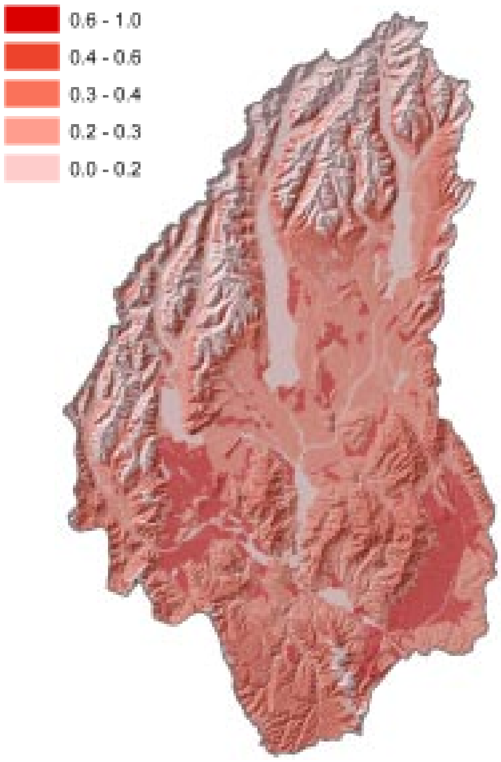


Figure 18. Biota loss associated with human removal. Values were applied to the LCDB cover classes based on some notion of compositional distance resulting from removal disturbances (mainly fire and vegetation clearance).

CLASS NAME	BIOTA REMOVED
Bare ground	0
Indig. forest	0
Wetlands	0
Inland water	0
Riparian willows	0
Shrub	0.3
Tall tussock (>900 m)	0.4
Short tussock (<900 m)	0.6
Plantation forest	0.6
Urban open space	0.95
Pastoral	0.98
Urban	0.98

8.1 BIOTA REMOVAL

The biota removal index measures the intensity of those human-induced disturbances that tend to ‘reset’ succession trajectories. These might be catastrophic but infrequent (e.g. fire, native vegetation clearance), catastrophic and frequent (e.g. tilling and cropping), minor and infrequent (e.g. selective logging), minor and frequent (e.g. hunting). Values for the index were based on an estimation of the biotic similarity between communities associated with each LCDB cover class and the communities that could be present in absence of human-induced biota removal processes.

The intensity of human removal of native biota (Fig. 18) was inferred from LCDB cover classes. Naturally bare ground, indigenous forest, inland water, riparian willows and inland wetlands were thought to be indicative of negligible vegetation clearance. Thus a value of zero was used to indicate the biota removal pressure on these cover classes and the resulting biota loss (i.e. none) from removal activities. Shrub communities were thought to be indicative of Polynesian fires long ago that have since recovered much native species richness and some of their natural biomass. A value of 0.3 was chosen to indicate the pressure on shrub cover. Since tussock cover is usually the result of more frequent fires, 0.4 was chosen to indicate the pressure on the less-frequently burned tall-tussock cover (assumed to be all tussock at altitudes over 900 m) and 0.6 for the more frequently burned short tussock (all tussock at altitudes below 900 m). Primarily pastoral land (including horticulture and crops) indicates frequent use of physical (harvest and tilling) and chemical (pesticide) disturbances to eliminate native and other unwanted plants and animals. A value of 0.98 was chosen to indicate biota removal pressure associated with primarily pastoral land cover. Planted forest probably does not indicate any removal of biota beyond that associated with the short tussock (0.6) into which most is planted. Urban areas indicate major disturbance pressure but there are often some plantings of native vegetation, particularly in the small rural towns in the Twizel study area: hence the large pressure values of 0.98 and 0.95 for urban and urban open space cover classes.

The assessment of 'removal' disturbance impact would benefit much from:

- structured field measurement
- estimation of vegetation composition in the absence of human-induced disturbances
- a model explicitly accounting for the frequency and impact of each type of human disturbance, the time since the last such event, and the rate of native community composition recovery.

The present pattern of biota loss caused by direct human removal was not expected to change. Tussock burning will continue in short tussock areas and occasional wildfires will occur in tall-tussock and shrub areas. Thus the same data were used to represent both current and future scenarios. However, it is clear that fire control should be taken into account because it is a significant conservation activity that reduces the frequency and intensity of biota loss, and so generates real conservation outcomes. The frequency and extent of fires has probably been declining over recent decades and current tussock burning policies suggest this trend is likely to continue.

Predicting the location and extent of fires and the impact of fire control needed for spatially explicit outcome definition is beyond the scope of this project. However, it would be possible to assess the difference made by fire control, by comparing the actual extent of wildfires with that estimated in the absence of fire control.

8.2 PHYSICO-CHEMICAL RESOURCE MODIFICATION

As the economy of a country grows, land use becomes more intensive, modifying ecosystem resources through alteration of soils, hydrology, nutrients, light and temperature. Alteration of the physico-chemical resources of ecosystems changes their species composition. The major resource modifications are drainage and flooding, displacement of soils with concrete, asphalt and buildings, alteration of nutrient levels, light and temperature. Values for the physico-chemical resource modification index were based on an estimation of the biotic similarity between communities associated with drained, flooded and paved areas and those communities that are likely to be present in places without human-induced physico-chemical resource modification.

In the Twizel area, the most extensive modification is alteration of the hydrology. The substrate has also been modified as a result of roads, buildings and earthworks associated with power development. However, these are of a scale that cannot be captured on the 1 km grid used here.

River beds, wetlands and lake margins have been flooded, river flows diverted and natural flow and lake level patterns lost to hydro-electric power generation. Other wetlands have been drained for agriculture. This has greatly reduced

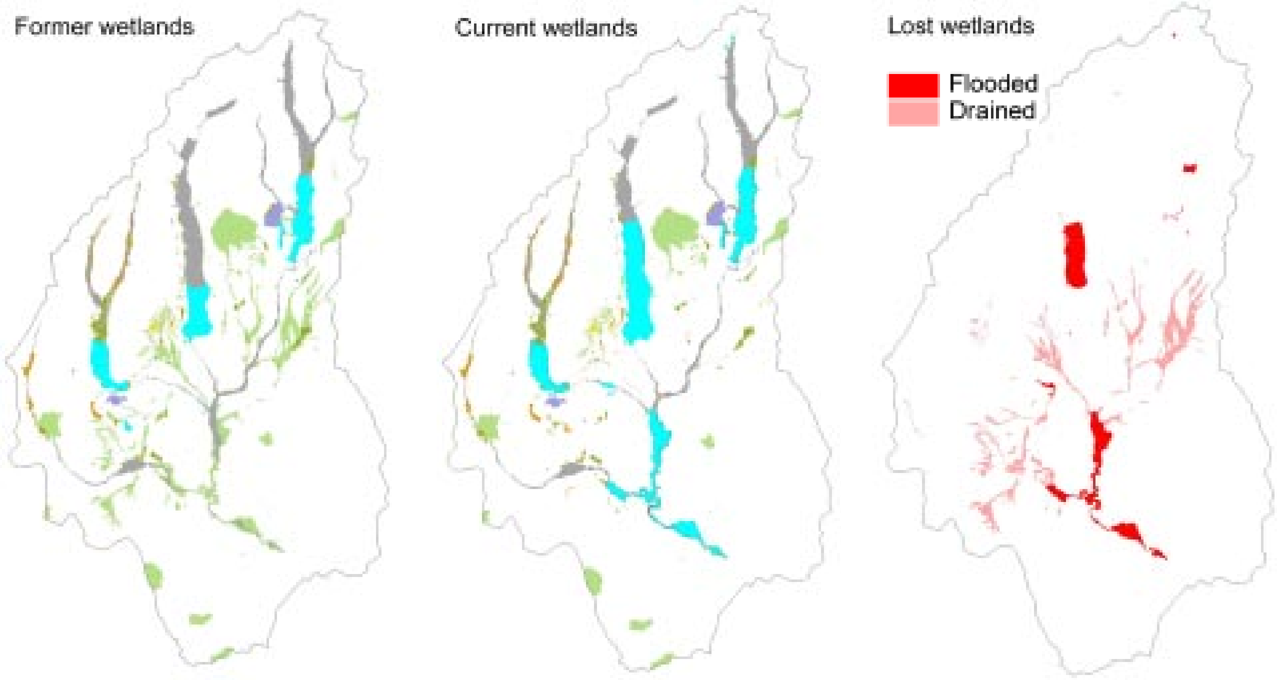


Figure 19. Alteration of the physico-chemical resource base. Altered hydrology is the major human-induced physico-chemical change in the Twizel Area. (Data supplied by Gareth Wilson.)

habitat availability, particularly for the aquatic biota of rivers, wetlands and lake-shores. Wilson (2000) quantified wetland loss from historic aerial photographs and soil maps (Fig. 19). His information was used to estimate the biota loss associated with modification of hydrological resources.

Flooding of lake shores, river beds and wetlands must result in near total change in species composition and physical structure, So, to reflect this, a value of 0.01 was used to indicate the degree of biota loss (i.e. 99%) associated with flooded areas. Loss associated with drainage is also substantial, though perhaps not as great as that caused by flooding. Hence a value of 0.02 was used to indicate the degree of biota loss associated with drainage.

While further resource modification will probably occur (given the continuing growth in demand for water resources), no attempt was made to predict where or when further flooding or drainage might occur. Thus, by default, we assume no change and so use the present pattern of resource modification as the best estimate of the future.

8.3 ANIMAL PEST ABUNDANCE

The consumption pressure index measures the direct impact of feeding and physical disturbance (e.g. stock trampling; rabbit burrowing) of introduced animals on native biota. Consumption pressure is determined by what introduced animals are present, their abundance, and the relationship between their abundance and native biota loss. Essential input information is the mapped abundance of each pest and explicit definition of the relationship between the abundance of each pest and associated native biota loss.

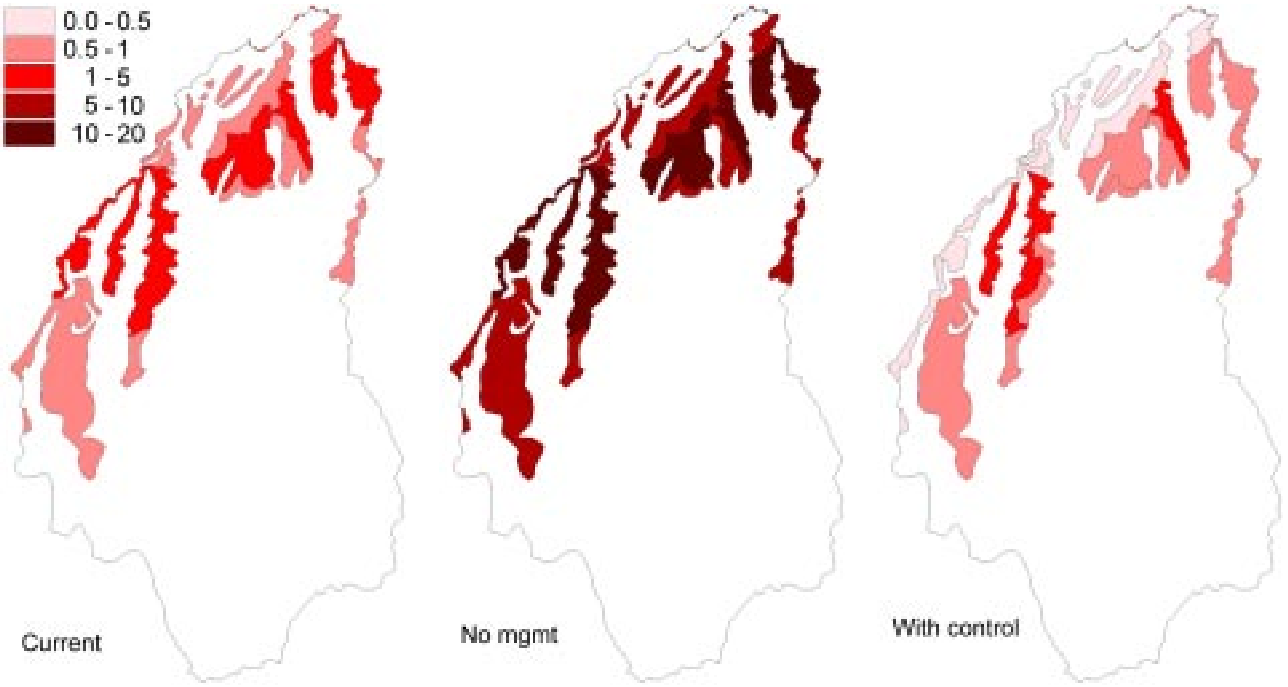


Figure 20. Thar abundance in the Twizel Area (number per km^2).

The distribution and abundances of animal pests were defined by capturing the knowledge and perceptions of staff responsible for pest management. Distribution maps and recent survey information informed these perceptions and provided the 'first cut' for maps which were then modified on the basis of staff field knowledge. Thus the maps which follow reflect the current perceptions of managers. Their accuracy is largely unknown.

Thar distribution and abundances (numbers per km^2) were based on information supplied by Landcare Research and modified on the basis of recent aerial survey information (Fig. 20). Present thar abundance is suppressed by intensive control. Projected thar abundance without management is based on survey data from the 1950s prior to intensive thar control. Thar range is not expected to change but order-of-magnitude increases in abundance are expected without control. Planned control is expected to reduce thar abundance below present levels in some areas.

Bennett's wallaby are presently spreading into the western part of the Twizel area (Fig. 21). Without control, spread will continue and wallabies are expected to become locally abundant. With current management, their spread is expected to continue unabated but their abundance will be controlled. Abundance was measured using the Guilford scale. This uses descriptors for the amount of animal sign to indicate animal abundance. The index has six levels, ranging from 0 to 5, with each level representing order-of-magnitude increases in absolute abundance.

Fallow deer have been liberated at a number of locations and now occur at ten sites (Fig. 22). While they are expected to breed and become more numerous at these places, animal pest control staff do not expect them to spread. No control is planned.

Stock: cattle and sheep (Fig. 23) graze most places that are not fenced, too wet (large rivers and lakes) or too high (above 2000 m). Only two large areas are effectively fenced: Mount Cook National Park and Kirkliston Range. Another

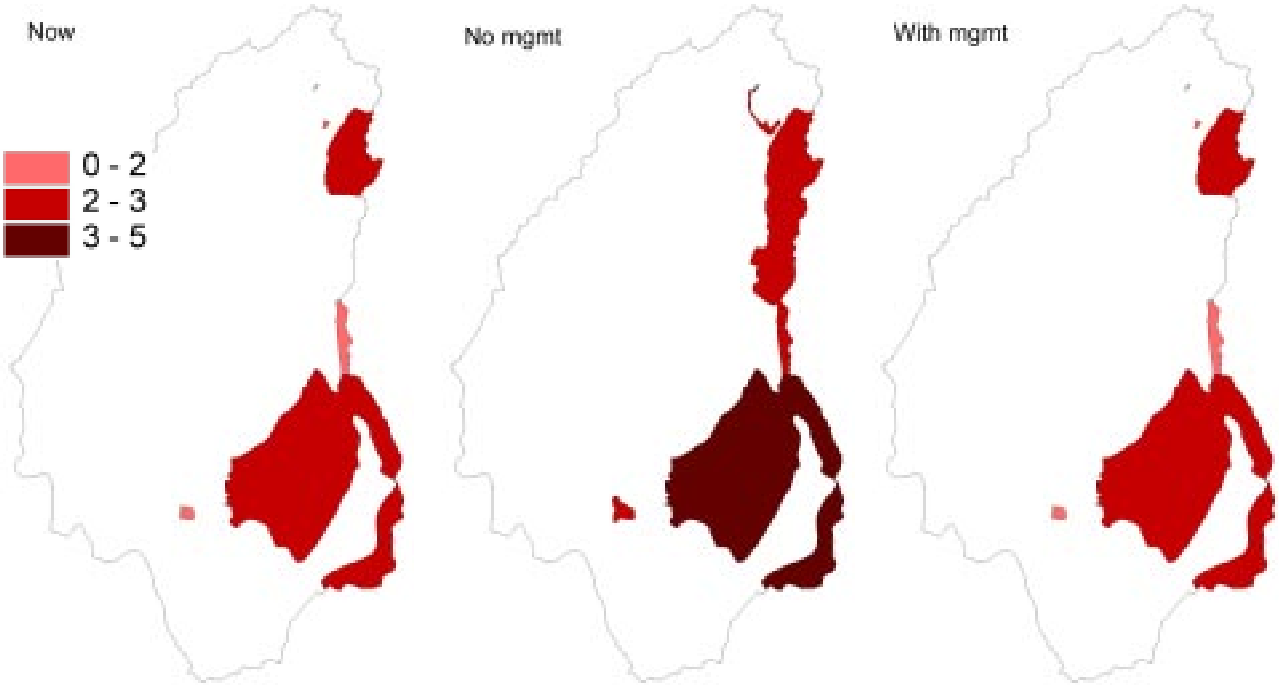


Figure 21. Bennett's wallaby abundance in the Twizel Area, using the Guilford scale (based on presence of animal sign, ranging from 0 to 5 representing order of magnitude increases in absolute abundance).

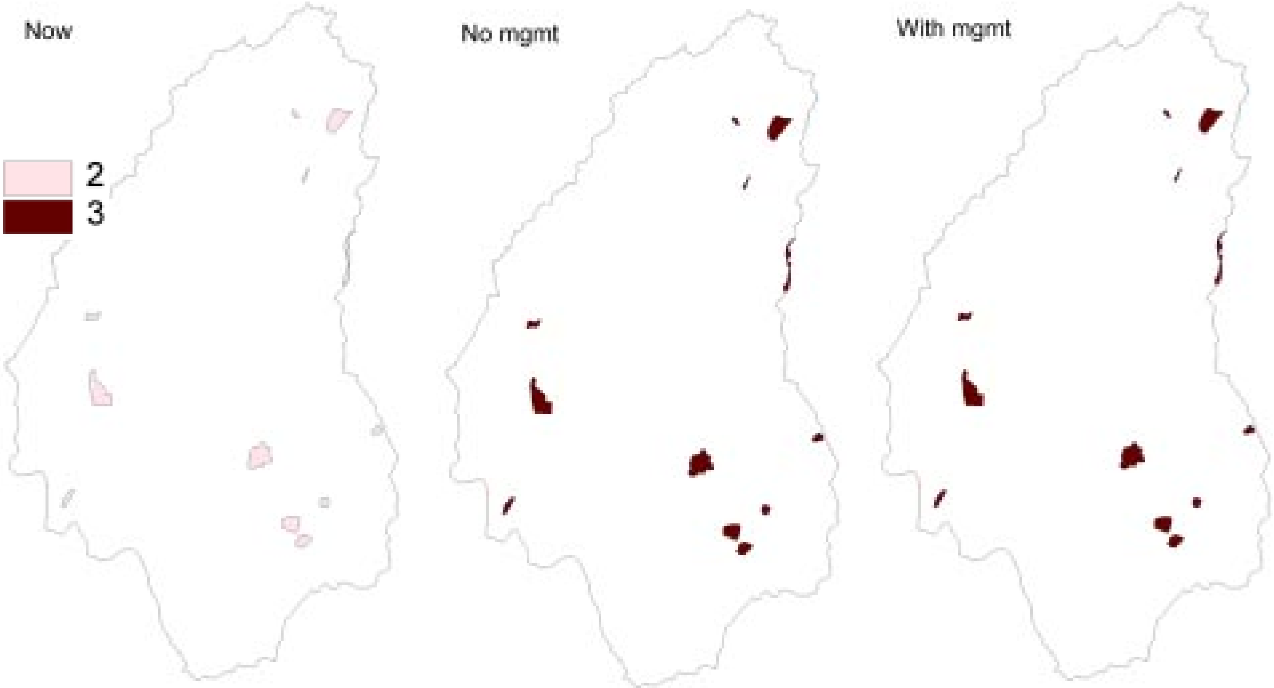


Figure 22. Fallow deer abundance in the Twizel Area (number per km^2).

three large areas are partially fenced but suffer significant stock trespass. Most other areas of land managed for conservation are not fenced and are grazed at the same level of intensity as adjacent private land. Without management, the fences will fail and stock will graze all conservation land that is not too wet, steep or high.

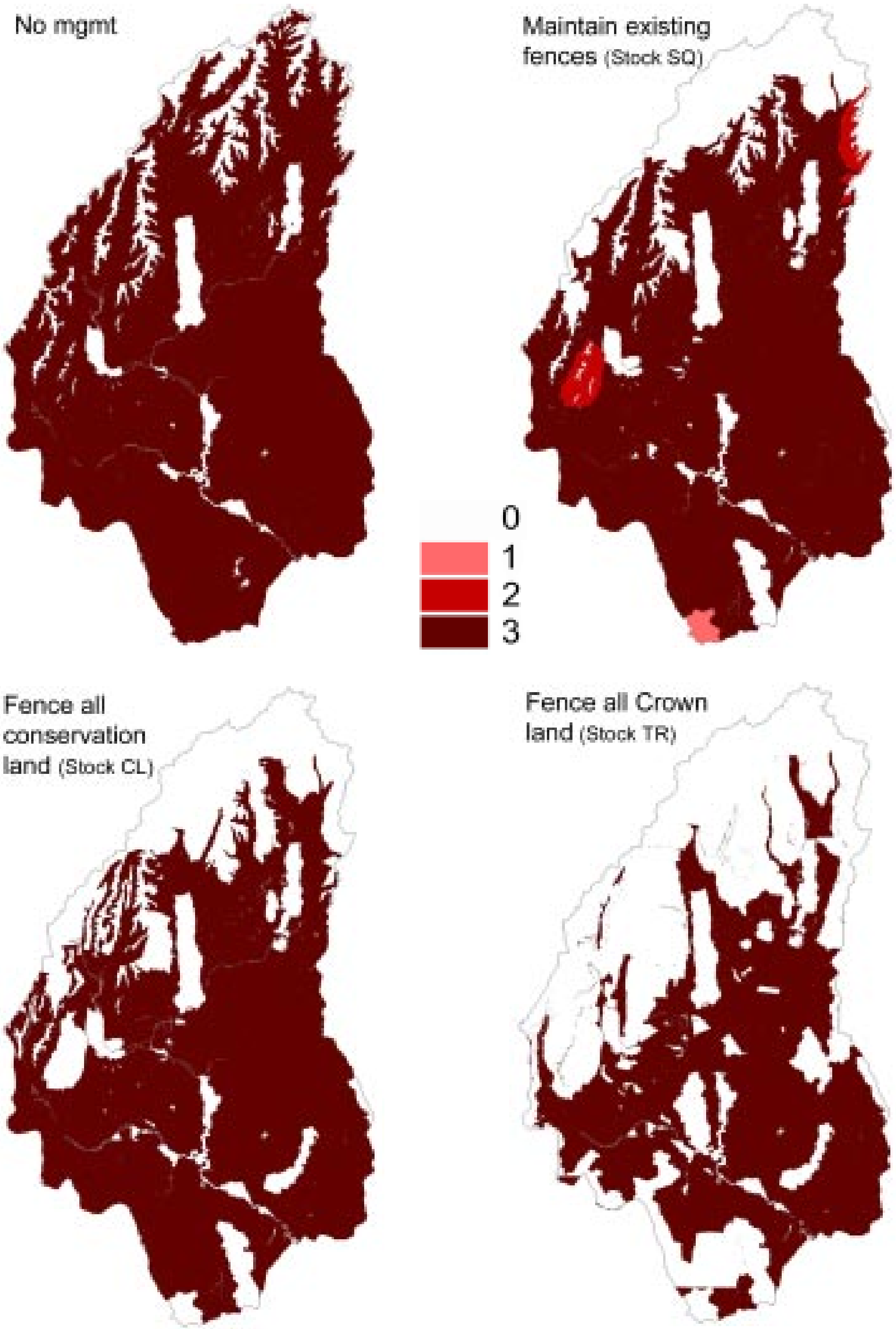


Figure 23. Stock (cattle and sheep) abundance index now and subject to four stock fencing management options. The options are: no management; maintain existing fences; fence all land managed for conservation purposes; fence all Crown land. In the absence of a measure of absolute stock abundance, a scale based on grazing duration was used to index stock grazing pressure where:
0 = no grazing;
1 = occasional grazing, not every year;
2 = seasonal grazing for < 3 months most years;
3 = grazed for > 3 months of the year.

The current management intention is to maintain existing fences so that the *status quo* continues. Two further management options were considered:

1. fence all conservation lands
2. fence all Crown lands and tenure-review lands.

Feral pigs occur in three areas at low abundance (Fig. 24). Current management is intended to halt their spread. Without management, recreational pig hunting is expected to prevent population irruption but some small range extension is expected.

Figure 24. Feral pig abundance. The abundance measure is the Guilford scale (see Fig. 21) with a uniform value of 2.

Figure 25. Distribution of introduced salmonids (rainbow trout, brown trout, sockeye salmon and quinnat salmon).

The Guilford scale (see Bennett's wallaby, above) was used to index feral pig abundance. However a better approach would be a measure of the area of ground rooted by pigs as this would be a more direct measure of their impact on biota.

Introduced salmonids (Fig. 25) distribution was described by the inland water bodies from the LCDB. Insufficient was known of their abundance patterns to provide any detail beyond distribution alone. Also, since the small rivers and streams cannot be represented by 1 km^2 pixels, the full extent of their range is underestimated.

Rabbit abundance was based on spotlight counts collected by the Canterbury Regional Council (Fig. 26). Environmental domains were used to extrapolate the spotlight count data across the landscape. Mean rabbit counts were estimated for each of the 24 environmental domains and then extrapolated across each to define the spatial pattern of rabbit abundance. Twizel staff considered that this overestimated rabbit abundance above 1000 m and in the high rainfall parts of the Area. Accordingly, the 1000 m contour was used to define additional areas of low rabbit abundance at higher elevations.

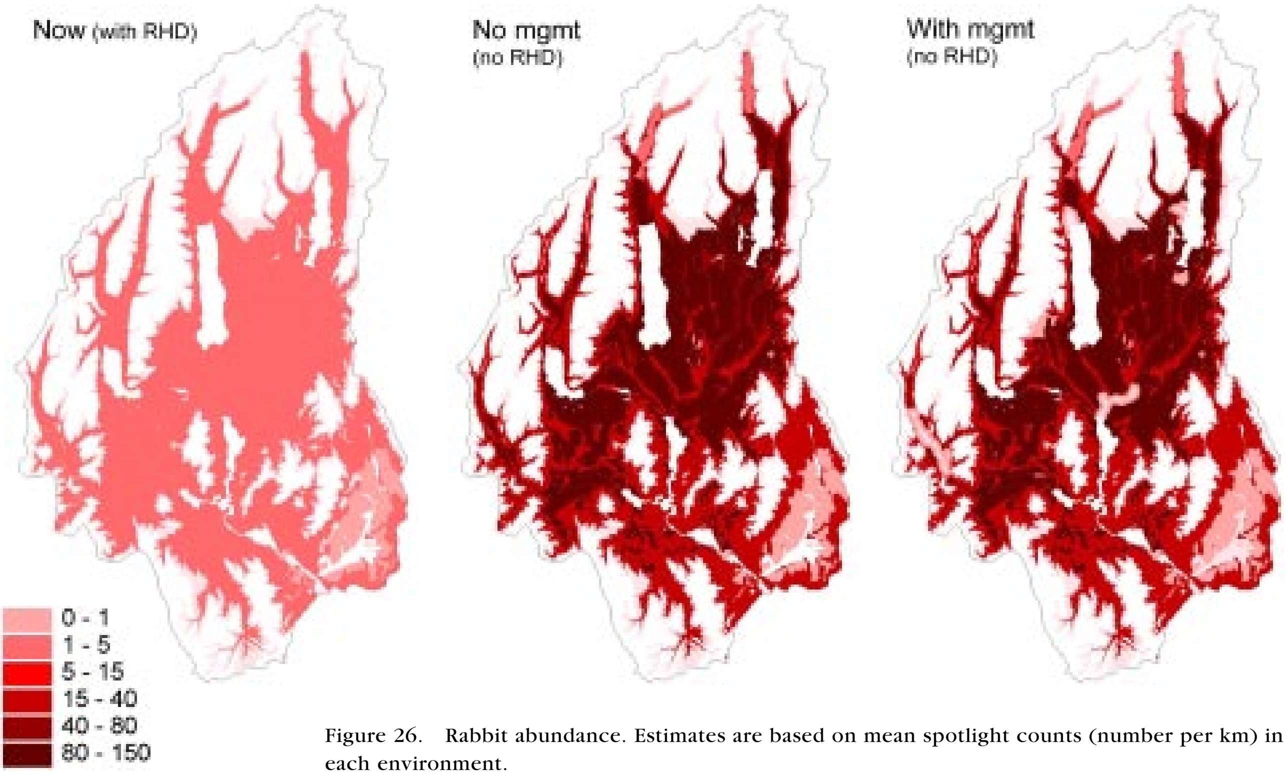


Figure 26. Rabbit abundance. Estimates are based on mean spotlight counts (number per km) in each environment.

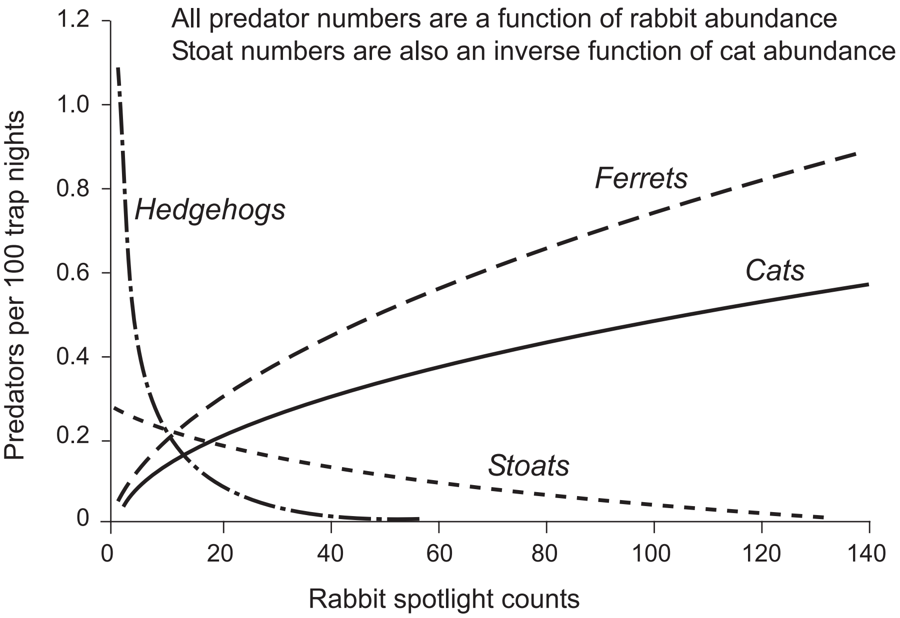
Mean spotlight count data was also estimated for each of the six rabbit proneness classes (derived by Landcare Research from soil and landform information taken from the Land Resources Inventory). With only six classes, this provided less differentiation of the spotlight count data than the environmental domains and so was not used.

Rabbits are currently at historically very low abundance (< 5 rabbits per km of spotlight count) and their distribution is anomalous because of rabbit hemorrhagic disease (RHD) and the intense control efforts of private landowners. Present rabbit abundance is most depressed in areas where they would normally be most abundant and less depressed in normally less favoured areas. It is not clear whether RHD will continue to depress rabbit populations or whether immunity will develop allowing rabbit abundance to recover. The latter scenario (RHD immunity) is considered more likely, and this is the scenario modelled unless otherwise stated. Rabbits are controlled in a number of small reserves, two of which are visible in the maps below.

Cat, stoat, ferret and hedgehog abundance estimates were based on numbers trapped in predator control operations designed to protect breeding black stilt. The location of trapping operations meant that only two environmental domains were sampled, providing little basis for defining spatial variation in abundance. All four species were presumed to be water- and altitude-limited (cat, stoat and ferret c. 2000 m; hedgehog c. 1200 m).

Cat, stoat, ferret and hedgehog numbers vary with rabbit abundance. Cats are known to displace stoats, so stoat numbers are expected to increase in response to lower cat numbers. Hedgehog abundance is known to decline with increasing rabbit abundance, presumably because of the impact of rabbit grazing on vegetation cover needed by hedgehogs. These relationships (Fig. 27) were defined and used to model predator abundance (Figs 28 and 29).

Figure 27. Modelling pest interactions. Cat, ferret, stoat and hedgehog numbers appear to be regulated by rabbit aundance. Functions describing this relationship were used to spatially predict predator abundance patterns (Figs 28 and 29).



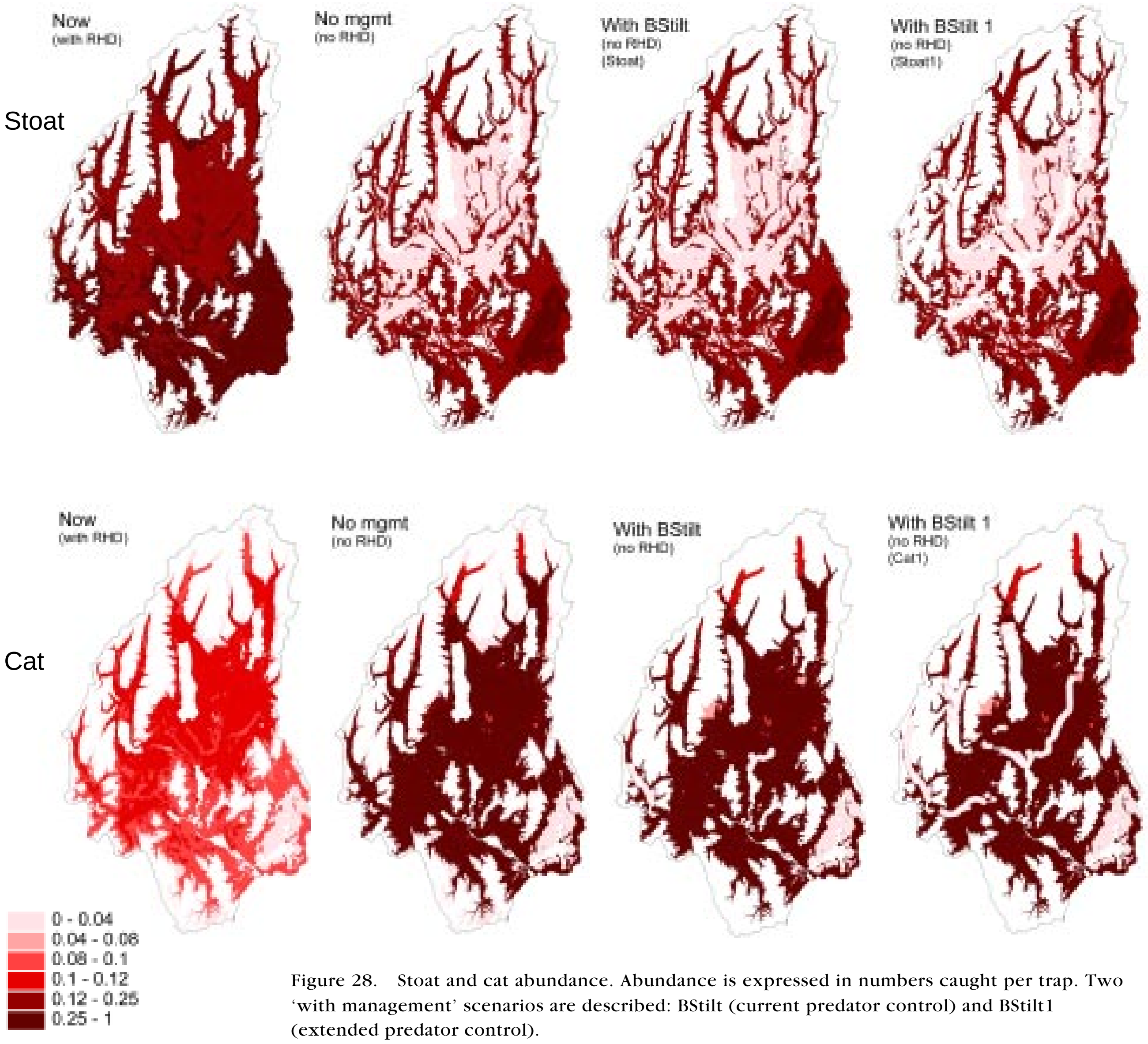


Figure 28. Stoat and cat abundance. Abundance is expressed in numbers caught per trap. Two ‘with management’ scenarios are described: BStilt (current predator control) and BStilt1 (extended predator control).

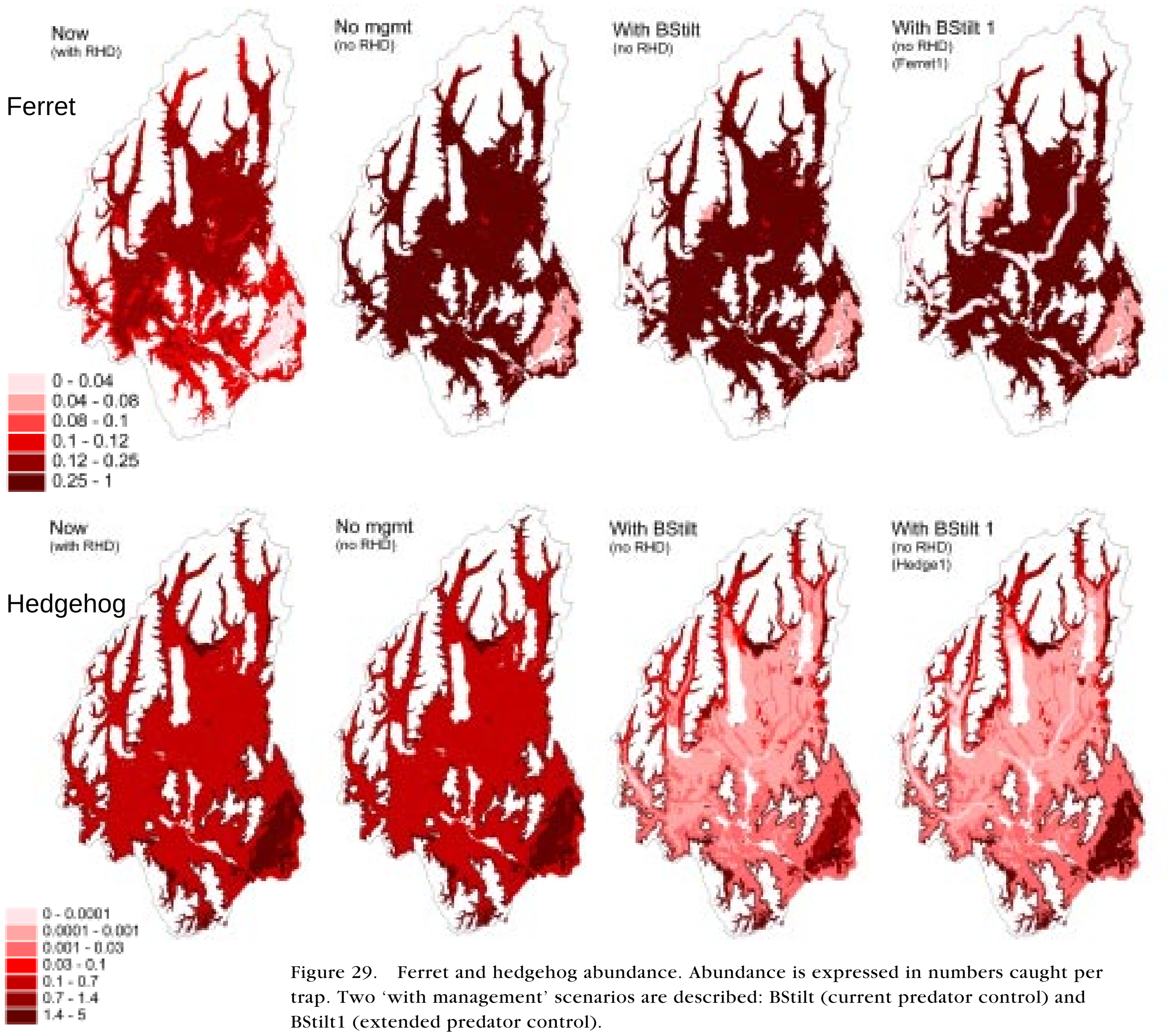


Figure 29. Ferret and hedgehog abundance. Abundance is expressed in numbers caught per trap. Two 'with management' scenarios are described: BStilt (current predator control) and BStilt1 (extended predator control).

Predator control operations are intended to eliminate these four predators from places on riverbeds and wetlands used by breeding black stilts. Two predator control scenarios are examined: the current situation and a more ambitious effort over a greater area of black stilt habitat (BStilt1).

8.3.1 Consumption pressure

The consumption pressure index is based on explicit definition of the relationship between the abundance of each pest present and the proportion of each community component lost. Three community components were recognised:

- plants
- invertebrates
- vertebrates.

Ten animal pests were included in the consumption pressure index. These were: thar, Bennett's wallaby, fallow deer, stock (cattle and sheep), feral pigs, rabbits, cats, stoats, ferrets, hedgehogs and introduced salmonid fishes (rainbow trout, brown trout and quinnat salmon).