# SFF 407984 Results 2019: Stimulating pasture production by increasing earthworm functional diversity

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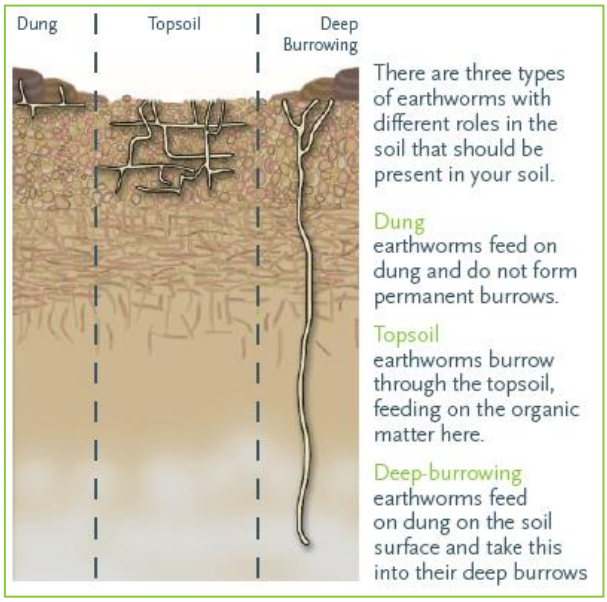
## Waitaki Irrigators Collective

**Background**

This project began in 2015 when Sustainable Farming Funding enabled us to introduce deep-burrowing earthworm species throughout New Zealand. Earthworms found under pasture are exotic, arriving accidentally into our country and as a result some species have a patchy distribution. Previous translocations of earthworms throughout New Zealand involved surface active earthworms, these earthworm introductions helped to reduce the turf mat, improving the movement of water and nutrients into the soil and increasing in pasture production. Having earthworm abundances over 400/m$^2$ can improve pasture production by 20%. In many pastures the deep-burrowing earthworm remains absent, and it is expected that increasing earthworm functional diversity will benefit the ecosystem services they provide, including recycling nutrients and improving soil structure.




**Project results**

A total of thirty farms were involved in the project, farms included both sheep and dairy and spanned from the Central Plateau to South Canterbury/North Otago. On each farm earthworms were added to three paddocks in July and August 2015. These plots were revisited during August and September 2016 and again in 2019.

One year after their introduction, the deep burrowing earthworms were observed to have established on 22 out of 30 farms, however their abundance was low (3/m$^2$). The site of the earthworm introductions were particularly evident in the South Canterbury sites, conditions at these sites had been dry, and it was clear where the introductions had occurred (with turves still present on the soil surface in some cases), and it was obvious earthworms had not dispersed away from the introduction sites.

In 2019 the deep-burrowing earthworms were found on 29 out of the 30 farms with an average abundance of 13/m$^2$, which was fairly consistent across the three farmer groups involved. Total earthworm abundance was on average highest for the South Canterbury Biological Farmers Discussion Group (SCBFDG), then the Waitaki Irrigators Collective, (WIC) and lowest on the Landcorp properties (Table 1). However, it is important to note that the Landcorp properties include those which have no earthworms, being recently converted from forest to pasture. Earthworm abundance at SCBFDG and WIC were above 400/m$^2$ (similar to results in 2016) and so can be expected to be contributing to soil services and enhancing pasture production. In both 2016 and 2019, the dung worm (*L. rubellus*) was most abundant under irrigation while the southern earthworm (*A. trapezoides*) was most abundant in the SCBFDG. This spatial distribution reflects species differences, with *L. rubellus* residing near the soil surface and being more prone to moisture fluctuations, while *A. trapezoides* is often associated with drier conditions.

Below we provide data for the average abundance of earthworms and other macrofauna across all the farms (Table 1) as well as the measured soil properties across all farms (Table 2).

Further project results will be provided later. These will help inform decisions on whether earthworm introductions, especially for deep-burrowing earthworms, are beneficial for pastoral

farms by 1) evaluating different methods of introduction, 2) determining influences on successful establishment 3) quantifying their influence on pasture production and other soil properties and 4) determining whether the benefits are still relevant under increasing levels of fertilizer application.

Table 1: Average earthworm and other macrofauna abundance (per $m^2$) across all farms in 2019. Treatments included where deep burrowing earthworms were 'Added' to resident surface active populations and a 'Control'where resident earthworm populations were sampled.

| Functional group | Target | Earthworm Species | Landcorp Added | Landcorp Control | SCBFDG Added | SCBFDG Control | WIC Added | WIC Control |
|---|---|---|---|---|---|---|---|---|
| All | >400 | Total earthworms[1] | 216 | 174 | 540 | 566 | 448 | 453 |
| Deep | >25 | Black head (*A. longa)* | 12 | 1 | 14 | 2 | 14 | 0 |
| Dung | >25 | Dung worm (*L.rubellus)* | 45 | 43 | 39 | 47 | 77 | 79 |
| Topsoil[2] | >350 | Grey worm (*A. caliginosa)* | 146 | 120 | 396 | 420 | 311 | 330 |
| | | Pink worm (*A. rosea)* | 6 | 2 | 62 | 64 | 34 | 31 |
| | | Yellow tail (*O. cyaneum)* | 3 | 2 | 6 | 4 | 6 | 4 |
| | | Southern worm (*A. trapezoides)* | 3 | 4 | 18 | 25 | 5 | 6 |
| | | Green worm (*A. chlorotica)* | 1 | 1 | 2 | 0 | 3 | 4 |
| Native | | Species unknown | 1 | 0 | 4 | 5 | 0 | 0 |
| Other | <20 | Porina (Wiseana sp.) | 0 | 0 | 1 | 2 | 1 | 1 |
| Macro- | <150 | Grass grub (*C. zealandica)* | 5 | 2 | 8 | 7 | 3 | 3 |
| fauna | <120 | Clover root weevil (*S. obsoletus)* | 6 | 2 | 34 | 18 | 82 | 75 |

[1] Total earthworm abundance includes juvenile earthworms which were not identified to species.
[2] This includes five species (*A. caliginosa, A. rosea, O cyaneum, A. trapezoides* and *A. chloritica*), the abundance of all these species combine needs to be above the target.

Table 2: Average soil moisture, temperature, bulk density and fertility across all farms at 2019 sampling date. Treatments included where deep burrowing earthworms were 'Added' to resident surface active populations and a 'Control' where resident earthworm populations were sampled.

| | | Target | Landcorp Added | Landcorp Control | SCBFDG Added | SCBFDG Control | WIC Added | WIC Control |
|---|---|---|---|---|---|---|---|---|
| Soil physical properties | Soil moisture (%) | | 66 | 65 | 43 | 43 | 34 | 35 |
| | Bulk density (g/$cm^3$) | 0.7-1.4 | 0.70 | 0.71 | 1.05 | 1.05 | 1.14 | 1.11 |
| | Macroporosity (%) | 8-30 | 28.7 | 28.2 | 17.5 | 17.9 | 14.0 | 14.5 |
| Soil fertility | pH[1] | 5-6.6 | 6.4 | 6.3 | 6.3 | 6.3 | 6.1 | 6.1 |
| | Olsen P (mg/L)[1] | 15-45 | 41.5 | 43.4 | 20.5 | 22.0 | 39.4 | 33.4 |
| | Potassium (QT) | 7-10 | 12.6 | 13.4 | 10.6 | 11.7 | 14.0 | 14.1 |
| | Calcium (QT) | >1 | 12.4 | 12.0 | 12.4 | 12.3 | 12.9 | 11.9 |
| | Magnesium (QT)[2] | 8-30 | 30.5 | 28.6 | 27.5 | 27.6 | 38.7 | 36.3 |
| | Sodium (QT) | >3 | 4.7 | 4.3 | 6.4 | 6.3 | 8.2 | 8.3 |
| Soil organic matter properties | Total carbon (%)[1] | >2.5 | 7.9 | 8.2 | 4.4 | 4.4 | 5.6 | 5.3 |
| | Total nitrogen (%) | 0.25-0.7 | 0.62 | 0.65 | 0.36 | 0.37 | 0.47 | 0.47 |
| | C:N ratio | 8-12:1 | 12.9 | 12.7 | 12.1 | 12.0 | 11.8 | 11.4 |
| | Potentially available nitrogen (kg/ha) | 5-250 | 156 | 156 | 192 | 195 | 222 | 215 |

[1] Target dependent on soil type
[2] 8-10 optimal for pasture, 25-30 optimal for animal health.