Animal pests: feral pig ground disturbance monitoring

Version 1.0

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Inventory and monitoring toolbox: animal pests

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Department of Conservation
Te Papa Atawhai

Synopsis

Feral pigs

Feral pigs (*Sus scrofa*) are among the most destructive vertebrate animals in Australasia (Bengsen et al. 2017). In New Zealand, they are now widespread and well established, occupying approximately 35% of the country's land area (around 93,000 km²).

Feral pigs have substantial and wide-ranging ecological impacts on forest ecosystems. These include habitat degradation, direct predation on native fauna, and competition with other species for food resources (Bengsen et al. 2017). As generalists and largely non-selective feeders, feral pigs can significantly alter plant communities by changing the composition and abundance of seedlings and reducing overall forest biomass (Bengsen et al. 2017). Their rooting behaviour disturbs soil structure, affects nutrient cycling, and disrupts seedling turnover, thereby impeding forest regeneration. In addition to their broad dietary impacts, pigs are known to prey on native invertebrates, including land snails, and may pose threats to other ground-dwelling or slow-moving species (Krull and Egeter 2016).

Feral pigs have been suggested as potential contributors to the spread of *Phytophthora agathidicida*, the pathogen responsible for kauri dieback, which has led to their control being prioritised in kauri forest protection efforts (Krull et al. 2013; Bassett et al. 2017; Niebuhr et al. 2024). While their role remains unconfirmed, their suspected contribution to soil disturbance in sensitive ecosystems has made them a focal point for disease risk management. Effective pig management is therefore considered important not only for reducing direct ecological damage, but also for limiting potential disease spread in vulnerable forest systems.

Feral pigs are highly mobile and adaptable animals. They can travel long distances in response to food availability, breeding pressures, and hunting activity (Bengsen et al. 2017). As a result, feral pig control is challenging, and eradication is seldom achieved. Most management programmes instead aim to reduce pig densities to levels where ecological or agricultural impacts are minimised.

While ecological and agricultural concerns often drive feral pig control, it is also important to recognise the cultural and social values that pigs hold in New Zealand. They are a valued food source and a prominent target for recreational hunting (Nugent et al. 1996), and in many communities they contribute to local identity and cohesion. For some Māori, feral pigs are highly valued, sometimes considered sacred (Nugent et al. 1996; Bengsen et al. 2017), which underscores the need for management approaches that account for a range of values and perspectives.

Given the range of ecological and cultural considerations associated with feral pig management, it is critical that control efforts are informed by reliable evidence. Monitoring plays a central role in this process, enabling managers to assess both the effectiveness of control operations and the

scale of ongoing impacts. Behaviours such as rooting and wallowing cause visible and immediate disturbance to soil and vegetation, making them practical targets for impact-based monitoring. However, the availability and consistency of monitoring methods for feral pigs in New Zealand remain limited.

Monitoring

While no well-established or nationally consistent monitoring method exists for measuring feral pig abundance, either actual or relative, in New Zealand, a variety of techniques have been utilised elsewhere (Swolgaard 2002; Mitchell and Balogh 2007; Fagiani et al. 2014; National Pest Control Agencies [NPCA] 2018; Gray et al. 2020). However, none of these have been formally calibrated against known population densities within New Zealand, which limits their reliability and comparability in a local context. Despite this, a few well-documented monitoring programmes in New Zealand have incorporated measures of soil disturbance, which remains one of the most immediate and visible impacts of pig activity (Krull et al. 2016; Whitmore 2022).

Monitoring can serve two broad purposes: operational monitoring, which tracks changes in the feral pig population, and performance (or outcome) monitoring, which assesses the condition of the resource being protected (NPCA 2018). Both approaches vary in rigour, from subjective or qualitative observations to rigorous quantitative experimental studies and surveillance. Although performance monitoring is important, the methods used are highly variable and generally need to be tailored to the specific resource of interest.

For example, pig activity has tentatively been linked to the spread of *P. agathidicida* (Krull et al. 2013; Bassett et al. 2017), but the specific mechanisms remain unclear (Niebuhr et al. 2024). It is uncertain whether rooting, wallowing, or other behaviours are the main contributors to soil-borne pathogen movement, and whether transmission is more likely to occur via disturbed soil, faecal contamination, or soil adhering to pigs' bodies. In such cases, performance monitoring must address not only changes in the condition of the resource (e.g. kauri health), but also the uncertainty around how pig behaviour contributes to the outcome of concern.

While both monitoring types play a role in informing management, this document focuses on operational monitoring, specifically through indicators of soil disturbance. Given the difficulty and cost of estimating pig abundance directly, and the need for practical, repeatable measures of impact, soil disturbance is used here as a proxy to indicate changes in pig activity over time. While pig abundance is one likely driver of disturbance, the relationship is influenced by environmental conditions, pig behaviour, and site characteristics. However, field studies in New Zealand have shown that disturbance generally increases with higher pig density, particularly as populations approach carrying capacity (Krull et al. 2016). This supports the use of disturbance as a proxy for impact in operational monitoring, while reinforcing the need for caution when interpreting disturbance patterns as direct indicators of abundance.

This approach is designed to detect trends in disturbance, not to estimate pig numbers or density. While high disturbance levels often indicate the need for sustained control, management decisions should be based on observed impact thresholds rather than assumptions about pig density. In this

context, consistent reductions in disturbance across monitoring periods are interpreted as signs of successful impact mitigation, irrespective of the actual number of pigs remaining.

This document presents a standardised method for monitoring changes in the proportion of soil substrate disturbed by feral pigs, offering a practical and scalable approach for operational monitoring in New Zealand.

Assumptions

The following assumptions help frame the interpretation of data produced by this method. They do not represent proven relationships, but instead highlight the conditions under which disturbance trends may provide reliable indications of feral pig activity. Recognising the limitations of these assumptions is critical to applying and interpreting the method appropriately. Some assumptions may not always hold, particularly where disturbance is influenced by environmental conditions, behavioural variation, or confounding factors.

- Feral pig control is implemented across the monitoring area within a defined and reasonably short time frame. Where the site is divided into management blocks, control is assumed to occur in all blocks within a limited time window (i.e. not phased or staggered over several months) to ensure that changes in disturbance levels can be attributed to control efforts.
- The frequency and proportion of ground disturbance observed along transects are assumed to reflect underlying pig activity. While pig abundance is one likely driver of disturbance, the relationship is not linear and may be influenced by factors such as food availability, environmental conditions, or pig behaviour. This method detects trends in disturbance rather than estimating abundance directly. Repeated reductions in disturbance over time may be interpreted as evidence of effective control, but must be contextualised.
- Feral pig foraging behaviour and activity patterns remain broadly consistent across the site and over the course of the monitoring period. For the method to detect meaningful change, pigs must respond predictably to control, and not shift behaviour or distribution in ways that affect detectability.
- Environmental conditions that affect detectability or pig behaviour, such as soil type, rainfall, slope, or habitat structure, do not vary systematically between sampling intervals or among management blocks. Any such variation may confound interpretation unless explicitly accounted for in analysis or study design.
- Feral pigs are the primary source of detectable soil disturbance. While disturbance by deer, goats, or cattle may occur in some locations, it is assumed to be either absent or clearly distinguishable by trained observers.
- The method is not designed to estimate feral pig abundance or density. It is used to detect changes in visible ecological impact, not population size. Although disturbance may be correlated with pig density in some cases (Krull et al. 2016), this relationship is context-dependent and not well understood.

Note: The assumption that disturbance reflects pig activity is central to the method's utility, but not all confounding variables are easily controlled. It is recommended that future research investigate the sensitivity of this method to different effect sizes and control intensities. For example, power analyses could help determine whether changes in disturbance can reliably detect reductions in pig activity of 20%, 50%, or other magnitudes under varying conditions.

Advantages

- This method provides a practical and repeatable way to monitor visible impacts of feral pig activity. While it does not measure pig abundance or account for all sources of ecological variation, it can help assess whether disturbance levels are changing following management efforts, particularly when reductions in disturbance are the desired outcome.
- This is a relatively simple and quick method to implement using minimal field equipment.
- This method is suitable for areas with moderate to high densities of feral pigs.
- Ground disturbance caused by feral pigs is typically easy to distinguish from that caused by deer, goats, or wild cattle.
- This method measures immediate and direct impacts of feral pig activity, rather than delayed or indirect ecological responses.
- Disturbance sign tends to persist long enough to allow seasonal or annual monitoring.
- This method is most effective when used to monitor changes following sustained pig control operations. Reductions in disturbance are interpreted as positive ecological outcomes, though observed trends may also reflect variation in pig behaviour, food availability, or environmental conditions.
- This method supports standardised data formats for long-term data storage and aggregation.
- Field implementation requires only small teams and modest levels of training.

Disadvantages

- This method may be less effective in areas with low feral pig densities, where disturbance is sparse and harder to detect. It is more informative when disturbance is initially high and expected to change meaningfully following sustained control.
- This method's effectiveness may be reduced in hard, compacted, or dry soils where rooting is limited or less visible.
- Disturbance detection can be influenced by recent weather events, soil moisture, and seasonality.
- Subjectivity may arise in classifying disturbance age and severity without adequate training or photographic references.
- This method does not estimate feral pig abundance, demographics, or movement; rather, it measures ecological disturbance that is assumed to be influenced by pig activity. The

strength of this relationship may vary depending on local context and has not been formally validated in all environments.

- Repeatability between observers may vary without standard protocols, calibration, or site familiarity.
- This method does not capture indirect or long-term ecological effects such as vegetation change.

Safety issues

Transect surveys may involve exposure to steep slopes, stream crossings, dense vegetation, and slippery or unstable terrain. Working in pairs improves observational accuracy and may reduce risk, especially in remote or uneven terrain. Appropriate field gear, navigation equipment, and communication tools are often necessary. Terrain and access limitations may restrict the placement or repeatability of some transects.

Suitability for inventory

This method may provide limited value for inventory purposes. While the presence of feral pig sign confirms site occupancy, it does not provide a reliable indication of feral pig abundance, either at or beyond the transect. In regions where feral pig presence is uncertain or variable, other tools such as camera traps, aerial surveys, or hunter-based reporting may be more appropriate for inventory.

This method is better suited to impact detection and long-term monitoring rather than one-off species detection or distribution mapping.

Suitability for monitoring

- This method is suitable for monitoring the presence, frequency, and extent of ground disturbance caused by feral pigs.
- It is best applied where the objective is to detect changes in impact over time following control efforts.
- It is most effective when implemented at permanent transects to allow consistent, repeatable measurement.
- The recommended remeasurement interval is within 12 months of the previous survey or most recent control.
- Monitoring intervals longer than two years may reduce data reliability unless disturbance remains clearly visible.
- In dry conditions or areas affected by frequent storms, more frequent monitoring may be required due to reduced detectability of disturbance.

- Monitoring focuses on disturbance trends rather than estimating pig abundance. While abundance is likely a contributing factor, this method is used to track whether the ecological impact of pigs is declining over time, regardless of precise pig numbers.
- For management purposes, disturbance reduction can serve as a tangible performance measure in the absence of robust abundance data.

Skills

- Observers must be able to identify soil disturbance caused by feral pigs, including wallows, rooting, and trampling, and distinguish it from sign left by other ungulates such as deer or cattle.
- Observers must be competent in classifying disturbance age using visual cues such as soil moisture, edge definition, and litter cover, and understand how these cues may vary with environmental conditions (e.g. rainfall, soil type, or canopy cover).
- Observers must be confident in the use of GPS, compass, measuring tapes, and hip chain equipment in field conditions.
- Observers must be comfortable navigating and working in potentially rugged and remote areas, often with limited visibility or access.

Resources

- Map of pig control area with random transect start points (and oversample points)
- Grid references of start points including spare start points (preloaded into GPS if possible)
- Compass
- GPS
- 100 m and/or several 20 m tape measures to measure transect length
- Hip chain distance measurer (optional)
- 5 m builders tape to measure disturbance patch dimensions
- Durable transect marker (e.g. Permolat) to mark start and end points and any direction changes
- Coloured flagging tape
- Permanent markers
- Clipboard/notebook
- Pen/pencils/permanent marker pen
- Camera (to document disturbance and site conditions)
- Printed photo guide for disturbance classification
- Data recording sheets (see Appendix B)
- Appropriate field clothing, footwear, and standard safety equipment for remote terrain

- Consistent data recording using standardised data sheets and notebooks is essential for repeatability and quality control.

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on your objective. For more information refer to 'Full details of technique and best practice'.

DOC staff must complete a 'Standard inventory and monitoring project plan' (doccm-146272).

At a minimum, the following attributes should be recorded for each transect and disturbance observation:

- Transect ID and location (GPS coordinates for start and end points)
- Date of survey and observer name(s)
- Total length of transect surveyed (metres)
- For each disturbance patch:
  - Distance along the transect from the start point
  - Age classification (Very Fresh, Fresh, Old, Very Old)
  - Type of disturbance (rooting vs wallowing, if possible)
  - General vegetation type at the site of the disturbance
  - Projected length of disturbance (metres)

These core attributes support consistent data collection and comparability across sites and years. Additional notes or photos are strongly encouraged where disturbance is ambiguous or difficult to classify.

Data storage

All field data should be transcribed into a digital format as soon as practical following survey completion. This includes both disturbance observations and transect metadata. Data sheets should be scanned or photographed for backup prior to leaving the field.

GPS tracks should be saved as GPX or shapefiles with filenames that clearly reference the transect ID and date. Associated photos should be labelled consistently and linked to their corresponding disturbance records where possible.

All data should be stored in a secure, backed-up location that allows long-term access and sharing where required. If contributing to a wider programme, follow any prescribed data standards, file structures, or naming conventions that support integration into national or organisational repositories.

Where multiple observers are involved, notes about team composition and any calibration steps taken should be included with the metadata.

Analysis, interpretation, and reporting

Introduction

Monitoring feral pig disturbance provides a means of assessing ecological impact in response to control operations. Unlike abundance-based methods, this approach focuses on changes in visible ground disturbance, which can be interpreted as a proxy for foraging activity and habitat degradation. Standardised data collection enables comparisons over time, across sites, and between management treatments.

The primary goal of analysis is to determine whether disturbance levels are decreasing following control, remaining stable, or increasing. Results can inform operational planning, resource allocation, and broader pest management strategies.

Practical considerations

Disturbance data are subject to a range of factors that must be considered when interpreting results. These include:

- **Seasonal variation:** Dry weather can harden soils and obscure rooting sign; wet periods may make disturbance more visible or increase rooting frequency. Seasonal shifts in food availability can also affect rooting intensity.
- **Annual variation:** Year-to-year changes in rainfall patterns, mast fruiting, temperature, or pig movement can influence both pig activity and the detectability of disturbance. These background fluctuations may obscure or amplify the effects of control efforts and should be considered when evaluating trends.
- **Observer consistency:** Differences in classification of age may affect data comparability between teams or survey years.
- **Soil type and terrain:** Some soil types hold disturbance longer, while others may collapse or recover more quickly.
- **Vegetation and litter cover:** Thick leaf litter or groundcover can obscure disturbance unless freshly made.
- **Control timing and intensity:** The time lag between feral pig control and visible reduction in disturbance may vary depending on local conditions and pig behaviour.

Careful metadata collection (e.g. weather, soil conditions, team members) helps to contextualise variation and improve the reliability of trend interpretation.

Analysis of feral pig disturbance data

Analysis typically begins with descriptive statistics such as:

- total number of disturbance patches per transect
- proportion of the transect disturbed (as a percentage of total transect length)
- frequency of disturbance patches by age class (Very Fresh, Fresh, Old, Very Old)
- change in the number or age class category between years.

These metrics can be summarised at the transect, block, or site level. Patterns may be visualised using bar plots, line graphs, or spatial maps to show disturbance extent and trends over time.

Interpretation should be made in the context of feral pig control history, site characteristics, and recent environmental conditions. Lag effects between control and observable disturbance reduction should also be considered.

Statistical analysis can be used to explore patterns in the data and test whether certain factors affect disturbance. For example, the presence or absence of pig damage might be compared across different habitat types, slopes, or times since control. If more detailed measurements are available, such as disturbed patch length (or depth), these can be analysed using standard methods suited to continuous data. The choice of method depends on how the data are structured and what questions are being asked. In the Waitākere Ranges, for example, analysis of ground disturbance and pig kill data showed that disturbance rates increased exponentially as pig densities approached carrying capacity (Krull et al. 2016). This modelling provided valuable insights into the expected scale of response to different control intensities.

Case study A

Case study A: Monitoring the effects of pig control on soil disturbance in Waipoua Forest

Synopsis

In 2016, feral pig management was implemented in Waipoua Forest, Northland (Fig. 1), to reduce ecological disturbance and possibly limit the spread of *Phytophthora agathidicida*, the pathogen responsible for kauri dieback disease (McNutt 2016; Whitmore 2022). Alongside the control efforts, DOC and Te Roroa implemented a ground disturbance monitoring programme to assess whether pig rooting and wallowing activity declined in response to management. Using a network of randomly located transects, the project measured presence and age of soil disturbance annually. Results from 2016 onward demonstrated a clear relationship between disturbance, environmental conditions (especially soil wetness), and control effort, providing a well-documented example of quantified impact reduction from pig management in a New Zealand forest setting.

Figure 1. Pig management area (70 km²) in Waipoua Forest, Northland.

Objectives

The primary objective of the monitoring programme was to measure the proportion of pig-induced soil disturbance within the core management area of Waipoua Forest and evaluate whether it declined over time in response to pig control efforts. A secondary objective was to identify the environmental factors most strongly associated with such soil disturbance, to better understand the spatial distribution of pig impacts and inform future management strategies.

Survey design and methods

The monitoring design consisted of 24 permanent 100 m transects distributed across the 70 km² core pig management area (Fig. 1). Transect locations were selected randomly to ensure unbiased sampling, with the broader area informally divided into three similarly sized monitoring blocks to facilitate logistical access. Oversample (or 'backup') points were established in advance, allowing for the replacement of sites that were inaccessible or unsafe.

Each transect was aligned to a randomly assigned compass bearing and permanently marked at both ends. Where physical obstructions or unsafe terrain prevented a straight 100 m survey, transects were redirected with a 90-degree turn, as per the NPCA Residual track Catch[1] and

[1] Possum population monitoring using the trap-catch, waxtag and chewcard methods National Pest Control Agencies (2015) https://www.bionet.nz/assets/Uploads/Publications/A1-Possum-Monitoring-2015-Nov-HR.pdf

DOC's Tier 1[2] monitoring protocols, to complete the distance, provided at least 50 m of the line could be sampled.

Annual monitoring was timed for winter, when moist soils made rooting disturbance most visible (McNutt 2016). Observers walked each transect while scanning a 2 m wide swathe (1 m either side of the line). When pig rooting or wallowing was encountered, they recorded the length of disturbance (projected onto the transect line), its location, and a classification of age: either 'fresh' (moist, soil exposed) or 'old' (drier, littered, or regrowing). These classifications were supported by a photographic guide developed for the project. Additional notes included general vegetation descriptions and features to aid repeatability in subsequent surveys.

Additionally, environmental covariates were derived from GIS layers and averaged for each transect. These included elevation, slope, distance to second- and third-order streams, and a relative wetness index. The number of pig kills in the year preceding each monitoring event was also calculated as a proxy for control intensity in the area. Analytical models were developed to predict the presence or absence of disturbance on transects, using generalised linear modelling and an information-theoretic selection framework (corrected Akaike information criterion – AICc) (Burnham and Anderson 2002). Attempts to model the magnitude (length) of disturbance proved unreliable due to limitations in the available data.

Results

The analysis showed that pig disturbance was more likely in wetter areas and less likely on steeper slopes or at higher elevations. The best-supported statistical model included two key variables: relative wetness and the number of pig kills recorded in the preceding interval. The results indicated that disturbance increased with soil moisture and decreased where pig control had recently occurred.

Vegetation class was not significantly associated with disturbance after accounting for its spatial extent and was therefore excluded from the final models. The presence/absence framework proved effective for detecting patterns and change, while modelling of disturbance magnitude was less reliable.

Overall, the monitoring design was successful in linking pig control to measurable reductions in soil disturbance, particularly in habitats with high rooting potential such as riparian and wetland zones. The fixed transect approach was practical for field teams and generated data of sufficient quality to support robust statistical analysis over multiple years.

[2] *Field protocols for Tier 1 monitoring—invasive mammal, bird, bat, and RECCE surveys* (docDM-826779), p. 18. https://www.doc.govt.nz/contentassets/a4f9a01cf29746139d593b3347168acf/field-protocols-for-tier-1-monitoring-invasive-mammal-bird-bat-recce-surveys.pdf

Limitations and points to consider

Some transects traversed mixed vegetation or difficult terrain, occasionally requiring rerouting or abandonment. While the classification of disturbance age was supported by visual references, the process remains somewhat subjective and may benefit from observer calibration or training.

The monitoring was limited to presence/absence of disturbance, as efforts to model total rooting length were constrained by data sparsity and zero-inflation. Additionally, although pig kill numbers were used as a proxy for control intensity, these data did not capture the full spatial dynamics of pig movement or hunting effort.

Relocation of transects for repeat monitoring required careful marking and documentation. Inaccurate GPS fixes or degraded markers could reduce the precision of follow-up surveys. The decision to avoid summer monitoring was well justified, as detection of disturbance is considerably reduced on hardened, dry soil surfaces.

Despite these constraints, the Waipoua programme remains one of the most structured and analytically sound examples of soil disturbance monitoring linked to feral pig management in New Zealand.

References for case study A

Burnham KP, Anderson DR. 2002. A practical information-theoretic approach. Second edition. New York: Springer.

McNutt K. 2016. Waipoua pig disturbance monitoring plan June 2016. Department of Conservation (unpublished; docCM- 2784525).

Whitmore N. 2022. An analysis of pig control and its impacts on ground disturbance in Waipoua Forest. A report for Te Roroa and the Department of Conservation. March 2022.

Case study B

Case study B: Monitoring the effects of pig control on soil disturbance in the Waitākere Ranges, Auckland

Synopsis

From 2008 to 2011, a three-year feral pig control programme was implemented in the Waitākere Ranges, Auckland, to assess how changes in pig density influence ground disturbance and to evaluate the cost-effectiveness of different control intensities (Krull et al. 2016). Pig rooting is a known driver of habitat modification and potential disease spread, but quantitative data linking control to ecosystem impact remain scarce. This study combined repeated hunting operations, transect-based disturbance monitoring, and simulation modelling to quantify a density–disturbance relationship and project how different levels of control effort would influence long-term ecological

and financial outcomes. The findings demonstrated that control significantly reduced pig density and disturbance, but also highlighted diminishing returns at higher levels of investment, reinforcing the need for targeted thresholds and cost-conscious decision making in wildlife management.

Objectives

The core objective of this programme was to link wildlife management inputs (pig control) to ecological outcomes (ground disturbance) by quantifying how pig density influenced both the rate of new disturbance and the recovery of previously disturbed areas. A secondary goal was to develop a simulation model capable of projecting the cost and ecological return of various hunting regimes. This allowed managers to compare the predicted outcomes of different control intensities and identify points of diminishing return.

Survey design and methods

The Waitākere Ranges study area was divided into three control blocks, each between 55 and 63 km² in size. Feral pig control was carried out by professional ground-based hunting teams with trained dogs, initially every six months and later every three months. A total of nine hunting operations were conducted over three years, removing nearly 900 pigs. Hunting effort and kill locations were recorded by GPS to standardise kill rates across blocks.

To monitor ecological impact, 23 permanent 200 m transects were established across the site, one per 2.8 km² grid cell. Transects were surveyed four times between 2008 and 2011. Pig disturbance within 1 m on either side of the line was mapped and aged as ‘new’, ‘aged’, or ‘old’ using photographic standards. These data were used to calculate disturbance prevalence and turnover (i.e. new disturbance, re-disturbance, and recovery), and were later used to parameterise models of disturbance as a function of pig density.

Changes in pig numbers over time were estimated using a simple population model that took into account how many pigs were removed and how many the area could support (about 8 pigs per square kilometre). Simulations were run to explore what would happen under different hunting schedules: every 3, 6, 9, or 12 months. Each scenario was used to assess how pig numbers, ground disturbance, and total cost would change over a 30-year period.

Results

Ground disturbance declined noticeably over the course of the control programme, despite pig numbers only being reduced by an estimated 40% relative to the initial population size. Much of the disturbance was concentrated in a few persistent hotspots. In the first monitoring session, 74% of all recorded disturbance occurred on just four transects, which were spread across the three hunting blocks. These same transects continued to show the highest levels of disturbance in subsequent surveys, accounting for 60%, 58%, and 66% of total disturbance in the following three sessions. This consistency suggests that certain areas were more susceptible to pig rooting, likely due to local environmental conditions or resource availability.

Monitoring data showed that the rate of new disturbance increased more quickly as feral pig numbers approached carrying capacity, while recovery rates remained relatively steady. As a result, even modest reductions in pig density led to much larger drops in disturbance levels.

Simulations informed by the monitoring results suggested that more frequent control could reduce disturbance further, but at much higher cost. Quarterly hunting was the only approach that continued to reduce disturbance over time. Less frequent control, such as annual efforts, led to stable but elevated levels of disturbance. This pattern highlights the principle of diminishing returns, where increasing control effort yields smaller improvements in ecological outcomes.

This study showed that standardised ground disturbance monitoring can detect meaningful ecological responses to pig control. The strongest benefits were achieved through sustained, moderate control, with the largest improvements occurring early in the programme. While the modelling helped quantify trade-offs between control intensity and outcomes, it relied on simplified assumptions about pig movement and population growth that may not apply everywhere. In the field, age classification of disturbance was supported by photo guides, although observer bias may still be present. The approach focused on areas prone to damage, and further work would be needed to apply these findings across broader landscapes.

Limitations and points to consider

This case study shows that higher feral pig numbers lead to more ground disturbance in New Zealand forests. It also shows that damage tends to occur in the same locations over time, allowing monitoring and control efforts to be focused more efficiently. Simulation models, built using data from disturbance monitoring, can help managers understand how different control options are likely to affect both feral pig damage and management costs. While more frequent pig control can reduce disturbance further, it may not always be worth the extra expense, particularly if moderate control achieves most of the benefit.

References

Krull CR et al. 2016. Reducing wildlife damage with cost-effective management programmes. PLoS ONE 11(1): e0146765.

Case study C

Case study C: Monitoring for signs of feral pigs on Aotea / Great Barrier Island

Synopsis

In early 2024, Wildlife Management International Ltd. (WMIL) was engaged to carry out pig disturbance surveys on Aotea / Great Barrier Island to gather baseline information on the presence and activity of feral pigs across several key management blocks (Lamb and Miskimmin 2024). The project responded to growing concern about the potential ecological impacts of pigs on the island,

including damage to vulnerable habitats and threats to native species. To conduct the surveys, WMIL applied the pig disturbance monitoring protocol used in case study A (McNutt 2016; DOC 2022; Whitmore 2022). Although the method facilitated data collection across a wide area, detections were sparse, particularly in steep or inaccessible terrain. This case provides a useful example of the limitations of applying standardised protocols without habitat suitability filters, and highlights the importance of matching method and design to context.

Objectives

The broad intent of these feral pig disturbance surveys was to obtain a baseline picture of pig activity across the island, particularly in areas of conservation concern. However, the specific monitoring purpose was not clearly articulated. It remained unclear whether the primary objective was to estimate occupancy, assess spatial distribution, evaluate management effectiveness, or simply determine whether pigs were present in each block. This lack of definition limited the interpretability of the results and made it difficult to determine whether the method, as applied, was appropriate for the question at hand. While the protocol used provided a consistent approach for detecting pig disturbance, its effectiveness relies on clear alignment with the intended monitoring goal.

Survey design and methods

WMIL carried out 20 disturbance transects across randomly selected sites within three survey blocks (Northern, Central, and Southern) between 23 February and 7 March 2024. An additional transect was conducted in the Medlands wetland area in partnership with the Oruawharo Medlands Ecovision (OME) community group. Each forested transect followed the pig disturbance monitoring protocol used in case study A, with permanent markers placed at 20 m intervals and pink flagging tape used between them to maintain alignment. Pig disturbance sign, including rooting, footprints, wallows, vegetation trampling and scat, was recorded within 1 m on either side of the tape. The wetland transect required minor adaptations due to the presence of open water and impassable bogs, and WMIL selected an adjusted bearing that allowed a minimum of 50 m of unobstructed survey area.

Results

Pig sign was not recorded on any of the transects completed in the Northern block, although fresh sign was observed during travel to two of the survey start points. In the Central and Southern blocks, pig sign was detected on four transects in total. These detections were generally low in extent, with fresh disturbance never exceeding 10.9% of transect length. At the Medlands wetland site, feral pig sign was recorded across almost 8% of the transect, indicating moderate activity in that particular habitat. Importantly, pig disturbance was often observed just outside the formal transects, including along ridgelines, informal tracks, and in areas where terrain began to level off. These incidental observations suggest that pigs were indeed present in many survey areas but were not detected within the limited footprint of the formal transects.

Interpretation and points to consider

This case study illustrates the risk of relying solely on randomly selected transect locations without incorporating filters for terrain suitability or expected habitat use. In several cases, transects were placed in areas that were too steep or otherwise unsuitable for pigs, which likely reduced the chance of detecting disturbance even when pigs were present. Given the large size and topographic variability of the survey blocks, a more targeted approach to site selection may have increased both the efficiency and effectiveness of monitoring. Feral pig sign was frequently observed adjacent to, but not within, the survey transects, which indicates that pigs were active in the landscape but under-detected by the method as applied.

Additionally, although the monitoring protocol used was initially developed for forested ecosystems, its application in a wetland environment highlights the need for further guidance on adapting the method for non-forest settings. The wetland transect produced meaningful data, but the adaptations were improvised rather than formally standardised, which limits comparability.

This case study highlights the need for careful planning when applying standardised monitoring methods in variable terrain. Site selection should incorporate ecological reasoning, including expected pig habitat and accessibility, to avoid wasting survey effort in locations unlikely to contain disturbance. Monitoring design should also be grounded in a clear objective, whether it is to detect trends, assess the outcome of control operations, or estimate baseline activity. When applying protocols in habitats that differ from the intended forested environment, method adjustments should be clearly documented and, if feasible, tested separately to ensure they produce reliable and comparable results. Without such considerations, results may be difficult to interpret or may lead to misleading conclusions about pig presence or absence.

References

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Full details of technique and best practice

Overview

This section provides detailed instructions for applying the standardised ground transect method used to monitor feral pig disturbance. The protocol is designed to generate reliable, repeatable data across sites and years, enabling consistent assessment of ecological impact from feral pig activity. To ensure comparability between observers and locations, field teams should apply the base method as described. Optional additions, such as supplementary transects or photo points, may be included if they do not alter the core protocol.

The method tracks visible signs of rooting and wallowing as a practical proxy for feral pig activity. Observers walk a 200 m transect and record the location, length, age class, and other characteristics of disturbance patches within 1 m on either side of the transect line. These visible soil disturbances reflect a direct consequence of feral pig behaviour, providing an impact-based measure that can be used to evaluate management effectiveness over time.

Originally developed for use in forested regions of the North Island, this method is best suited to sites where feral pig sign is present and disturbance is reasonably detectable. It can also be applied in more open or seasonally dry environments, though visibility of disturbance may be reduced in compacted soils or during drier periods. The method is not designed to estimate feral pig abundance, but rather to assess trends in ecological disturbance that result from feral pig presence and whether disturbance is reduced following control efforts.

Transect design and layout

The first step is to divide the monitoring area into three or more blocks of similar size and ecological character. These monitoring blocks are used to balance spatial coverage and reduce field time. They are not intended to match operational control zones or hunting areas.

Within each block, a set of randomly located transect start points should be generated, along with oversample (or ‘backup’) points. A standard length of 200 m is used to ensure consistent sampling and sufficient coverage. This is a change from earlier versions of the protocol, which used 100 m transects. Reductions in length are only permitted if the terrain is unsafe or impenetrable. At least 6 to 15 transects should be established in each monitoring block, with a total of 20 to 30 transects across the entire management area. This sample size provides broad coverage across the management area while remaining practical for small field teams to complete within available time and resources.

Two observers are recommended for transect establishment and measurement; however, remeasurement can be completed by one or two observers depending on conditions.

Field teams should aim to complete two 200 m transects per day, including travel to and from the transect locations.

Transect establishment

Before visiting a transect site, desktop checks should be used to assess the feasibility of reaching and completing the transect. Tools such as aerial imagery, topographic maps, or staff familiarity with the area can help flag unsafe terrain such as cliffs, rivers, or dense vegetation.

Observers should navigate to the GPS-marked start point in the field. While facing downslope, a coin toss is used to decide whether to walk the transect left or right along the slope contour. The transect should follow the contour of the slope as closely as possible to maintain a consistent substrate.

If an obstacle is encountered partway along the transect, the observer may rotate the line 90 degrees from the original magnetic bearing and continue in the new direction until 200 m is reached. This is consistent with DOC Tier 1 and NPCA RTC protocols. However, if less than 50 m of the transect can be surveyed, it must be abandoned and replaced by the next oversample point.

The transect start and end points must be permanently marked with durable transect marker (e.g. Permolat). Labels should include the transect ID and bearing. The path should be flagged using coloured tape at regular intervals and at any change in direction. All bearings and direction changes should be recorded in the field notebook and data sheet.

Measurement protocol

Each transect is walked slowly, with the observer scanning 1 m on either side of the line. The GPS track of the transect must be recorded and saved as a GPX or shapefile. Filenames should reference the transect ID and date. Observers may also choose to GPS-mark disturbance points, provided these are labelled consistently with the data sheet. Rooting and wallowing are the two main forms of soil disturbance recorded using this method. Observer calibration is important for consistency across time and between personnel. Useful approaches include reviewing labelled photo examples, comparing assessments during initial transects, and referring to records from previous surveys.

For each patch of soil disturbance, the observer must record:

- distance along the transect from the start point
- age classification (Very Fresh, Fresh, Old, Very Old)
- type of disturbance (rooting vs wallowing, if possible)
- general vegetation type at the site of the disturbance
- projected length of disturbance (metres).

When feral pig disturbance is observed (either rooting or wallowing), its length should be projected onto the transect line and measured to the nearest 0.1 m. The aim is to record how much of the transect itself is affected, rather than the total area of disturbance beyond it. Fig. 2 illustrates this with two disturbance events: Disturbance 1 is 2.5 m long and Disturbance 2 is 1.2 m long.

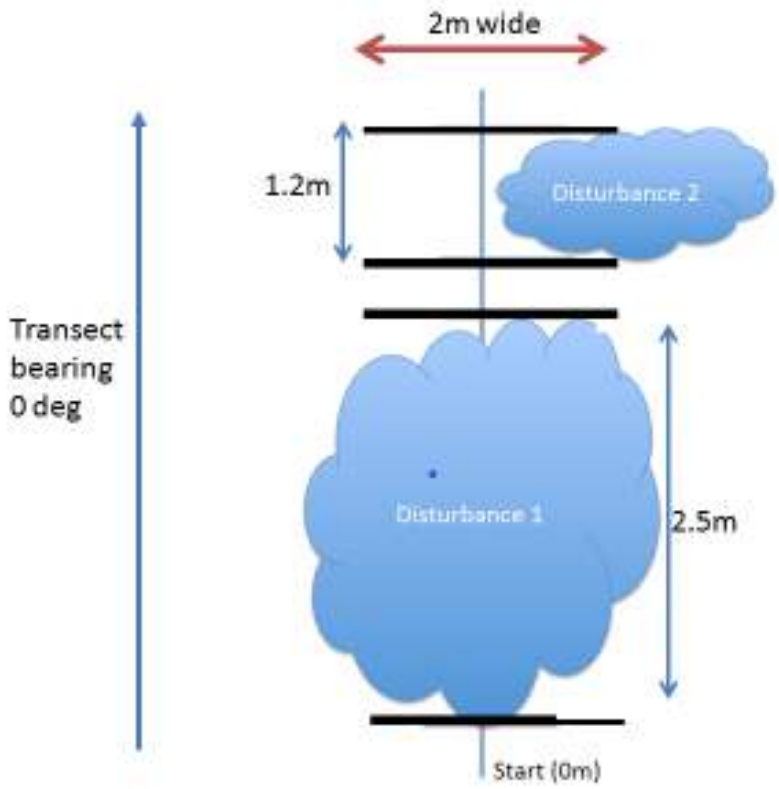

Figure 2. How to 'project' the length of the disturbance on the transect and measure the length in metres to the nearest 0.1 m. (adapted from figure supplied by C Krull, 2016).

Disturbance age classification

The updated method includes four age classes to help track the response to control more accurately over time. These are:

- **Very Fresh**: moist soil, sharp edges, no leaf litter or regrowth
- **Fresh**: friable soil, defined edges, early signs of leaf litter
- **Old**: dry soil, collapsed edges, leaf litter present
- **Very Old**: seedling regrowth present, disturbance integrated into forest floor

Photographs of example patches in each category should be reviewed before fieldwork begins. These images can also be used for training and calibration. Figures 3–5 provide a photographic guide to distinguish between 'Fresh', 'Old', and 'Very Old' disturbance (images courtesy of Cheryl Krull). 'Very Fresh' would look similar to 'Fresh' (Fig. 2) but without leaf litter. Figures 6-7 provide photographic evidence of pig wallows and footprints (images courtesy of Dan O'Halloran, 2024).

Figure 3. ‘Fresh’ disturbance – moist and early signs of leaf litter.

Figure 4. ‘Old’ disturbance – dried out and leaf litter present.

Figure 5. ‘Very Old’ disturbance – presence of seedling growth in disturbance patch.

Fig 6. Old pig wallow in Puketi Forest

Fig. 7. Pig print in Puketi Forest

Timing and frequency

Monitoring should be conducted in the same season each year. Winter is generally preferred, as soft soils make pig disturbance easier to detect. In summer conditions, dry or compacted ground may reduce the visibility of rooting and wallowing, making disturbance more difficult to detect.

Each transect should be remeasured once per year, ideally following control operations. If this is not possible, monitoring should occur at least once every two years. Delays longer than two years make it more difficult to identify and classify disturbance reliably. In some regions, high rainfall or storm activity may also shorten the window of visibility, requiring more frequent surveys.

Suitability and limitations

This method is most appropriate for forested areas with moderate to high pig densities that are targeted for sustained control operations. It is designed to detect recent and cumulative impact, not to estimate abundance or movement patterns. It may be less effective in dry, compacted environments or in areas where pig sign is infrequent.

Observer calibration

Observer calibration ensures consistent classification and recording of pig disturbance across field teams and survey periods. Recommended practices include:

- reviewing a set of labelled photographs showing the four disturbance age classes
- comparing observer classifications in the field on the same disturbance patch and discussing any differences
- having new observers accompany experienced staff for at least one full transect (with feral pig sign) before collecting data independently
- referring to photos or notes from previous years when revisiting established transects
- holding end-of-day discussions to identify any inconsistencies and reinforce shared decision rules.

These steps help improve consistency between observers and over time, and are especially useful when new personnel are involved.

Data recording and quality assurance

All data must be recorded on standardised field data sheets (Appendix B). This includes transect ID number, start and end coordinates, observer names, date, and environmental notes. Each disturbance patch should be clearly documented with start distance, length, disturbance type, age class, and vegetation context (Appendix C).

Once back from the field, data should be transcribed into a digital format as soon as possible. GPS tracks should be saved with filenames that match the transect ID and date. If photographs were

taken, these should be labelled and linked to the corresponding disturbance entries. Backup copies of field notes and data sheets should be scanned or photographed and stored securely.

Where teams are contributing to a larger programme or database, all files should follow agreed naming conventions and folder structures. Notes on observer calibration and team composition should be retained as part of the metadata.

Troubleshooting and field challenges

Common issues include:

- poor visibility of disturbance in dry or compacted soils
- disturbance recorded outside the designated 2 m transect width
- inconsistent interpretation of disturbance age or type
- unsafe terrain requiring transect abandonment or rerouting
- observer fatigue affecting accuracy.

Where disturbance is ambiguous, the best approach is to flag and photograph the patch for later review. Disturbance outside the 1 m buffer on either side of the transect should not be recorded, even if clearly caused by feral pigs.

Summary of key updates from case studies

This protocol represents the final recommended version of the method. It includes updates based on lessons from earlier trials in places such as Waipoua Forest (Whitmore 2022) and the Waitākere Ranges (Krull et al. 2016). Key changes include:

- standard use of 200 m transects, replacing 100 m lengths used in some earlier work
- expansion from two to four disturbance age categories
- stronger emphasis on observer calibration and consistency
- minor refinements to measurement rules, GPS tracking, and metadata collection.

All future use of this method should follow the version described in this section to ensure consistency, comparability, and reliability across sites and over time.

Optional data and site-specific additions

In some cases, field teams may have the capacity to collect additional observations that support local management questions or provide ecological context. These additions are not required by the core protocol but may offer useful supplementary information if time allows.

One optional metric is the maximum depth of disturbance, which may be recorded for selected patches where it is feasible and meaningful to do so. This can help characterise disturbance intensity in particular habitats but is not required for trend monitoring and should not delay or compromise core data collection.

Observers may also wish to note other signs of feral pig presence, particularly where they relate to behaviours not captured by rooting or wallowing. These may include:

- rub marks on trees
- tusk marks or bark stripping
- faeces
- hoof prints or trails.

While some of these, such as hoof prints, may involve minor soil disturbance, they are not part of the standard impact measurement used in this protocol. Recording such sign can help provide a more complete picture of pig activity at a site, but it must be clearly distinguished from disturbance observations that contribute to formal monitoring outputs.

All supplementary data should be documented in a way that avoids confusion with required measurements. If recorded, these additions should be clearly noted in the metadata and data sheets, along with the reason for inclusion.

References and further reading

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Appendix A – DOC reference documents

The following Department of Conservation documents are referred to in this method:

docCM-146272	Standard inventory and monitoring project plan (v1.1)
docCM-2784525	Waipoua pig disturbance monitoring plan June 2016
docCM-7008631	Protocol for monitoring pig disturbance
docDM-826779	Field protocols for Tier 1 monitoring—invasive mammal, bird, bat, and RECCE surveys

Appendix B – Data sheets

Feral pig disturbance – monitoring data

Date: **Observer names:**

Monitoring block number: **Transect number:**

Pig disturbance event #	Disturbance type Rooting (**R**) Wallowing (**W**) Either (**R/W**)	Age class Very Fresh (**VF**) Fresh (**F**) Old (**O**) Very Old (**VO**)	Approx. distance along transect (m)	Total length of disturbance (0.1 m)	Vegetation description along transect	Additional notes

Feral pig disturbance – transect data

Date:

Observer names:

Monitoring block number	Transect number	Grid ref start (include error)	Bearing changes		Total length of transect (m)	Grid ref end (include error)	Notes
			Approx distance (m) along transect	Bearing change grid ref (include error)			
		E N		E N		E N	
		E N		E N		E N	
		E N		E N		E N	
		E N		E N		E N	
		E N		E N		E N	
		E N		E N		E N	

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Appendix C – Example data

EXAMPLE: Feral pig disturbance – monitoring data

Date: XX/XX/XXXX **Observer names:** XXXXXXXX

Monitoring block number: 2 **Transect number:** 1

Pig disturbance event #	Disturbance type Rooting (**R**) Wallowing (**W**) Either (**R/W**)	Age class Very Fresh (**VF**) Fresh (**F**) Old (**O**) Very Old (**VO**)	Approx. distance (m) along transect	Total length of disturbance (0.1 m)	Vegetation description along transect	Additional notes
1	R/W	F	28 m	1.2 m	Mostly kohekohe with māhoe understorey. Thick supplejack in places.	Photo taken; pig faeces also observed

EXAMPLE: Feral pig disturbance – transect data

Date: XX/XX/XXXX

Observer names: XXXXXXXX

Monitoring block number	Transect number	Grid ref start (include error)	Bearing changes		Total length of transect (m)	Grid ref end (include error)	Notes
			Approx distance (m) along transect	Bearing change grid ref (include error)			
2	1	E XXXXXXXXXX N XXXXXXXXXX +/− 1 m	80m	E XXXXXXXXXX N XXXXXXXXXX +/− 1 m	200m	E XXXXXXXXXX N XXXXXXXXXX +/− 1 m	Bearing change due to river obstruction.