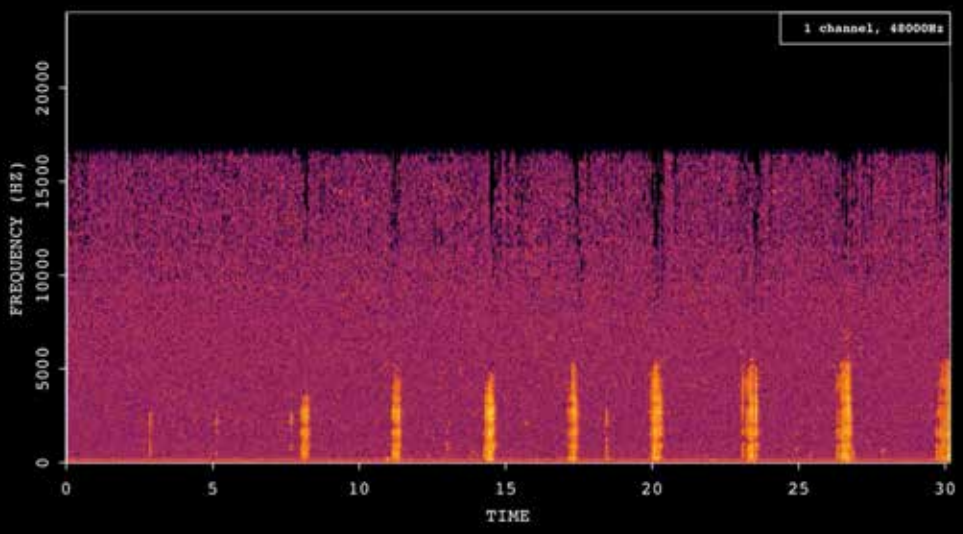

Sound of the underground

Soil ecoacoustics

Could recording the sound of biodiversity below ground be used by farmers as an indicator of soil health status? *CPM* investigates an Innovate UK-funded project which aims to apply the principles of ecoacoustics to what's happening at a topsoil level.

By Janine Adamson

Similar to the creatures which populate above ground habitats, those found below the surface also exhibit their own behavioural traits and as a consequence, emit a breadth of unique sounds as they move through the soil and go about their business.

Now, with a little help from sound technology, it's possible to record that underground hubbub to help farmers understand whether their soils are a biological hotbed or deathly silent.

This approach is known as ecoacoustics – an emerging science which investigates natural and anthropogenic sounds and their relationship with the environment. While ecoacoustics has historically been used to listen for bats and birds and other above-ground wildlife, as the technology developed and became cheaper, Baker Consultants, and other like-minded researchers around the world, saw the potential to take the science below ground and apply the same methods to the soil.

> *"The theory is, a healthy soil is a noisy soil."*

As such, soil ecoacoustics was born, says consultancy director, Gavin Ward. "Having undertaken explorative work ourselves to establish a methodology, we knew we had the basis of an initial concept for how to measure and analyse the sounds within the soil.

"However, we wanted to take this further to develop a conclusive proof of concept, which resulted in a successful Defra grant application through Innovate UK for £250,000 of project funding," he continues.

"This involves a two year study working alongside the University of Warwick Crop Centre, where we develop a system to try to monitor the absence or relative activity of soil fauna, including earthworms, within agricultural topsoils."

Field and lab trials

The work began in April 2023 and already, progress has been quick, highlights Gavin. Baker Consultants, led by director of ecoacoustics Dr Carlos Abrahams, has been undertaking a range of UK-wide field trials, while the University of Warwick has been conducting controlled laboratory tests.

For both trial environments, it's involved recording and then assessing the sub-surface soundscape using a range of Acoustic Complexity Indices (ACI) – which measure how complex the soundscape in an environment is, in this case, within the soil.

Gavin says progress with this has been promising with the ability to characterise typical soundscapes through recordings taken from a large number of arable and dairy pasture sample sites. Next, the team is hoping to start looking for the unique tell-tale sounds from a range of target species, from both pest and beneficial groups, he adds.

This data will lead to the development of a detailed library of acoustic signatures for certain species, alongside a robust database of soundscapes which future recordings can be benchmarked against.

"The theory is, a healthy soil is a noisy soil and by analysing the changes and differences in the soil soundscapes, we're hoping to understand and monitor the hidden functional biodiversity within the topsoil," explains Gavin.

"You may wonder what an earthworm sounds like; although this does vary depending on its movements, we mostly hear it as a crunching noise as it contracts and expands within the soil. Other descriptions include popping, slurping or rasping.

"We've also recorded beetle larvae who, similar to a grasshopper, rub an appendage on the side of their body to create some very surprising sounds indeed. We're unsure exactly why they're making this noise – is it for hunting, attracting a mate or deterring predators? But now we know it's happening, we can investigate that further," he says.

Other unusual noises recorded during the project so far include a field vole squeaking as it travels through its tunnel, and an ants'

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nest, which sounds similar to rain on a tent.

As well as the sound library, the project also involves finalising a protype for the technology which produces the recordings in the first place. Based on a patent-pending device, the aim was to develop an accessible and affordable tool, emphasises Gavin.

"Similar to a hand-held bat detector, the unit is run on batteries and an SD card with a 6-10" (15-25cm) long soil probe and an in-built GPS chip. From a user-perspective, you push the probe into the ground, hit the button on the hand-held unit, step away and wait for a couple of minutes while it makes the recording.

"The probes can only listen to a radius up to 1m, depending on the soil conditions, so it's recommended that multiple recordings are taken from each field and then averaged to give an overall score, as the soil invertebrates communities can be very patchy in each field on any given day," he says.

Advanced analysis

Although the technology is relatively simple, it's the analysis which does the heavy lifting, suggests Gavin. "Advanced analysis allows us to rapidly evaluate the samples and produce a report, including how it compares against our reference database.

"As we're now nearing the end of the research stage, the next step is to start offering a commercial service – we're hoping that the probe and first year of analysis will be available for less than £1000. After that, it would simply be a case of a low monthly subscription and any replacement probes, as and when required."

Gavin believes soil ecoacoustics could be an easy and rapid way to supplement the intelligence gathered from traditional soil pits. But overall, he sees it as a simple way for growers and agronomists to benchmark soil health on farm.

"Recording the soundscape before and after an intervention or cultivation, would help land managers understand its impact on the topsoil fauna. Equally, the technology could also be used to compare different fields with different soil types to help understand their biological status.

"As people submit their sound samples for analysis, this will then allow us to gain more insights from the database – training the system to be even smarter, fine-tuning it and improving the benchmarking so it can also account for different factors such as soil type etc," he says.

As part of its work so far, Baker Consultants has partnered with Wildfarmed to compare the soundscapes of conventional and regenerative soils. It's also been working with the dairy sector through a relationship with First Milk.

"We envisage various different uses for this technology, but essentially, it's a means of measurement. In the future, as emphasis continues to be placed on environmental schemes, it could even be used to monitor the biodiversity gains or soil improvements that result from SFI actions," suggests Gavin.

He adds that so far, the technology has been well received. "We began with earthworms as our 'poster boy' and everyone understands that they're a solid indicator of soil health – the more worms, the better the soils.

"Equally, we knew the demand was there for a more efficient system to measure earthworm communities, however our system has also provided a gateway for other species-groups too."

According to Gavin, one goal is to enable farmers to identify the presence of soil-dwelling insect pests. "Because invertebrates all have their own specific sound cues, it might be possible to assign these to certain pest species such as symphilids.

"This intelligence could then be used prior to taking out the lease on some new land, for example, so that farmers could enter into an agreement with greater knowledge of the pests they're about to inherit," he says. "We're also hoping to start looking for the sound signatures of beneficial insect species soon too." ■

From lab to field

As a partner in the soil ecoacoustics project, the University of Warwick Crop Centre has been collecting sound recordings from the laboratory right through to the field.

Soil scientist, Dr Jacqueline Stroud, says work began by introducing different species of earthworm to model soils sourced from real-life farms. "We recorded hundreds of hours of worm sounds and this took place in a highly controlled environment; Baker Consultants use this information to feed its database."

Then, collaborating with Rothamsted Research, the principles were applied to the field where data was collected during a 6-month period – for both fallow grass and wheat – to identify longer-term trends.

"By moving from a highly controlled environment through to a real-life scenario we're able to provide a robust dataset to train the algorithms involved," she adds.

According to Jacqueline, ecoacoustics is an opportunity to learn more about soils – a topic which much remains unknown. "Rather than using sight, soil-borne organisms communicate through vibration. As such, soil ecoacoustics taps into this communication system and works alongside it, capturing data through their ways, rather than ours.

"It also allows us to capture the interactions between invertebrates – enabling us to learn so much. Soils are a sophisticated system which we know so little about; it's exciting to contribute towards creating a baseline for future monitoring techniques," she concludes.

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