*Paper*

# Determining a conservation threat classification for the Nevis skink, *Oligosoma toka*

**Trent Bell[1], Craig Wilson[2] & Sarah Herbert[1]**

[1]EcoGecko Consultants, Level 1, 32 Egmont Street, New Plymouth 4310

[2]Central Otago Area Office, Department of Conservation, PO Box 176, Alexandra 9340

[1]Corresponding Author: trent@ecogecko.co.nz

**Abstract:** A survey was undertaken during October 2011 to obtain information which would allow the data deficient Nevis skink (*Oligosoma toka*) to be assigned a conservation threat classification. We recommend that this species be assigned the new threat category of 'Naturally Uncommon (One Location)', since this rank appears to be the best fit for this species, in accordance to currently available information on range and abundance. The qualifier 'One Location' is based on the following considerations: (a) the Nevis skink appears to be unique to the Nevis Valley—a geographically distinct intermontaine basin, (b) the entire skink population should be considered as one large meta-population, and (c) the range of the Nevis skink is no more than 8,900 hectares in extent. In this scenario, a single event (such as a predator irruption or further habitat loss) could affect all individuals in the meta-population. We have crudely estimated the population to be around 20,000 individuals; this figure is a starting point for more accurate estimation in the future.

## Introduction

The Nevis skink (*Oligosoma toka*) is a recently described species from a group of skinks formerly considered to be part of the cryptic skink (*O. inconspicuum*) species complex. This species is currently known only from the Nevis Valley in Central Otago. However, the taxonomic status of this skink was once so cryptic that both historical and more recent lizard surveys of the Nevis Valley did not recognise the species as distinct from common skinks (*Leiolopisma nigriplantare maccanni* forms "spotted" or "speckled", in Whitaker (1986)), or subsequently, from cryptic or McCann's skinks (*O. inconspicuum, O. maccanni*) during the tenure review processes of various high country stations in the 2000's (LINZ 2002-2010). This was despite it being the most abundant skink species within the lower Nevis Valley (Jewell, 2010; Chapple et al., 2011). The species was only formally recognised in 2011 via genetic analysis of DNA material from historical voucher specimens held in the collection of *Te Papa Tongawera,* the Museum of New Zealand (Chapple et al., 2011), although Whitaker (1986) may have recognised the species during the Wildlife Service surveys. This genetic analysis revealed *O. toka* to have a very deep genetic divergence from *O. inconspicuum* (15.2%) and from its two closest relatives; the Burgan skink *O. burganae* (10.4%) and the Eyre Mountains skink *O. repens* (9.1%) (Chapple et al., 2011).

*Oligosoma toka* is a medium-sized (45-71 mm snout-vent length) brown-grey skink, sometimes dorsally flecked or striped, or both (Chapple et al., 2011; Figs. 1 & 2). It is noted to be strongly heliothermic and saxicolous (Jewell, 2010; Chapple et al., 2011). The range of *O. toka* is thought likely to be the entire Nevis Valley and adjacent areas, and possibly also the neighbouring Hector and Garvie Mountains (Jewell, 2010). As such, it is considered to have potentially one of the more restricted ranges for a mainland skink species.

The Nevis Valley is a self-contained, long and narrow catchment encircled by mountainous ranges, and can be described as an intermontaine basin. This basin contains a diverse array of landforms including spur ridges, rock tors, river flats, incised channels and gorges, gravel braids, alluvial terraces and fans of different ages. The environment has been altered due to historical fire, grazing by pastoral leaseholders from 1859 to present times and intensive alluvial gold sluicing and dredging operations predominantly between the 1890's and early 1900's (the gold prospecting period spanned from 1863 into the 1960's) (Land Information New Zealand (LINZ), 2004, 2005a, 2006a and 2007b).

The Nevis Valley falls within the LAKES 66.05 Remarkables, CENTRAL OTAGO 67.05 Old Man, and WAIKAIA 74.01 Nokomai Ecological Districts (ED) (McEwen, 1987). The Remarkables ED consists of extremely steep, rugged and strongly glaciated schist mountains to 2,300 m asl, outwash gravels and alluvium valleys, and the vegetation composition is predominantly scrub, fernland, tussockland, alpine cushion, and occasional beech forest remnants in valleys (McEwen, 1987). The Old Man ED consists of block-faulted schist mountains, extensive tablelands, and has a dry subcontinental climate with intense frosts and frequent snow occurrences (McEwen, 1987). This ED has an altitudinal sequence of grassland, tussockland, scrub, herbfield and cushionfield. The Nokomai ED consists of broad plateaus and hills of a moderate altitude (> 600 m to 1500 m asl) with a complex geological composition, but usually consisting of schist and greywacke rock formations (McEwen, 1987).

Lizards also known from the Remarkables, Old Man and Nokomai EDs include the geckos *Woodworthia* aff. *maculatus* 'Cromwell', *W.* aff. *maculatus* 'Otago Large', *W.* aff. *maculatus* 'Central Otago', *W.* aff. *maculatus* 'Southern Mini' and *Mokopirirakau* aff. *granulatus* 'Roys Peak'; and the skinks *O. chloronoton*, *O. inconspicuum*, *O. maccanni* and *O. polychroma*. Historical accounts for *O. grande* exist for the Remarkables ED and *O. otagense* for the Old Man ED, while subfossil remnants of what appears to be *Hoplodactylus delcourti* are recorded from the Earnscleugh cave within the Old Man ED (DOC BioWeb *Herpetofauna* database, accessed October 2011).

Species currently known from the Nevis Valley itself, other than *O. toka*, are the skinks *O. inconspicuum*, *O. maccanni* and *O. polychroma*, while the geckos *M.* aff. *granulatus* 'Roys Peak', *W.* aff. *maculatus* 'Cromwell', *W.* aff. *maculatus* 'Otago Large', and *W.* aff. *maculatus* 'Southern Mini' are recorded at higher altitudes (Jewell, 2010). The jewelled gecko (*Naultinus gemmeus*), green skink *O. chloronoton*, grand skink *O. grande* and Otago skink *O. otagense* are thought to be rare or extinct within the valley (Whitaker, 1986; Jewell, 2010).

*Oligosoma toka* has been found to be abundant around man-made rock piles (historical gold tailings) alongside the Nevis River and in natural rock formations (Jewell, 2010; Chapple et al., 2011, see Fig. 3). Nevis skinks also occur in lower abundances on the river flats, around the foothills and north to Nevis Crossing. In rocky habitat, *O. toka* appear to have important associations with tussocks, rank grasses, *Coprosma*, *Discaria*, *Muehlenbeckia*, *Melicytus* and *Rubus* species (Chapple et al., 2011). Grazing has probably degraded the habitat by reducing the quality and complexity of the native vegetative cover surrounding the skink's rocky habitat.

Prior to this work, little was known about this species' range, abundance and population viability. This lack of knowledge about the species arose from its prior taxonomic obscurity, and has caused some difficulty in assigning the species a conservation threat status other than data deficient (Hitchmough et al., 2010). This study aims to search for prior and historical information, undertake surveys and to determine the range, abundance and habitat for *O. toka*, and make recommendations about the conservation threat classification assignment for this species.

## Methods

### *Literature and records review*

A literature review was undertaken with tenure review reports and other previous lizard surveys in order to source further information on lizards and habitats within the study area. Tenure review reports were obtained for the following pastoral leasehold properties: Ben Nevis, Carrick, Craigroy, Glen Roy, Glen Nevis, Kawarau, Loch Linnhe, and Mt Difficulty Stations (LINZ, 2002a & b, 2004, 2005a & b, 2006a & b, 2007a & b, and 2010; Table 1). No tenure review reports currently exist for Nokomai or Wentworth Stations. A historical lizard survey report was reviewed (Whitaker, 1986) and a statement of evidence for the Special Tribunal on behalf of Pioneer Generation Limited (Jewell, 2010)—a report with special reference to *O. toka*—was also reviewed.

Finally, the Department of Conservation's BioWeb *Herpetofauna* location records database was utilized to map lizard records for the general locality to identify known lizard distributions.

### *Field survey*

The collated reports and records were used to plan rapid presence/absence and abundance surveys across a number of locations during 11th-23rd October 2011, which were used to assess the distribution of *O. toka*. The rapid surveys began at the type locality in the Nevis Valley (Chapple et al., 2010) and expanded outwards in all accessible directions. These surveys were centred on the lower and upper Nevis Valley and

were within the bounds of the Kawarau River to the north, the Hector Mountains to the west and the Garvie Mountains to the south. This rapid surveying involved visual surveying of habitat and potential refugia during the day time. The aim of this survey was to search as many locations and habitat types as possible over as large an area as possible, within access limitations. The data collection format followed the structure within the Department of Conservation's Amphibian and Reptile Distribution Scheme (ARDS) cards. Data collected during the surveys included date of search, observers, location name, global positioning system (GPS) waypoints of skinks and locations surveyed, time of search (start and finish), altitude and slope aspect, species found and the number of individuals for each species, habitat and skink photographs, major habitat type (including plant species), microhabitat, weather (including temperature, relative humidity and wind).

Minimum convex polygons (MCP) combined with an altitude gradient representing the range of *O. toka* were calculated from the locations where their presence was detected. This method can overcome most issues with land access, bypassing non-permitted areas. The Nevis skink is a highly detectable diurnal and terrestrial species that inhabits an open and simplified ecosystem. Use of visual surveys and direct searching of refugia are proven methods for detection of this species. There is little risk of a false absence result, except during inclement or cold weather, or on extremely hot days.

To assess abundance at smaller sampled locations, a pilot trapping trial was undertaken, using g-minnow, pitfall and funnel traps. Such trapping was initially expected to be randomized against habitat type and altitude, and we planned to extrapolate the data against mapped habitat and range information to infer abundance. Trapping trials for the abundance assessments were trialled at seven locations within tailings on the lower Nevis Valley (700 m asl) where Nevis skinks were clearly abundant. These locations had GPS waypoints fixed, and photo-points taken. At each location, two g-minnow traps, one funnel trap, and two pitfall traps were placed on 11 October 2011, baited with tinned pear and checked daily for three days. Pitfall traps were ringed with a 50 x 50 cm black polythene sheet and placed in crevices between rocks to protect the structural integrity of the tailings, which are important archaeological features. A total trap effort of 21 funnel trap days, 42 g-minnow trap days and 42 pitfall trap days were achieved under optimum weather conditions for skink activity. However, these trapping techniques resulted in very low skink captures, therefore visual and refuge search transects across 30 m of apparent skink habitat were later adopted as the abundance measure.

Habitat classification and mapping was conducted using two GIS programmes (MapToasterTopo and Google Earth) using the presence/absence information for *O. toka* against habitat metadata. Assumed historical changes in habitat type and structure were assessed using aerial photography, topographic information, and literature research. This habitat mapping attempted to determine the species' range and abundance, and potentially the rate of habitat increase or loss over the past few decades, and the amount of legal protection using the Threatened Environments Classification (Walker et al., 2007).

## Results

*Literature and records review*

The historical lizard survey undertaken by Whitaker (1986) recorded "spotted" and "speckled" forms of a skink species in the Nevis Valley then known as *Leiolopisma nigriplantare maccanni*. The species grouped at the time under *L. n. maccanni* are today recognised as *O. maccanni*, *O. polychroma*, and *O. inconspicuum* (and two other species not local to the Nevis area), and these observations within the Nevis Valley may refer to any of the locally recorded species (Patterson & Daugherty, 1990). However, Whitaker (1986) apparently recognised the "speckled" form as distinct from the more widespread "spotted" form (= ? *O. maccanni*), and records the "speckled" form at two localities: "… found only in the Nevis Valley in the vicinity of Nevis Crossing and in the lower reaches of Coal Creek. They occurred in well-vegetated sites, often on south-facing slopes, where there was additional cover provided by loose stones" (Whitaker, 1986).

Tenure review reports of various high country stations carried out by the Department of Conservation and expert contractors in the Nevis Valley and adjacent area provide some lizard records and information. Not surprisingly, none recognised the existence of the skink within its known range, as the surveys occurred before the realisation that the Nevis skink was a distinct species. However, whenever the skink's populations were recognised (as *O. inconspicuum*), the tenure review did not apparently realise the abundance of the skink, reporting only single individuals. This was despite the notable abundance of *O. toka* in the Nevis Valley reported by Jewell (2010) and Chapple et al. (2011). None of the tenure review reports recognised the significance of these skink populations because they failed to recognise the distinctiveness of the species or note the local abundance of a lizard.

A survey of the lower altitude areas of the Nevis Valley was carried out by Jewell (2010) during January 2010. In this survey, seventeen sites were surveyed between the Nevis Crossing and Sproules Creek. Nevis skinks were found to be widespread in the lower altitudes in the upper gorge, the mountain

foothills and the river flats (BioGecko GeoReferences[1] 1-12). In most areas where Nevis skinks were found, they were the most common and abundant species (Jewell, 2010). Nevis skinks were found predominantly in association with rock piles: tailings, old stone walls, screes, and terrace edge tumbles (Jewell, 2010).

*Rapid presence/absence surveys*

At least 372 Nevis skinks were recorded during our extensive survey of the Nevis Valley and adjacent areas. We also recorded McCann's skink (n=232), cryptic skinks (n=22), common skink (n=22), Otago Large geckos (n=16) and Cromwell geckos (n=28). A further sixty-six skinks were seen but not identified.

Ben Nevis Station had very abundant Nevis skinks in the historical gold mining tailings alongside the Nevis River and on the Nevis flats (GeoRefs 157-186, 193-271). A series of natural screes at Commissioner's Creek and Schoolhouse Creek, two tributaries of the Nevis River, also had Nevis skink populations (GeoRefs 180-186). Individual skinks were recorded up to 1,000 m above sea level (asl) (GeoRefs 497-499). Cryptic skinks (*O. inconspicuum*) were recorded at the foothills of the Hector Mountains (GeoRefs 201-203), often in sympatry with Nevis skinks in these locations, although they were not generally recorded on mine tailings. McCann's skinks were sparse within Ben Nevis and along the Hector Mountains foothills, only occurring in abundance at one location (GeoRef 201). This location is notable as it was the only location where all three skink species were recorded as sympatric. No geckos or common skinks were recorded in Ben Nevis.

Nevis skink populations were recorded on Carrick Station (Carrick Block) up to 1,000 m asl (GeoRefs 272, 298-299, 306-307, 311-312), along with McCann's skinks from around 900 m asl and higher (GeoRefs 288-289, 292-293, 300-305, 309-310). A population of *Woodworthia* geckos (Cromwell and/or Otago Large; the taxonomy remains to be determined by DNA analysis) were present at some rock outcrops in the Potters Creek area (GeoRefs 292-293, 295-296, 300, 310). An apparently new skink species was also captured in the Potters Creek area (GeoRef 313, see p.43 of this issue).

Carrick Station (Nevis Block) also had Nevis skinks up to 1,020 m asl (GeoRefs 333, 337-338, 340-341, 347-350). No other skinks or geckos were recorded.

McCann's skinks were particularly abundant at Kawarau Station, although there were some unidentified skinks (GeoRefs 368-399). These were in moderate abundances on rock outcrops. No Nevis skinks were identified in Kawarau Station.

At Mt Difficulty Station, McCann's skinks were also particularly widespread, although not all skinks were identified (GeoRefs 161, 163-196) and *Woodworthia* sp. 'Cromwell' geckos (GeoRefs 461-462, 470-474) were recorded. No Nevis skinks were discovered.

We also accessed the property on the opposite side of the Kawarau River from Mt Difficulty Station where the AJ Hackett Nevis Bungy operates, and also the Bannockburn sluicings; only McCann's skinks were recorded there.

At Loch Linnhe, McCann's skinks were recorded from over 1,300 m asl down to the valley floor (GeoRefs 401, 403, 423-428, 430-432), with common skinks on tailings and along the river edges (GeoRefs 422, 433-440, 457, 441, 445, 447, 449, 450 and 457), and cryptic skinks along rocky talus slopes up to the south of Commissioner's Creek (GeoRefs 454-456, 458-459). No Nevis skinks or geckos were discovered.

One McCann's skink was recorded at Glen Nevis near the sluicings (GeoRef 362), however several unidentified skinks were seen running in snow tussockland (GeoRefs 363-367). These skinks are unlikely to be *O. toka*, as there is no significant rock habitat in this area.

No survey was able to be undertaken at Craigroy Station, although the valley floor habitat is very similar to that of Ben Nevis immediately opposite across the Nevis River. Nevis skinks were also present at both the Carrick Block and Nevis Block sections of Carrick Station which are adjacent to Craigroy. Further, Whitaker (1986) and Jewell (2010) have also recorded Nevis skinks on Craigroy (GeoRefs 2, 4, 6 for the latter). Other stations not able to be surveyed during this work either due to time or access limitations includes Cone Peak, Mount Rosa, Nokomai, Wentworth, Glenroy, or Kingston Stations.

*Habitat classification & mapping*

Since the rapid survey information suggested that Nevis skinks are confined to areas of the lower Nevis Valley < 1,020 m asl, we estimated the species' range to occupy approximately 8,900 ha. However, their habitat varies within this range, from high densities in both natural scree and mining tailings to sparse occurrence across grazed tussocklands on the river flats and foothills—these may represent dispersing individual skinks. Accordingly, we estimated the combined sizes of each habitat type using remote GIS and ground-truthing at some sites. Grazed high country and lowland tussockland made up the greatest proportion of the available habitat (8,020 ha). Mine tailings was the next most abundant habitat available (65.5 ha, 10 sites), while finally scree habitat on natural river terraces was the least available habitat (14.3 ha, three sites), although the actual area for this habi-

[1] To obtain the BioGecko GeoReference file and associated files for this paper, please contact the editor.

tat type is difficult to identify and quantify via remote GIS. There are likely to be further such habitat that we were not able to identify. There was an additional maximum potential of 94.8 ha across 16 sites for river terraces, which may contain further natural scree habitat, but again, we note the difficulty of confirming the rocky nature of such sites via remote GIS analysis.

*Local abundance*

Despite the apparent abundance of skinks in the trapped area during the three-day trapping trial, only one skink was trapped with a funnel trap on the first day. Trapping as an abundance assessment was discontinued in favour of 30 m transects across tailings, as it was found that skinks could be readily detected by simply walking over their habitats on warm, sunny days. The 30 m transect surveys of 11 October 2011 used a double- or triple observer method, where the lead or primary observer moved slowly looking for skinks, and the second and third observers turned over rocks for inactive or hiding skinks. Transects were assumed to detect skinks within a 5 m search zone on each side of the lead observer, and no conscious attempt was made to extend this search area beyond 5 m. These surveys took place at two locations: the tailings (16 transects) and at a series of natural scree at Commissioner's Creek (seven transects) (Table 2). Natural scree habitat, a generally sparse habitat in the Nevis Valley, had the most skinks per transect (mean 8.86 skinks per transect, range 3-18), while tailings had variable numbers of skinks (mean 3.13 skinks per transect, range 0-14). No skinks were noted in grasslands away from rocky habitat during the entire survey, therefore no transects were carried out for this habitat type. It appears that natural scree and fellfield also had the most complex habitat and vegetation structure available, in contrast to tailings. Natural scree and fellfield habitats usually had larger rocks along with communities of *Aciphylla aurea*, *Melicytus alpinus*, *Leucopogon fraseri*, and *Coprosma propinqua*, as well as native and exotic grasses. Tailings were usually associated with *Rosa rubiginosa*, exotic herbs and grasses and *Hieracium*, with occasional *A. aurea* and *M. alpinus*. These habitat factors may explain the abundance differences of *O. toka* across transects. However, since tailings are a far more abundant habitat type than natural scree and fellfield, they remain an important habitat for *O. toka*.

Surprisingly, despite the extensive rock tor habitat present, particularly those on the eastern side (true right) of the Nevis River across Carrick Station (both the Carrick Block & Nevis Block) and Craigroy Station, no Nevis skinks were recorded in this habitat type.

We extrapolated the observed naïve density of Nevis skink populations recorded in transects for the habitat types we encountered in the lower Nevis Valley (in skinks per hectare, calculated as: average number of skinks per 300 m² transect x 33 1/3). Mining tailings were calculated to have approximately 104 skinks per hectare, while natural scree habitat on river terraces had approximately 295 skinks / ha. Based on our wide ranging observations in both grazed tussockland and river terraces without well-formed scree but with sparse rock habitat, we arbitrarily estimated that there was only one skink / ha for these habitat types. We therefore have conservatively estimated that there are approximately 19,160 Nevis skinks within their entire range.

*Other observations*

Nevis skinks appear to have excluded both McCann's and common skinks from occurring in broad sympatry with them in the lower Nevis Valley. In the upper Nevis Valley south of Commissioner's Creek, Nevis skinks cease to be found (apart from a single record by Jewell (2010)), but common and McCann's skinks become the predominant lizard species, in what are essentially similar habitats for both valleys.

Although McCann's skinks have been recorded in the valley itself, and are often recorded in similar habitat elsewhere, they appear to be largely restricted to the Hector and Garvie mountain foothills or higher (usually above 1,000 m asl). Where Nevis skinks occur in abundance, no or particularly few McCann's were present, and where Nevis skinks appear to reach their altitudinal extent (1,020 m asl), McCann's skink then become abundant. This is in contrast with the upper Nevis Valley, where McCann's skink and also common skinks are abundant down to the valley floor (~800 m asl). In the particularly drier and more degraded environments of the stations to the north, McCann's skinks also become abundant once the primary ground cover becomes the introduced plant, thyme (*Thymus vulgaris*), a conspicuous feature of the Central Otago drylands. It appears that in such dryland ecosystems (as is in the case to the north and east of the Nevis Valley), or at altitudes of above ~9,00-1,100 m asl, Nevis skinks cease to be recorded. Since the Nevis Valley appear to be a self-enclosing intermontaine valley system, it is unlikely that *O. toka* are present outside the valley.

In addition to the apparent competitive displacement of *O. maccanni* within the lower Nevis Valley, the skinks themselves appear to be behaviourally more similar to *O. maccanni* than to any of the other species within the *O. inconspicuum* species-complex (Chapple et al. 2011). *O. toka* are notably strongly heliothermic and saxicolous, and occupy dry rocky habitats. This is similar to *O. maccanni*, supporting the genetic evidence of Chapple et al. (2011) that the two are more closely related than *O. toka* is to *O. inconspicuum*. *O. inconspicuum* usually prefer damp microhabitats, typically with tussock, herb and shrub

associations. Locally resident populations of *O. inconspicuum* and *O. maccanni* are also heliothermic and saxicolous, but not to the remarkable extent that *O. toka* are.

*Oligosoma toka*,when under threat, often curl up with their tail above their head (Figure 2). Such behaviour has been noted and photographed before (Geoff Patterson pers. comm.) and was also displayed in *O. inconspicuum* populations from Big Bay (Mandy Tocher, pers. comm.)

Other observations included (a) *O. toka* recorded as solitary individuals within long grass (sweet vernal, tussock, *Festuca rubra*), near rocks, or underneath solitary rocks; (b) a gravid female *O. toka* with a pink mite near its eye; (c) the sighting of a black-fronted tern (*Chlidonias albostriatus*) with a skink in the upper Nevis Valley, which was possibly an *O. maccanni*. Terns were observed to have particular interest in McCann and common skink populations on tailings in this location.

During our wide-ranging survey, we confirmed the presence of rabbits, hares, wild cats, pigs, goats, red deer, sheep, Angus cattle, possums, dogs, magpies and blackbirds. Other avian fauna also include the abovementioned black-fronted tern, spur-winged plovers, black-backed gulls, variable oystercatcher, pipit, Australasian harrier, NZ falcon, skylark, yellowhammers and banded dotterels.

## Discussion

### *Threat classification rank*

The Nevis skink appears to be almost entirely restricted to the lower Nevis Valley and the adjacent mountains up to 1,020 m asl. No populations were detected north of Potter's Creek, nor south of Commissioner's Creek, the latter despite apparently suitable habitat, including further tailings, alongside the Nevis River gorge up to the upper Nevis Valley. We note Jewell (2010) did record one Nevis skink in the gorge (GeoRef 11), but we were unable to verify this. We detected other skink species north of Potters Creek and south of Commissioners Creek, indicating that our search methods in these areas were reasonably effective. Further, the most abundant populations appear to be on the mining tailings alongside the river and wherever natural block fellfield or alluvial scree occurs, since the skink becomes particularly sparse away from extensive rock habitat. This suggests that this skink is highly saxicolous, although rocky habitat is typically patchy in the area.

The Nevis skink is best described as having a meta-population structure across the entire range of this species. A meta-population consists of spatially separated groups of populations of the same species which interact at some level, along with areas of unoccupied habitats (Levins, 1969; Hanski, 1999). In Townsend et al. (2008), this distinction is different for sub populations since the latter are defined as "groups of individuals that have resulted from past or ongoing fragmentation (natural or human induced) between which there is now little genetic exchange". We do not believe that the population clusters around tailings and fellfield habitat are sufficiently isolated as to prevent genetic exchange, due to the frequent but sparse encountering of individual Nevis skinks in grassland and river terrace habitat. In classical meta-population theory, each population cycles in relative independence of the other populations and eventually goes extinct as a consequence of demographic stochasticity (fluctuations in population size due to random demographic events); the smaller the population, the more prone it is to extinction (Hanski, 1999). However, both source-sink dynamics and rescue effects (by immigration and emigration of animals between populations) are important meta-population processes which maintain the integrity of the overall meta-population (Hanski, 1999). This highlights the importance of connectivity between seemingly isolated populations. Although no single population may be able to guarantee the long-term survival of a given species, the combined effect of many populations may be able to do this.

The abundance of this species at certain localities can be remarkable (Jewell, 2010; this paper). However, such abundance does not necessarily imply overall species security, given the apparent restricted range of the species. There are other lizard species with high local abundances in rocky habitat, but a highly uncertain future, including the 'Nationally Critical' grand and Otago skinks (*O. grande*, *O. otagense*) (Norbury et al., 2006).

Although there is no direct evidence of any current agent of decline, circumstantial evidence suggests that the habitat of the Nevis skinks probably have undergone vast scale changes. The Threatened Environments Classification (a combined description of past losses of indigenous vegetation and current legal protection; see Walker et al., 2007), has identified a high proportion of habitats within the range of *O. toka* as being either Category 1 (Acutely Threatened) or Category 2 (Chronically Threatened) on the lower Nevis Valley flats (where no more than 20% of the original vegetation cover has remained). On the foothills, Category 3 (At Risk; 20-30% of original vegetation cover remaining) habitat is predominant. Less than 10% of environments in Categories 1-3 are legally protected, and Categories 1 and 2 are Priority 1 for the New Zealand Government's National Priorities for Protecting Rare and Threatened Biodiversity on Private Land (MFE 2007). This classification for this area indicates extensive clearance has occurred of what would once have been extensive tussockland and scrubland, interspersed with natural rocky fellfield and scree habitats. This extensive habitat modification of the lower Nevis Valley would have been caused by a combination of agriculture practices, hu-

man-induced fire and mining during the 1860's to mid-1900's (LINZ 2004, 2005a, 2006a and 2007b). In fact, during our survey we struggled with the fact that there was apparently little natural rock habitat, apart from the rocky river gorges and tors, evident today for a strongly saxicolous species, and led us to question what their original habitat could possibly have been like during pre-human times. One theory is that sluicing operations may have removed natural rock habitat on river terraces and gullies and deposited these as tailings, potentially covering up other original alluvial scree habitat, while river dredgings added further tailings, which the skinks took up. Some rock from low altitude scree and fellfield habitat on the foothills may have been used for stone buildings and stone walls or framing in settlements during the gold rush period from the 1860's to 1900's—particularly around 1866 when more than 600 people settled in the area across two townships at the Nevis Crossing and Schoolhouse Flat (Hamel, 1994). While many buildings may have been mud brick or wooden, there are certainly several stone buildings and ruins still standing in the lower Nevis Valley. However, the use of stone for buildings is unlikely to be of a scale that would have affected the habitat of the Nevis skink. Regardless, it is a possibility that mining operations have created rockier habitat than previously existed, a man-made habitat which provided new refugia after the complex natural rock, scrub and grassland habitats that were lost due to anthropogenic factors. Large scale vegetative change within the range of *O. toka* provides skinks with few available refugia from introduced mammal predators, which may be exacerbated by multi-pest population dynamics driven by introduced rabbit abundances (Norbury, 2001). Norbury (2001) suggests that loss of refugia results in very severe predation on skinks and is most severe in areas of high rabbit and predator numbers, where vegetation is depleted. It is therefore their potential vulnerability to land-use changes — especially for underprotected lowland habitats, possible degradation or loss of protection of human historical sites, and potential exposure to introduced mammals that indicate this species is of conservation concern.

However, in the absence of any evidence of *present or recent* declines — an important consideration when determining threat classifications — we cannot be certain whether or not *O. toka* have recently declined, or are currently declining in number, as this species is certainly locally abundant today. Due to the lack of applied lizard studies given the remoteness of the area, and the recent taxonomic uncertainty of this species, few studies had been conducted on *O. toka*, and none involved population studies. Because of the short nature of this survey, and the absence of any historical data, we were not able to assess population trends of *O. toka*, although juvenile and neonate skinks were frequently encountered during our work, which indicates successful breeding is occurring for this species.

We therefore recommend the conservation threat classification of 'Naturally Uncommon (One Location)' for this species. The rationale for this listing are that the Naturally Uncommon rank is the best fit for this species, in accordance to currently available information on range and abundance, despite the highly modified habitats available. Both estimated population size and area of occupancy are too large to trigger inclusion in any of the Threatened categories in the absence of any evidence of ongoing decline. The qualifier One Location was triggered by the following considerations: (a) the Nevis skink appears to be unique to the Nevis Valley—a geographically distinct intermontaine basin, (b) the entire skink population should be considered as one large meta-population, and (c) the currently known range of the Nevis skink does not exceed 100,000 ha. In this scenario, a single event (such as a predator irruption or further habitat loss) could affect all individuals in the meta-population.

This threat classification may be subject to revision if further evidence of population trends becomes available. Our recommendation is that a multi-year population monitoring programme would be particularly useful in determining population trends, identifying any current or predicted agents of decline, and develop management recommendations for the species and their habitat.

*Study limitations*

We are aware of some limitations to our survey. We were unable to survey the area past the Nevis Burn on Ben Nevis Station, thus the north-western limit of the range of *O. toka* remains to be determined. The population at Potter's Creek, a tributary on the true right of the Nevis River, therefore represents our northernmost record for Nevis skinks. Additionally, we were unable to access Craigroy due to access restrictions, Kingston Station (which was inaccessible due to snow over the high pass), and the northern portion of Nokomai Station, which is on the eastern side (true right) of the Nevis River and south of Commissioner's Creek. No tenure review reports were available for Wentworth or Nokomai Stations, yet these are areas of particular interest for our study. We recommend follow-up lizard surveys of these areas.

We acknowledge that our 'back of an envelope'-type of abundance and range estimates for Nevis skinks appear unconventional, even somewhat arbitrary. This problem arose as a result of the lack of trappability of skinks using different trap methods in our trap trial, which made mark-recapture studies difficult. However, because we combined visual surveys with refuge searches, we were able to reduce weather effects on detection, especially whenever

conditions became marginal. Nevis skinks were easily observed, avid sun baskers that returned quickly to their original basking spot after being disturbed. Our abundance and range estimates are conservative, but these estimates fall comfortably within the large ranges offered to categorize abundance and range when determining threat classifications for different species (Townsend et al., 2008). Our estimates were therefore appropriate for this purpose, and offer a starting point for more accurate and precise population estimation studies in the future.

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FIGURE 1: Nevis skink, *Oligosoma toka*.

FIGURE 2: Defensive display of *Oligosoma toka* when threatened.

FIGURES 3 & 4: Typical habitat of Nevis skinks: (3) natural alluvial scree formations (left); (4) man-made tailings from alluvial gold sluicing and dredging operations (right).

TABLE 1: Results of literature review and surveys for Nevis skink, *Oligosoma toka*.

| Property | Lizard species recorded | *O. toka* presence | Reference | Notes |
|---|---|---|---|---|
| Cone Peak | *Oligosoma maccanni* | ? | Tenure review report not reviewed or available | Access not permitted during our survey. |
| Glenroy | Likely to be both *Woodworthia* aff. *maculatus* 'Cromwell'and *O. maccanni*<br><br>Records of common geckos near the valley floor in the Doolans Creek Left Branch, including one sloughed gecko skin (LINZ 2007a). McCann's skink confirmed at 1,100 m – 800 m asl (LINZ 2007a), 3 supraocular scales touching frontoparietal suggests identity is not *O. toka* (which would have had two in contact). | ? | LINZ 2007a | Not surveyed |
| Mount Rosa | *O. maccanni*, *Woodworthia* aff. *maculatus* 'Cromwell' | ? | Tenure review report not reviewed or available | Not surveyed |
| Wentworth | *O. maccanni*, *Woodworthia* aff. *maculatus* 'Cromwell'<br><br>It is possible that historical records of *O. maccanni* may have been *O. toka*, therefore a survey would be useful in following up this possibility. | ? | Tenure review report not reviewed or available | Not surveyed |
| Mount Difficulty | *O. maccanni*, *Woodworthia* aff. *maculatus* 'Cromwell' | - | LINZ 2002a, this paper | |
| Kawarau Station | *O. maccanni*,? *Woodworthia* aff. *maculatus* 'Otago Large' | - | Whitaker 1986, LINZ 2002b, this paper | |
| Carrick Station | *O. toka*, *O. maccanni*, *W.* aff. *maculatus* 'Otago Large' and *W.* aff. *maculatus* 'Cromwell'<br><br>The Nevis skink may have been identified as *O. inconspicuum* during the tenure review for this pastoral lease station (LINZ 2005a). "The cryptic skink occurs on the property as two distinctive colour forms (with occasional intermediate specimens), each of which is endemic to the Nevis Valley. The species is most abundant, and its colour forms most striking, on the floor of Nevis Valley." (LINZ 2005a). | + | LINZ 2005a, this paper | |

*Table 1 continued from page 27*

| | | | | |
|---|---|---|---|---|
| Ben Nevis | *O. toka, O. maccanni, O. inconspicuum* (syntopic), unidentified *Woodworthia* gecko species.<br><br>"During the tenure review inspection in 1994 a small cryptic skink *O. inconspicuum* was discovered near the Lower Nevis township." (LINZ 2004). Further, LINZ (2004) states that there are "no skinks of significance" on Ben Nevis; this is erroneous. | + | Whitaker 1986, LINZ 2004, Jewell 2010, this paper | Access permitted for south of Nevisburn. |
| Craigroy | *O. toka*, *O. maccanni*, *W.* aff. *maculatus* 'Otago Large'<br><br>Although we were unable to access Craigroy, we had some lizard information from this property which is particularly interesting. It seems that *O. maccanni* is abundant on Craigroy, or at least, more frequently recorded than *O. toka* was. Whitaker (1986) has recorded the "speckled" form of *O. nigriplantare polychroma* on this property. During the tenure review inspection in 1994, only one "cryptic skink" (= ? *O. toka*) was recorded (LINZ 2006b). | + | Whitaker 1986, LINZ 2006a & 2006b, Jewell 2010, this paper | Access not permitted during our survey. |
| Loch Linnhe | *Mokopirirakau* aff. *granulatus* 'Roys Peak', *O. inconspicuum*, *O. maccanni*, *O. polychroma*.<br><br>Our survey appears to contradict LINZ 2007b report in some aspects. It appears that the abundant *O. nigriplantare polychroma* of high altitude (1,400 m to 900 m are actually *O. maccanni*, our observations). To add further confusion, LINZ (2007b) also suggests *O. maccanni* to be sparse below 1,000 m, yet fails to mention *O. maccanni* in any notable abundance at higher altitude. LINZ (2007b) notes *O. maccanni* and *O. inconspicuum* has been recorded as present in the Whitten's Creek tailings in 1986, but did not record either of these species during their survey, although they did find "common skinks". The block fellfields along the Nevis Road were "searched extensively" but did not reveal any lizards during the LINZ survey, whereas we recorded *O. maccanni*, *O. inconspicuum* and *O. polychroma*. Jewell (2010) also recorded *O. polychroma* in this area. | - | Whitaker 1986, LINZ 2007b, Jewell 2010, this paper | |
| Glen Nevis | *O. maccanni*<br><br>No lizards were recorded during tenure review (LINZ 2005b) nor recorded on the DOC BioWeb *Herpetofauna* database. However, *O. maccanni and* several other unidentified skinks were seen in snow tussocklands (possibly *O. polychroma* or *O. maccanni*) (this paper). | - | LINZ 2005b, this paper | |
| Nokomai Station | No lizards are recorded on the DOC BioWeb *Herpetofauna* database. | ? | Tenure review report not available | Not surveyed |
| Kingston Station | No lizards are recorded on the DOC BioWeb *Herpetofauna* database. | ? | Tenure review report not available | Not surveyed |

TABLE 2: Results from 30 m abundance transects for *Oligosoma toka*.

| Transect Number | GeoReference | Habitat type & description (rock; vegetation) | Observers | Search effort (time in minutes) | Number of *O. toka* recorded |
|---|---|---|---|---|---|
| 1 | 164 | Tailings; briar (*Rosa rubiginosa*) 20%, browntop (*Agrostis* sp.) 50%, willow (*Salix fragilis*) <10% | TB, MNT, AB | 8 | 1 |
| 2 | 165 | Tailings; briar, exotic herbs and grass, *Hieracium* sp. | TB, MNT, AB | 7 | 3 |
| 3 | 166 | Tailings; briar, exotic herbs and grass, *Hieracium* sp. | TB, MNT, AB | 8 | 5 |
| 4 | 167 | Tailings; briar, exotic herbs and grass, *Hieracium* sp. | TB, MNT, AB | 7 | 5 |
| 5 | 168 | Tailings; sparse rock and shallow rock piles; briar, exotic herbs and grass, *Hieracium* sp. | TB, MNT, AB | 7 | 2 |
| 6 | 169 | Tailings; briar, exotic herbs and grass, *Hieracium* sp. | TB, MNT, AB | 9 | 2 |
| 7 | 170 | Tailings; briar, exotic herbs and grass, *Hieracium* sp., *Raoulia* sp., *R. australis* | TB, MNT, AB | 6 | 1 |
| 8 | 171 | Tailings; briar, exotic herbs and grass, *Hieracium* sp. | TB, MNT, AB | 8 | 3 |
| 9 | 172 | Tailings; briar, exotic herbs and grass, *Hieracium* sp, *Leucopogon fraseri* | TB, MNT, AB | 7 | 3 |
| 10 | 173 | Tailings; shallow, sparse rock, no piles; briar, exotic herbs and grass, *Hieracium* sp., *R. australis* | MNT, AB | 9 | 2 |
| 11 | 174 | Tailings; considerble rock piles; briar, exotic herbs and grass, *Hieracium* sp., *R. australis*, *L. fraseri*, *Aciphylla aurea*, *Melicytus alpinus* | MNT, AB | 9 | 2 |
| 12 | 175 | Tailings; briar 20%, browntop 50%, willow <10%, *M. alpinus* < 5% | CW, SH | 4 | 0 |
| 13 | 176 | Tailings; briar 20%, browntop 50%, willow <10%, *M. alpinus* < 5% | CW, SH | 6 | 2 |
| 14 | 177 | Tailings; briar 20%, browntop 50%, willow <10%, *R. australis* | CW, SH | 7 | 1 |
| 15 | 178 | Tailings; matagouri (*Discaria toumatou*), *M. alpinus*, briar, browntop | CW, SH | 19 | 4 |
| 16 | 179 | Tailings; *M. alpinus*, briar, browntop, *L. fraseri* | CW, SH | 16 | 14 |
| 17 | 180 | Natural scree; tussockland + pasture, within schist slip; browntop + *A. aurea*; open ground, on top of rocks basking | TB, SH, CW | 11 | 8 |
| 18 | 181 | Natural scree; tussockland + pasture; browntop, *Festuca novaezealandiae*; *M. alpinus*; briar | TB, SH, CW | 7 | 9 |
| 19 | 182 | Natural scree; long tussock and pasture incl. *Carmichaela petriei*, *M. alpinus*, briar, *Coprosma propinqua*, *Festuca novaezealandiae*, brown-top | TB, SH, CW | 14 | 8 |
| 20 | 183 | Natural scree; long tussock, pasture incl. *C. petriei*, *M. alpinus*, briar, *C. propinqua*, *Festuca novaezealandiae*, browntop | MNT, AB | 6 | 3 |
| 21 | 184 | Slip; rounded rocks; *Aciphylla*, browntop 50%, matagouri 10% | MNT, AB | 20 | 8 |
| 22 | 185 | Natural scree; large rocks; exotic herbs & grasses, *Aciphylla*, mosses, *M. alpinus*, *L. fraseri* | MNT, AB | 19 | 8 |
| 23 | 186 | Natural scree; large rocks + scrub; exotic herbs, *A. aurea*, moss, *M. alpinus*, native grass, *C. propinqua*. | MNT, AB | 29 | 18 |