used to estimate the nett present value (NPV) of project outcome size:

$\text{NPV Outcome} = (\text{Outcome Size}) \times e^{-dt}$

where t is years until the outcome will happen and d is the current discount rate (i.e. 0.1).

The high discount rate and the wide variation in time until the outcome will happen (1 to 50 years) results in two orders-of-magnitude variation in e^{-dt}, leading to five orders-of-magnitude variation in the NPV of project outcomes (Table 9). Of the projects currently being implemented, thar control and fence maintenance have the largest NPV of outcomes. The wilding pine control project has a much larger outcome but this will take a long time to be achieved (50 years) and so has been heavily discounted compared with alternative designs in which the outcome is achieved in just 7 years.

The NPV of Outcomes for multi-project scenarios was estimated by scaling up the efficacy of component projects to account for the added value synergy of doing several projects at the same place and then summing the adjusted NPV of Outcomes of individual projects. The calculation is illustrated in Appendix 1.

11.2.3 Weighting for outcome feasibility

All conservation outcomes are subject to risk. Five risk factors contributing to outcome failure were identified:

Outcome risk: the risk that planned actions are not appropriate to achieve the outcome sought, usually because the conservation problem is not understood well enough to identify appropriate courses of action.

Operational risk: the risk that unexpected events cause insufficient project implementation to achieve the intended outcome. A complex work environment, poor planning, contingencies, resources or weak commitment are major sources of operational risk.

TABLE 8. PROJECT OUTCOME SIZE. Outcome size is the difference in project site value with and without (w/o) project implementation. Components of site value with and without management are given. The project code refers to the project descriptions and scenario compositions described in Table 3.

PROJECT CODE	AREA (km^2)	MEAN DISTINCT-IVENESS	PRESSURE		IMPORTANCE		PROJECT SITE VALUE		OUTCOME SIZE
			WITH PROJECT	W/O PROJECT	WITH PROJECT	W/O PROJECT	WITH PROJECT	W/O PROJECT	
MoreMan	9155	0.285	0.732	0.901	0.98	0.962	2.874	1.045	1.829
PineRPMS	8409	0.282	0.8	0.922	0.934	0.865	1.956	0.706	1.25
CMan	5317	0.215	0.705	0.844	0.965	0.877	1.898	0.91	0.986
PineDOC	1966	0.153	0.555	0.772	0.804	0.705	1.145	0.511	0.63
Thar	1951	0.117	0.616	0.67	0.886	0.874	0.823	0.697	0.126
StockTR	4127	0.162	0.901	0.928	0.773	0.765	0.348	0.25	0.098
BStilt1	631	0.522	0.971	0.986	0.802	0.649	0.159	0.064	0.095
StockCL	1831	0.152	0.856	0.896	0.691	0.678	0.304	0.216	0.088
PRR	434	0.579	0.982	0.997	0.698	0.22	0.084	0.004	0.08
StockSQ	1289	0.157	0.873	0.903	0.543	0.52	0.19	0.138	0.052
BStilt	190	0.523	0.989	0.995	0.619	0.211	0.028	0.005	0.023
Willow	276	0.56	0.994	0.999	0.723	0.149	0.023	0.001	0.022
Rlupin	232	0.595	0.993	0.997	0.525	0.112	0.018	0.002	0.016
Bennetts	1807	0.223	0.976	0.979	0.66	0.575	0.07	0.055	0.015
Broom	161	0.513	0.992	0.998	0.436	0.111	0.014	0.001	0.013
Gorse	16	0.672	0.987	0.997	0.305	0.212	0.008	0.001	0.007
Ylupin	146	0.776	0.996	0.997	0.132	0.079	0.003	0.001	0.002
Pig	342	0.167	0.942	0.943	0.749	0.748	0.075	0.074	0.001
Rabbit	38	0.534	0.998	0.998	0.169	0.069	0.001	0	0.001

TABLE 9. DISCOUNTING OUTCOME SIZE FOR DELIVERY TIME. The discount rate is 0.1. Projects are ranked by the NPV of their outcomes. Projects shown in bold are currently being implemented. Codes refer to the project descriptions and scenario compositions described in Table 3.

CODE	YEARS UNTIL OUTCOME	NPV	OUTCOME SIZE	NPV OF OUTCOME
PineRPMS	7	0.497	1.250	0.62088
PineDOC	7	0.497	0.630	0.31275
Thar	1	0.905	0.126	0.11414
BStilt1	1	0.905	0.095	0.08564
StockTR	5	0.607	0.098	0.05920
StockCL	5	0.607	0.088	0.05368
StockSQ	1	0.905	0.052	0.04687
Bstilt	1	0.905	0.023	0.02117
Bennetts	1	0.905	0.015	0.01357
PineRPMS	50	0.007	1.250	0.00842
Willow	10	0.368	0.022	0.00822
Rlupin	10	0.368	0.016	0.00599
Broom	10	0.368	0.013	0.00493
PineDOC	50	0.007	0.634	0.00424
Gorse	10	0.368	0.007	0.00258
Ylupin	2	0.819	0.002	0.00156
Pig	1	0.905	0.001	0.00127
Rabbit	1	0.905	0.001	0.00063
Willow	50	0.007	0.022	0.00015
Rlupin	50	0.007	0.016	0.00011
Broom	50	0.007	0.013	0.00009
Gorse	50	0.007	0.007	0.00005

Legal risk: occurs when other stakeholders can determine whether or not a project (or some of its components) can be implemented. Legal access and resource consent requirements are sources of legal risk.

Collateral damage risk: occurs when an action has adverse effects on other natural heritage assets, as may occur in a pest control operation that causes some by-kill of native species or leaves toxic residues.

Socio-political risk: the risk that public concern and opposition limit or prevent project implementation. Effective public consultation and involvement are important in the management of socio-political risk.

Just two attributes of each risk need to be evaluated to quantify project feasibility: the effect (E) of the risk factor on the project outcome and the proportion (P) of this risk that is effectively managed.

Feasibility with respect to one risk factor can then be measured by:

Feasibility = $1 - (E - (E \times P))$

Project feasibility is the product of the individual feasibility values for each risk factor.

E and P for each risk factor were quantified by asking the project manager the following sequence of questions:

1. Is this risk factor an issue for this project? If No, then E = 0 and P = 0; move on to next risk factor. If yes, go to 2.
2. If the risk is not managed, and the risk eventuates, what proportion of the outcome will still be achieved? If none, then E = 1. If only half (e.g. achieved over only half the area), then P = 0.5.
3. What portion of this risk is effectively managed? If all, then P = 1. If E is negligible then there is little benefit in expenditure aimed at managing this risk, so P is likely to be small.

There was less than two-fold variation in feasibility scores (Table 10) from 0.554 (Russell lupin control) to 0.992 (pig control). This variation is small compared with the order-of-magnitude variation in outcome size and NPV outcome size. This probably reflects the risk-averse culture common in government departments.

The feasibility of a combination of projects was the weighted (by NPV of outcome size) average of the feasibility values associated with component projects. The calculation is illustrated in Appendix 1.

TABLE 10. PROJECT FEASIBILITY. The effect (E) of five risk factors on each project and the portion (P) of each that is managed. Project codes refer to the project descriptions and scenario compositions described in Table 3.

PROJECT	YEARS TO	OUTCOME		OPERATIONAL		LEGAL		COLLATERAL		SOCIAL		FEASIBILITY
CODE	OUTCOME	E	P	E	P	E	P	E	P	E	P	
Pig	1	1	1	0.15	0.98	1	1	0	0	0.1	0.95	0.992
PineDOC	50	1	1	0.5	0.98	0.1	1	0.02	0.8	0.1	0.95	0.981
PineDOC	7	1	1	0.5	0.98	0.1	1	0.02	0.8	0.1	0.9	0.976
Gorse	50	1	1	1	0.95	1	1	0	0	1	1	0.950
Broom	50	1	1	1	0.95	1	1	0.02	1	0.5	0.95	0.926
Gorse	10	1	1	1	0.9	1	1	0	0	1	1	0.900
Rabbit	1	1	1	1	1	0.3	0.98	0	0	1	0.9	0.895
Thar	1	1	0.98	0.6	0.95	0.1	0.95	0	0	0.6	0.9	0.889
Cat	1	1	0.99	1	0.9	0	1	0.05	0.98	0.02	0.9	0.888
Ferret	1	1	0.99	1	0.9	0	1	0.05	0.98	0.02	0.9	0.888
Hedge	1	1	0.99	1	0.9	0	1	0.05	0.98	0.02	0.9	0.888
Stoat	1	1	0.99	1	0.9	0	1	0.05	0.98	0.02	0.9	0.888
Cat1	1	1	0.99	1	0.9	0.2	0.95	0.05	0.98	0.05	0.9	0.877
Ferret1	1	1	0.99	1	0.9	0.2	0.95	0.05	0.98	0.05	0.9	0.877
Hedge1	1	1	0.99	1	0.9	0.2	0.95	0.05	0.98	0.05	0.9	0.877
Stoat1	1	1	0.99	1	0.9	0.2	0.95	0.05	0.98	0.05	0.9	0.877
Willow	50	1	1	1	1	0.6	0.9	0	0	0.8	0.9	0.865
Ylupin	2	1	0.98	0.6	0.9	1	0.95	0.05	0.5	0.1	0.98	0.852
PineRPMS	50	1	1	0.5	0.98	0.1	1	0.02	0.8	0.6	0.75	0.838
Willow	10	1	1	1	1	0.75	0.9	0	0	0.8	0.85	0.814
Broom	10	1	1	1	0.9	1	0.95	0.02	0	0.5	0.9	0.796
StockTR	5	1	1	0.8	0.9	1	0.95	0	0	0.6	0.85	0.795
Rlupin	50	1	0.98	0.5	0.98	0.2	0.9	0.05	0.6	0.6	0.75	0.792
StockSQ	1	1	1	0.8	0.8	1	0.95	0	0	0.5	0.98	0.790
StockCL	5	1	1	0.8	0.8	1	0.95	0	0	0.5	0.9	0.758
PineRPMS	7	1	1	0.5	0.98	0.1	1	0.02	0.8	0.7	0.55	0.641
Bennetts	1	1	0.98	0.6	0.9	0.5	0.5	1	1	0.5	0.8	0.622
Rlupin	10	1	0.98	0.5	0.85	0.6	0.6	0.05	0.6	0.6	0.7	0.554

12. Estimating project cost

Perhaps the most useful application for measurement of conservation output is estimation and comparison of project cost-effectiveness. This enables the most cost-effective work programme to be identified and provides a robust framework for demonstrating that funds are being used in the most effective way. This requires standardised cost estimation for projects with diverse cost structures. This was done by estimating the NPV (discount rate = 0.1) of annual costs over a 50-year period (NPV_{50}). Project cost estimates (Table 11) are crude, based on manager's best guesses of project design and cost. Estimation was complicated by variable approaches to associated activities (e.g. overheads) that are often not perceived to contribute to project outcomes. Manager's opinions varied as to what overheads should be allocated to the cost of a project. For example, Project River Recovery and the black stilt recovery

TABLE 11. CONSERVATION PROJECT COST PROFILES. The Nett Present Value (NPV) of project costs was estimated from 50 year costs but only the first 15 years of costs are given here. Constant cost streams indicate an expectation of constant annual effort, higher early costs followed by more constant costs indicate concentrated effort to achieve pest knockdown followed by ongoing maintenance. Project codes refer to the project descriptions and scenario compositions described in Table 3.

PROJECT	YEARS TO	NPV_{50}	YEARS FROM NOW														
CODE	OUTCOME	COST ($k)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bennetts	1	156.7	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
Broom	10	49.8	5.0	15.0	15.0	10.0	8.0	4.0	5.0	0.0	5.0	0.0	3.0	0.0	2.0	0.0	2.0
Broom	50	49.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Cat	1	103.5	11.8	0.0	0.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Cat1	1	495.7	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Ferret	1	103.5	11.8	0.0	0.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Ferret1	1	495.7	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Gorse	10	49.8	5.0	15.0	15.0	10.0	8.0	4.0	5.0	0.0	5.0	0.0	3.0	0.0	2.0	0.0	2.0
Gorse	50	49.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Hedge	1	103.5	11.8	0.0	0.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Hedge1	1	495.7	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Pig	1	51.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
PineDOC	7	997.1	126	110	200	300	200	180	80	80	0	80	0	80	0	80	0
PineDOC	50	851.6	90	90	100	100	100	80	80	80	80	80	80	80	80	80	80
PineRPMS	7	1,037.5	130	150	205	300	200	180	80	80	0	80	0	80	0	80	0
PineRPMS	50	914.1	130	120	110	100	90	80	80	80	80	80	80	80	80	80	80
Rabbit	1	625.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1	63.1
Rlupin	10	603.2	60	100	100	90	80	70	65	60	55	50	45	45	40	40	40
Rlupin	50	594.9	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Stoat	1	103.5	11.8	0.0	0.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Stoat1	1	495.7	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
StockCL	5	7,138.7	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720
StockSQ	1	1,115.4	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113
StockTR	5	10,261.8	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035
Thar	1	711.8	71	80	71	71	71	71	71	71	71	71	71	71	71	71	71
Willow	10	797.6	60	80	100	120	100	100	90	80	80	75	75	75	75	70	70
Willow	50	872.5	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88
Ylupin	2	21.0	8.0	6.0	4.5	3.5	3.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

project both include activities that do not contribute directly to conservation outcomes (e.g. advocacy; research; captive breeding). Costs used here were for the actions that generate outcomes. Thus although the full cost of Project River Recovery is $400k, only $160k was clearly associated with weed control and hence production of conservation outcomes. Similarly, the full cost of the black stilt recovery project is probably around $800k per annum but only $200k was associated directly with output delivery (i.e. riverbed pest control). It is not clear how much of other activities within these programmes contribute to management of risks and so support outcome delivery. If they do contribute to management of risks by increasing project feasibility, then they should be included in project costs.

Since project design and consequent cost structure determine both the project's risk profile and how long it will take until the outcome happens, managers were asked to define the project cost structure *before* outcome time and risks were considered.

The NPV_{50} of the costs of currently implemented conservation projects (Table 11) ranged from $21k for yellow tree lupin eradication to $1.1 million for maintaining existing stock fences. The NPV_{50} of the cost of project combinations was estimated by summing the annual costs of component projects and then calculating the NPV_{50} for this stream of costs.

13. Sensitivity issues

Project cost-effectiveness requires the integration of nearly all the information and component models described and it is pertinent to identify which information elements and models have most influence on the estimates derived. Some insights can be gained by working back down through the process, starting from the cost-effectiveness estimation.

The cost-effectiveness calculation combines conservation output estimation (i.e. project merit) with implementation cost estimation. Three issues arise with cost estimation:

- reliability and consistency of input cost data
- inter-annual pattern of expenditure
- the discount rate.

Variation in NPV_{50} cost estimation arises from both inconsistency in cost estimation and the inter-annual pattern of expenditure. Variation in the order of ±10% in the estimation of NPV project cost will cause only minor changes to the project cost-effectiveness rankings given in Table 23. Variation in the discount rate changes the relativity between projects with imminent costs from those with high costs in more distant future years. The higher the discount rate, the greater the cost-effectiveness of projects with low immediate costs but higher ongoing costs (e.g. for delayed pest control). A low discount rate gives more weight to future maintenance costs and so will tend to favour pest eradication over control which typically has high immediate costs but low ongoing costs.

Project merit combines outcome size (i.e. change in project site value) with feasibility and delivery time information. Since variation in feasibility is small (less than two-fold) relative to all other factors contributing to project merit, project rank sensitivity to error in feasibility estimation is also small. Discount rate sensitivity is more important. A high discount rate favours projects which deliver outcomes sooner over those that deliver later. For example, PineRPMS7 (wilding pine control on conservation land with wilding pines included in the RPMS within 7 years) has very much higher project merit (0.398) and ranking (i.e. 1st) than the same project designed to deliver the same outcome in 50 years (0.0071).

Outcome size is driven by the impact of management on mean pressure. A drop in mean pressure raises project site importance. The other two components of site value (i.e. size and mean distinctiveness) are unaffected by management and so do not contribute to outcome size. Importance estimation is sensitive to the number of groups recognised in the environmental classification. The greater the level of classification resolution (i.e. more groups recognised) the greater the increase in the importance of a site will tend be for a given decrease in pressure. The exception occurs when the site without management is the best of what remains of its environment type. In this case its importance will increase little with reduced pressure.

Site value is the product of four variables. One variable (i.e. size) is continuous while the other three range between zero and one. This multiplicative relationship results in large variance in site value. The variables contributing most variance are size (primarily because it is a continuous variable and may be large relative to the other three; and secondarily because area is a factor in the importance variable) and mean pressure (because pressure is also a component of the importance variable). Mean distinctiveness contributes least to the variance in site value.

A alternative multiplicative function that generates less variance in site value estimates was tested:

$$\text{Site Value} = \text{Site Area}^{0.4} \times (1+\text{Distinctiveness}) \times (1+\text{Importance}) \times (1+\text{Pressure})$$

However this resulted in some anomalous change in site value (ΔSite Value) estimates for sites of different size in the same environments with change in average pressure held constant. The contribution of changed importance to ΔSite Value diminishes as the site occupies more of an environment type. In some circumstances, this causes ΔSite Value to be smaller for a large management area than for a small one. This is clearly untenable. The same problem arises with an additive model.

Thus it appears that the underlying issue here is the design of the importance model. The problem being that the rate of importance increase with site area (and/or pressure) diminishes excessively as the importance index approaches 1. The chosen multiplicative model (Section 3.0 cf. the model above) masks this issue. It does not resolve it.

Site value is most sensitive to area estimation. In most situations where area estimates are based on vector data, error is negligible. However, project site area is estimated by counting pixels and so is not precise, particularly when the project site is small (percentage error increases with diminishing project site area). Thus the percentage error in the area estimate for the gorse control project will be large relative to the fencing or pine control projects. This error in area estimation has no impact on subsequent estimates of project outcome size, but may affect cost-effectiveness estimation if project costs are area-dependent and based on different origins of the area estimate.

Pressure is the core variable upon which all derivative variables (site importance, value, irreplaceability, vulnerability and project cost-effectiveness) depend. The consumption pressure model is perhaps the weakest component because it relies on definition of presumed animal pest abundance-impact relationships. The form of the relationship determines the consumption pressure change brought about by pest control. The problem is that there is no objective method for defining animal pest abundance-impact relationships. For the purposes of this proof-of-concept demonstration, it was assumed that biota loss and recovery share the same animal pest abundance-impact relationship and that this relationship is constant across different environments. It is likely that recovery actually follows another trajectory, often with less native biota present for a given level of animal pest abundance (e.g. Nugent et al. 1997) and that some environments are more resilient than others. These and other issues of relating pressure to condition seem best resolved through better understanding of the relationship between human-induced disturbance pressure and native biodiversity condition loss and recovery.