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ARGOS biodiversity surveys on Kiwifruit orchards and Sheep/beef farms in summer 2004/05: rationale, focal taxa and methodology

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Executive Summary

The Agriculture Research Group on Sustainability (ARGOS) programme seeks to document and compare whole-farm sustainability between farming sectors and management approaches. The primary aim is to assist landholders to increase whole-farm sustainability and resilience.

This report describes the baseline field surveys undertaken on ARGOS sheep/beef farmers and kiwifruit orchards in summer 2004/05. The ARGOS programme researches a wide diversity of habitats and landscapes and ecological processes operating at very different spatial and temporal scales. It will involve many researchers, staff and field workers. Long-term monitoring will involve repeated surveys for trend analysis. Consequently, it is important to ensure that actions and sampling protocols are standardized and that any sampling error is minimized to have the best chance of reliably detecting changes in farming environments. It is therefore essential that the sampling methods used are clearly and logically defined, scientifically defensible, and repeatable. Scientific papers will eventually be published from the surveys described here, but the normal space restrictions will preclude recording sufficient detail for new field teams to repeat the work in exactly the same way in 10 or 20 years. This report is dedicated mainly to provide that necessary detail, but also to support the retrieval and interpretation of the raw data files from the ARGOS database in years to come. The first reports and papers to emerge from the analysis are unlikely to include analyses of all the variables measured because they do not appear to be immediately important – but future researchers may want to retrieve and understand the omitted data to meet new priorities.

Accordingly, this report:

- outlines the focal taxa selected for study in the summer 2004/05 biodiversity surveys, and the reasons for their selection,
- describes the techniques chosen to survey the focal taxa,
- records specific methods used in the surveys to ensure the sampling effort can be accurately repeated at other times or locations as required, and
- identifies improvements for repeated surveys, especially at a field operational level.

The 2004/05 survey methodology included line transect distance sampling for birds, stream and pond habitat surveys, night spotlight counts and trapping for freshwater fish and frogs, and walking transects at dusk for bats using hand-held bat detectors. The bird results are described in full elsewhere, but preliminary records of bat, stream and pond surveys are recorded here.

Two separate teams of four workers were used for the surveys, one based on the sheep/beef farms and one on the kiwifruit orchards. The methods used were chosen so that one farm could be completely surveyed in one day on the sheep/beef farms and in less than a day on the kiwifruit orchards. All four team members participated in the bird surveys, while they worked in pairs to conduct the fish and bat surveys.

Diverse bird communities were found on both sheep/beef farms and kiwifruit orchards. The species present and their abundance differed markedly between farms and orchards and from birds in other natural habitats in New Zealand. The greatest difficulties we experienced in the surveys resulted from observer inexperience in identifying different bird species, particularly when the birds were far away or did not sing their full distinctive song. Bird monitoring proved workable, cost effective and obviously of interest to participating farmers, so it should become part of regular biodiversity monitoring on ARGOS farms and orchards.

No bats were found on any of the sheep/beef farms, but one long-tailed bat probably occurred on one kiwifruit orchard in the Te Puke region. A small-scale follow-up survey

using automated bat detectors is recommended to confirm the use of orchards by bats in this area.

Eighty-nine percent of sheep/beef farms had streams, but not all were flowing at the time of our survey. Streams in rolling hill country (Blenheim, Amberley, Waimate, Oamaru and Gore) tend to be small, slow flowing streams found in paddocks and gully lines. They are typically edged by pasture and so have no riparian shading, and have soft sandy or gravelly bottoms. Fish species typically associated with them are common and upland bullies, longfin and shortfin eels and trout. Streams on the Canterbury Plains (Leeston, Methven, Ashburton and Fairlie) are all farm drains or irrigation water races. These are typically long straight reaches, 1-2 metres wide with flat sandy or silty bottoms, and grazed or long pasture along the banks. Species commonly found in these clusters included upland bullies, longfin and shortfin eels, torrentfish, whitebait and adult galaxiids. No trout were recorded in these clusters, perhaps because screens prevent access to irrigation canals, and because low-oxygen levels in exclude them from drains. Persistence of native fish in these farm drains and irrigation canals may reflect escapement from predation and competition by trout. We recommend intensification of surveys and experimental tests to asses the potential value of irrigation canals and farm drains for native fish conservation in farming landscapes. The farms in the three remaining clusters (Banks Peninsula, Outram and Owaka) contain much steeper terrain with greater amounts of native scrub and bush. Consequently, the streams in these clusters are typically small and shaded by native vegetation, with coarser bottoms of cobbles and boulders. They typically contain pools, ripples and rapids which provided more varied habitat for fish. Species recorded included upland and redfin bullies, banded kokopu, inanga, longfin eels, brown trout and koura.

Only eight kiwifruit orchards had running water on them, so determination of any differential impacts of organic and Integrated Management farming on stream health is impossible by studying ARGOS orchards alone.

The field teams' lack of knowledge of each farm's layout prior to the surveys sometimes presented a problem, necessitating time spent with each farmer on the day of the surveys. However, this was useful for building a dialogue with each landholder and provided an opportunity to explain and demonstrate the survey techniques and provide assurance that the teams would not disturb stock or cause disruption or damage on the farm. Team members should budget more time to meet with the farmers when they first arrive at the property to give both parties the opportunity to discuss the survey techniques and build rapport before the surveys begin.

We recommend that in future all field workers have the sampling techniques more fully explained to them and that they undertake 3-4 training sessions on farms before they commence the survey work on actual ARGOS farms. Workers should also have the opportunity to debrief and discuss the techniques prior to the first surveys on an ARGOS farm.

Despite teething problems and some inefficiencies stemming from unfamiliarity with the farms, this pilot run provided sufficient baseline measurements from which changes in bird abundance can be assessed. The preliminary surveys of streams demonstrated that a reasonably balanced, extensive and cost effective stream health monitoring programme can be instigated on ARGOS sheep/beef farms, but not on kiwifruit orchards. Deepening and extending the stream work on sheep/beef, dairy and high country runs should be the next priority for the environmental research. Farm ponds obviously provide distinct and potentially valuable habitats for biodiversity on farms, but they were too infrequent to allow intensive study for testing the potential differential environmental impact of organic, Integrated Management and conventional farming.

The absence of bats from all but one of our study farms and orchards simplifies our environmental research and monitoring priorities, as bats were the most likely threatened species to occur on ARGOS farms. A further check for rare lizards and plants is advisable, but forthcoming long-term biodiversity monitoring on ARGOS farms can concentrate on indicators of environmental impact and restoration of more common species and agricultural biodiversity without diversion of resources to a few threatened species. Immediate quantification and mapping of the extent and variety of habitats is the next research priority to allow better testing of whether organic, IM or conventional farming results in different outcomes for biodiversity in New Zealand's faming landscapes.

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1. Introduction and aims of this report

Ecological processes and biodiversity values in New Zealand production landscapes have received very little attention to date. This results from a largely preservationist, single-species approach to environmental stewardship in New Zealand (Moller *et al*., 2005), which has focused most attention on threatened species and natural areas. The ARGOS project takes a trans-disciplinary, systems-based approach to agro-ecosystem management, with the aim of understanding and increasing economic, social and environmental sustainability and resilience of production landscapes. However, we cannot effectively manage systems that we do not understand. Consequently the ARGOS team will focus on studying general ecological processes in agro-ecosystems, rather than simply monitoring the effects of different farming systems. This understanding will provide the basis for informed and effective advice on how to best improve whole-farm sustainability and resilience.

An early focus of the ARGOS project is to test the 'farming systems null hypothesis': that conventional, organic and Integrated Management (IM) farming will have the same environmental, economic and social outcomes. Accordingly the surveys described here were conducted on 12 'clusters' of matched organic, IM and conventional sheep/beef farms and kiwifruit orchards[1].

The first step in this quest is to complete baseline biodiversity surveys on all farms, to inventory the environmental resources we have to work with. Baseline surveys of habitats and landforms will be supplemented by surveys of on-farm biodiversity in the first two years of the project. This will benchmark the species and communities present on the farms within the project, as well as allow the refinement of monitoring methods and the selection of 'focal species' for efficient long-term monitoring. Surveys for plants, soil biota, terrestrial and freshwater invertebrates, fish, frogs, lizards, birds, bats and terrestrial mammals are planned for all farms in the project.

These surveys will be undertaken by different members of the ARGOS Environment Team. Financial resources are extremely limited when scaled against the proposal to monitor around 100 farms and the huge diversity of plants and animals present. The decision of which taxa to monitor, and when and how to survey them, will be affected by a range of factors, including:

a) seasonal trends in presence, density and detectability of different taxa,
b) financial and logistical constraints on the time available to survey on each farm,
c) the degree of information on farm sustainability and resilience that can be gained from the surveys, and
d) the wishes of participating farmers.

A final set of focal species for ongoing and more intensive research will therefore emerge in the coming two years. In the meantime the research described here should be considered exploratory, and the first year's methods and results are best viewed as pilot studies.

It was decided to focus the survey effort in the sheep/beef and kiwifruit sectors on fish, frogs, birds and bats in the summer 2004/05 surveys for the following reasons:

1. We began by studying taxa judged relevance or interesting to participating farmers. Birds are highly visible, widely recognized members of the fauna that were frequently commented upon by farmers during the fist round of interviews by the sociology team (Hunt *et al*., 2005). Similarly, farmers are keenly aware of issues relating to water availability and quality. Hence surveys of fish as known indicators of aquatic ecosystem health were seen as valuable.
2. Funding and time constraints limited the time and methods to a rapid 1-day survey per farm for sheep/beef and 0.7 days for kiwifruit orchards. Given these time

[1] See Blackwell *et al*., (2005) for more detail on the location and make-up of these panels of farms.

constraints, taxa that required longer time, or more intensive or specialized sampling were not included in the first round of sampling. This excluded terrestrial mammals (requiring several days of trapping, tracking or indexing to gain a representative sample) and vegetation (large spatial scales and a higher degree of specialized knowledge required for in-field identification) from the biodiversity surveys.

3. Some other taxa were either already being surveyed as part of the ongoing program and were therefore not included in the biodiversity surveys. These included soil biota (earthworms and nematodes), pasture pests (porina and grass grub), and lizards.
4. Basic habitat and vegetation descriptions are obviously important, but are more efficiently surveyed as part of a separate GIS mapping exercise.

The surveys began on November 17, 2004 and ended on January 31, 2005. In the following sections, we describe the survey techniques that were employed for each of the chosen taxa and outline in detail the field methods used.

2. Bird surveys

2.1 Distance sampling

Most of our surveying of bird communities used 'distance sampling' techniques (Buckland *et al.*, 2001). In this approach, the observer notes the distance and angle from a predetermined transect line that each individual bird or flock was seen. It is assumed that all the birds located right on the transect line or at the observation point are seen, and a 'detectability function' is calculated that describes the way in which probability of detection declines at increasing distance from the transect or observer. The sampling unit can be defined as either an individual or a flock, in which case a separate score of the number of birds per flock is made and the distance sampling procedure estimates the density of flocks.

The DISTANCE™ software is available free of charge and fits models to observed frequency distributions to pick the best detectability function. This allows calculation of the area surveyed and thereby the 'absolute density' of each species (birds per unit area). The supreme advantage of the method is that variation in detectability does not interfere with the estimates. The method is particularly appropriate for the open-space habitats predominating on ARGOS pastoral farms, but may be less robust in the kiwifruit orchards where vision of the observer is seriously occluded by the vines and shelterbelts between blocks.

We have noticed the potential for individual variation in the way optimal models for determining the detection function are prescribed. There is considerable scope for over-parameterization of the function (with different truncations and choice of the underlying model). Clearly some of the effects may relate to changing the field workers, but other aspects of the determination of appropriate detection functions are likely to be driven by unchanging features in the landscape (like tall woody vegetation). This suggests that future trends should only be established by one analyst reworking the full set of raw data, including this first year's set.

All observers took part in training exercises on a non-ARGOS farm before the surveys commenced to ensure all personnel were familiar with the survey techniques and could correctly identify bird species found on the farms.

2.1.1 Line transect sampling on sheep/beef farms

Five to eleven transects were surveyed on each of the 37 sheep/beef farms in the study. Farm boundaries were placed onto aerial photographs of each farm using the Tumonz™ GIS software (Vision Software 2004). Transect start points were randomly located within the farm boundaries, with the proviso that start points were at least 200m apart and each transect was at least 100m from the farm boundary. Transects ran due south from the start point and were 500m long in most cases. A stopping rule was applied if the transect came within 100m of a farm boundary, so that some transects were less than 500m long. An initial pilot run of the survey technique was conducted on the first cluster (Outram), where one observer was placed on each of the three farms in the cluster and transects were surveyed simultaneously on 3 successive days. This would have been the ideal design because it perfectly balances observers and days/weather amongst the farming systems. However, this approach proved to be logistically unfeasible, mainly because it took a long time to set up the field personnel in position each day, leaving little time for actually counting birds. For the remaining clusters, all transects on a single farm were surveyed on the same day. Each transect was surveyed once by one of four trained observers between the hours of 0800 and 1400, to avoid the peak calling periods at dawn and dusk where conspicuousness and detectability can change rapidly (Dawson & Bull, 1975).

Each observer was supplied with an aerial photograph of the farm with the latitude and longitude (in decimal seconds ddd mm.mmm) of transect start points marked on it. Twelve to 14 potential transects were generated for each farm and their suitability was discussed with the individual farmers before the survey began. This excess of transects meant that paddocks where stock were breeding, or where crops had recently been sown, or where access was difficult or dangerous could be excluded. Once transects had been selected, the start point of each transect was located using the photograph and a Garmin eTrex hand-held GPS unit (Garmin International Inc) set to the WGS84 datum.

The current ambient temperature, average wind speed (in km/h) and relative humidity were recorded using a Kestral 4000 portable weather meter (Nielsen-Kellerman, PA) and the relative cloud cover (on a 5-point scale where 0 = no cloud and 5 = complete cloud cover) and weather conditions (fine, overcast, raining) were recorded (see the sampling sheet at Appendix 8.1).

The observer entered the exact location of the start point into the GPS unit as a waypoint and then walked due south irrespective of farm orientation, terrain or topography, recording all birds seen or heard. In general, observers walked at a constant pace (2-3 km/h), although they were allowed to stop to record details of sightings, particularly if more than one bird was sighted simultaneously.

Each observer was supplied with a pair of binoculars and bird identification sheets (from Heather & Robertson, 1996) to aid in bird identification, and a Bushnell Yardage Pro® laser range finder (Bushnell Performance Optics, Overland Park, Kansas) to determine the distance of the bird from the transect line.

We tested the range finders for accuracy by getting each observer to estimate the distance to the same object at a range of distances from 10 m to 250 m. The accuracy of the readings was affected by the size of the object and the distance from the observer. The range finders and observers were reasonably precise, reading ± 2 m at distances < 100m, and ± 5 m at distances of 200m.

Distance™ requires perpendicular sighting distances for analysis (Buckland et al., 2001), so a compass was used to determine the angle of the bird **from the line** if the sighting angle was less than 90°. In these cases, the perpendicular distance was calculated using trigonometry:

$$X = \sin\theta . H$$

Where X = the perpendicular distance, θ = the sighting angle between 0 and 90°, and H is the hypotenuse given by the recorded distance to the bird. In most cases birds were first detected ahead of the observer as she or he moved along the transect, but the data and analysis include occasional birds first detected behind the observer.

In cases where groups of birds were seen, the number of birds in the group and the distance to the centre of the group was recorded. For birds that were heard singing or calling (but not seen) within a clearly defined habitat feature (e.g. a tree in a paddock or shelterbelt), the distance was estimated to the habitat feature. Birds that were heard with no location determined were recorded as heard only and were not used in the subsequent Distance™ analysis. Flying birds were recorded with a distance only if there was a habitat feature that was within 5m of the bird when it was first seen that could be used to determine the distance. Otherwise, the bird was recorded as flying but not used in the Distance analysis. For each bird, the observer recorded the habitat it was in (e.g. open paddock, shelterbelt, riparian vegetation) and its behaviour (e.g. flying, singing, feeding: see Appendix 8.1 for a full description of habitats and behaviours). If the individual bird could not be recognized it was recorded as an unknown and its location, habitat and behaviour were recorded as for known species.

The observer continued along the transect line until they had walked 500m (using the GPS to determine the distance traveled), or until they came within 100m of the farm boundary (as determined by the laser range finder). At this point they recorded the latitude and longitude of the end point of the transect, and then conducted a five-minute bird count (see below). Data from five-minute bird counts were not added to the data set used for distance analysis, but was used as an independent assessment of bird communities on the farms and for comparison with other habitats in New Zealand where the five-minute counting techniques was used (Blackwell *et al*., 2005).

Data collected from the bird surveys were entered into a Microsoft Excel template (Appendix 8.8) with each individual observer entering their own data to minimize errors. Entered data were then cross-checked by a second observer (usually the team leader) to ensure accuracy. Data from both the distance sampling and the five-minute counts were entered into the same Excel spreadsheet, but were coded to allow separate analyses at a later date. The template included columns for all site-specific variables (farm, transect number and latitude and longitude, and weather details) as well as all the survey data (see Appendices 8.1 and 8.5).

All data were entered on PC workstations, and saved in a folder titled "bird surveys" in a master folder titled "ARGOS summer biodiversity surveys200405", held at CSAFE at the University of Otago. Once the ARGOS database has been established and tested, these data will be uploaded for general access. The original copies of the field data sheets are archived at the Zoology Department, The University of Otago. Preliminary analysis of the line transect sampling on sheep/beef farms has been reported by Green *et al*. (2005) and more detailed investigation will be described in forth coming reports once habitat information has been included.

2.1.2 Line transect sampling on kiwifruit orchards

The enclosed nature, regular rows of vines and small spatial scales forced changes in the bird community sampling protocol on kiwifruit orchards. Transects were marked a day or more prior to undertaking surveys. A start point was randomly chosen by first selecting a corner along the property boundary and then a distance within 50m along the boundary perpendicular to the direction of the kiwifruit rows. The transect started on the property boundary in the 'headland' and, in general, observers walked down the middle of the vine 'alleyways' through the kiwifruit blocks until they reached the distant property boundary. Subsequent transects were located 50m apart and parallel to the preceding ones. When the orchards were irregularly shaped, the transects were not all parallel. When the block was small and ran in a different direction to the majority of blocks, we ran transects across rather than down the rows. Due to their random placement, some transects were not located through kiwifruit blocks but in 'sidelands' (between vines and a shelter belt), in grassed areas adjacent to vines, or in different types of orchards (e.g. avocado) that were part of the farm unit. When time did not allow complete coverage of the property, priority was given to kiwifruit blocks that were of the same classification as the orchard (i.e. green, gold or organic); then to kiwifruit blocks that were different to that classification (e.g. green blocks that were part of a gold orchard); and finally to other types of orchard (e.g. avocado, citrus, passion fruit). The location of transect start and end points was noted using a GPS unit, while transect length was measured with a range finder.

Surveys at Cluster 4 (Paihoia) were conducted over three days, but this was reduced to two days for all the remaining orchards due to time and budget constraints. Two days was sufficient to ensure at least 40 sightings were made on each orchard for the two most commonly observed species (blackbirds *Turdus merula* and song thrushes *T. philomelos*). Orchards within each cluster were surveyed concurrently and observers were rotated between orchards and management systems to control for potential bias.

Observers were supplied with a map of the farm with the transects marked on it. Surveys were conducted between the hours of 0800 and 1500, and observers noted climatic and bird variables (Section 3.1.1). In addition, observers recorded the habitat where the bird was first detected and whether the bird was seen, heard, or both (Appendix 8.3). Birds that flew past were not included in analyses. The results of the line transect sampling on kiwifruit will be reported elsewhere.

2.2 Five-minute bird counts

Five-minute bird counts were conducted following the procedure of Dawson & Bull (1975), where all birds seen or heard over a five minute period are recorded. A separate five-minute count was recorded at the end of all line transects that were conducted on each of the sheep/beef farms. On kiwifruit orchards, five minute counts were undertaken every 200m along line transects, with the first count starting at a randomly selected distance within the first 200m of line transect. The location of the point was recorded on a GPS unit. Upon reaching the site, a two-minute wait before starting the five-minute bird count was observed to allow any species that may have been disturbed to return back to the site.

As with the line transects, the location, habitat and behaviour of each bird or group of birds was recorded, although for the five-minute counts radial angles between 0 and 360° were used. Angles were recorded so that individual birds could be assigned to particular locations in the orchard. However, the data were only used to calculate the relative five-minute index and not for the distance sampling. Within each count, no birds were knowingly counted twice, nor were birds assumed to be present without some visual or auditory clue to their presence (Dawson & Bull, 1975). Common names of species were used to record observed birds for both the line transects and five-minute point counts.

Analysis of the five-minute bird counts have been reported by Blackwell *et al*. (2005).

2.3 Problems and opportunities for bird surveys

The main factor affecting the accuracy of the bird surveys was the team members' initial lack of expertise in identifying different bird species based on their markings or calls. This was particularly true for many of the introduced songbirds, such as redpolls, greenfinches, goldfinches, house sparrows and yellowhammers. These species were often seen at a distance on the wing, or did not make their full call. Other birds that could be difficult to distinguish were blackbirds, song thrushes and starlings, among the introduced birds, and tui and bellbirds among the native species.

Accuracy of the sampling increased with observer experience, although all observers were encouraged to record individuals as unknown if they were unsure of identity, rather than risk mis-identification. This suggests that the date should be added as a covariate in the analysis, partially to control for observers' learning, but also because of potential breeding season effects. There were also differences between observers in the speed at which they conducted their surveys, with consistent differences emerging in the time that it took different observers to complete transects and in the number of birds they recorded. Observers also varied in their familiarity and confidence on the farms and around stock, particularly cattle on sheep/beef farms, which sometimes resulted in transects being cut short if they entered paddocks with cattle in them. In general, observer confidence increased with experience, although all team members were instructed not to enter paddocks if they felt uncomfortable or uncertain of likely stock behaviour.

The habitat descriptions were developed after the preliminary farm visits to train observers and were designed to encompass the broad habitat likely to be encountered on the ARGOS farms. However, as the farm surveys progressed, it was necessary to add additional habitat types. These included recently ploughed or planted paddocks that were predominantly bare ground, crop paddocks with cereal or brassica crops, dense grass (paddocks reserved for hay production), cliff areas and a variety of man-made structures that were not present on the training farms (see Appendix 8.1). Individual observers also sometimes gave the same habitat type a different name; for example 'dense grass' or 'hay paddock' may have both been applied to paddocks of fallow pasture that had been closed for hay production. In future surveys it will be necessary to check that habitat descriptions are better standardized in future surveys and that any new habitats encountered during the survey are relayed to all team members. Appendix 8.2 shows the range of habitat descriptions used by the observers and the broad category summaries used in subsequent analyses.

Similarly, variation emerged in the behavioural descriptions used by different observers (Appendix 8.4), particularly in the way observers characterized behaviours of birds that were exhibiting several behaviours at once. For example, a yellowhammer perched on a fence singing may have been described variously by observers as ‘on a fence’ for its habitat and ‘perching’ or ‘singing’ as the behaviour; or with ‘paddock’ as the habitat and ‘sitting on the fence singing’ as the behaviour. As the surveys progressed and the teams discussed their observations and experiences, the behaviour and habitat descriptions became more standardized. Greater attention will need to be paid to this process in future surveys if changes in behaviour are to be monitored rigorously from the outset of the next set of surveys.

Our pilot study only measured the angle and distance to each bird without recording where on the transect that it was sighted, nor which side of the transect it occurred. In future we will try to find an efficient way of recording the actual location of the birds so that it can be plotted on habitat maps currently being drawn for each farm. This will greatly enhance the subsequent analysis by allowing investigation of where on the farm each species occurs.

3. Bat surveys

Bats have a special importance in New Zealand conservation because they are the only native terrestrial mammals. Both the long-tailed (*Chalinolobus tuberculatus*) and short-tailed bat (*Mystacina robusta*) are considered threatened and now occupy a much smaller area than they did historically, although some of this distribution does include farmland, for example in the Geraldine region in South Canterbury (Sedgeley & O'Donnell, 2004). However, surveys of bat distribution in New Zealand farmland landscapes are sparse and incomplete and it is unclear how frequently bats roost or forage in farmland. Additionally, the bats are cryptic unless specialised 'bat detectors' are used to convert their ultrasonic echo-location calls into audible signals. Consequently, it was decided that searches for both long-tailed and short-tailed bats should be made on all ARGOS farms as part of the baseline biodiversity surveys, with research only to be intensified in later years if bats were detected.

3.1 Walking transects on sheep/beef farms

The bat surveys used a slightly modified version of the standard protocol devised by O'Donnell & Sedgeley (2001) where observers walked slowly (around 3 km/h) while carrying a hand-held 'Bat Box III' bat detector (Stag Electronics, Sussex, UK). Prior to the farm visit, all roads and areas of on-farm potential bat habitat (e.g. tall woody vegetation, shelter belts and riparian vegetation) were identified from aerial photographs using Tumonz. Their presence was ground-truthed on the farm during daylight before the bat survey was conducted (Tumonz images are somewhat out of date). We mapped out a survey route that took in habitat features where bats were most likely to frequent and included all public roadways around the perimeter of each farm. This was walked by two observers in the first two hours after nightfall. The observers recorded the latitude and longitude of the start and end point of the transect and recorded the same weather variables as for the bird transects (see Section 3.1.1, Appendix 8.5). Surveys were only conducted if there was no rain and the ambient temperature was over 7°C at the start of the transect sampling (O'Donnell & Sedgeley, 2003). The observers carried two bat detectors, one tuned to 40 kHz for detecting long-tailed bats and the other 27-28 kHz for short-tailed bats, and counted the number of 'bat passes' recorded on the transect.

A total of 48 transects were surveyed on the 37 sheep/beef farms (average 1.3 per farm), with an average survey time (± standard deviation) of 32 ± 13 minutes for each transect. Assuming an average walking speed of 3 km/h, this equates to a 77 km search path[2]. The bat boxes detect long-tailed and short-tailed bats up to around 50m and 20 m respectively, so approximately 3.8 Km^2 and 1.5 Km^2 have been scanned for long-tailed and short-tailed bats respectively on ARGOS sheep/beef farms altogether. No bats were recorded on any of the surveys.

3.2 Walking transects on kiwifruit orchards

The bat sampling protocols used on the kiwifruit orchards were similar to those used on the sheep/beef farms, but had two key differences: (i) the smaller size of the kiwifruit orchards meant that one observer could walk next to the tall woody shelter belts along the entire perimeter of the property (and often all the internal shelter belts), and (ii) more than one property could be surveyed in a night. Generally all the orchards in a cluster were surveyed in one night, so that all bat surveys (12 clusters, 37 orchards) were conducted over a total of 15 separate nights. There was only one search on a single night per orchard. As with the sheep/beef farm surveys, the start and end time of the survey was noted, transect start and end points were recorded using Garmin eTrex GPS units, and ambient weather conditions were noted and recorded using a Kestrel 4000 weather meter.

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[2] An accurate estimate of each transects length will be calculated when GIS maps of all the farms and orchards are complete.

A total of 67 individual transects were surveyed on the 37 kiwifruit orchards (average 1.8 per orchard), with an average survey time (± standard deviation) of 32 ± 14 minutes for each transect. At a walking speed of 3 Km/h, this equates to a total search path of 107 Km, and search areas of approximately 5.4 Km^2 and 2.1 Km^2 for long-tailed and short-tailed bats respectively on kiwifruit orchards.

There was one unconfirmed bat recording during the surveys: On the night of 17 December 2005, two passes were recorded at 12:29 and 12:43 am on the bat box set at 40kHz on the KiwiGreen Hayward orchard in Cluster 11 (Pongakawa, Te Puke). This was most likely a single long-tailed bat, although this can not be confirmed based solely on so few isolated apparent bat passes.

As with the bird surveys, data from the bat transects were entered into a Microsoft Excel template (Appendix 8.9) with each individual observer entering their own data to minimize errors, which was then cross-checked by a second observer (usually the team leader) to ensure accuracy. The template included columns for all site-specific variables (farm, transect number and latitude and longitude, and weather details) as well as all the survey data (see Appendices 8.2 and 8.6). All data were entered on PC workstations, and saved in a folder titled “bat surveys” in the “ARGOS summer biodiversity surveys200405” master folder, held at CSAFE at the University of Otago. The original copies of the field data sheets are archived at the Zoology Department, The University of Otago.

3.3 Problems and opportunities for bat surveys

The two main concerns with the bat surveys were ensuring that a representative and safe transect was searched, and that the observers were confident that they were hearing bat passes. The recommended DoC methodology required that observers walked all public roads within 1 km squares of the SM1 Map Series. Sheep/beef farms differed in the extent of road frontage and in the suitability of that road as bat habitat. For example, farms in Oamaru and Gore had little roadside vegetation and were unlikely to be flyways. We decided to only survey roads that immediately abutted the boundary of each farm. The amount and type of woody vegetation present on the farms ranged from regular pine and Macracarpa shelterbelts in Canterbury, to very little woody vegetation of any kind on some of the Waimate, Oamaru and Gore farms. With only one night for surveys on each farm, it was necessary to chose a transect route that was a compromise between coverage and ease of access. Survey routes also need to be easily followed by the observers and not take them through areas of rough or unsafe terrain or into paddocks were they would disturb stock or cause damage (e.g. paddocks with fawning deer or bulls). Kiwifruit orchards were smaller and closer together and all had areas of tall shelterbelt surrounding them. Consequently, it was easier to map transect routes that could encompass the entire boundary and land within each individual orchard. Given the smaller area, a pair of observers could survey all three orchards in the cluster in the one night, and the team could survey more than one cluster in a night, increasing the efficiency of the surveys.

While bat passes are distinctive and easily recognized with practice, the boxes also picked up cicadas, crickets, electric fences and other sources of interference. Bat passes were very rare (only two possible passes were recorded on one kiwifruit farm), making it less likely that observers would be confident if/when they indeed heard a bat. This problem could be countered to some extent by regularly playing recordings of bat passes to the observers to refresh their memories and to ensure they were vigilant while walking the transects. An alternative in the future would be to deploy automated bat boxes on the farms, which consist of a bat detector and voice activated tape recorder housed in a water proof container. The detectors are usually left in place near likely bat habitat (e.g. along a stream or on the edge of bush gullies or shelterbelts) overnight and retrieved in the morning. While the tapes provide a permanent record of the night’s activity, they are more expensive. If fewer units were available, it would take much longer to survey the farms.

4. Surveys of streams, ponds, fish and frogs

There is a large body of evidence linking freshwater biodiversity and physio-chemical properties to adjacent land use (van Roon & Knight, 2004), and there is an increasing awareness of the role aquatic ecosystem health and function can perform as indicators of the sustainability of surrounding land use. Freshwater fish have been widely used as bio-indicators of overall stream function (Harris, 1995; Joy & Death, 2003; Oberdorff et al., 2001), because they are:

- relatively easily identified,
- of widespread aesthetic, cultural and commercial value,
- primarily affected by macro-environmental variables such as those operating on whole-farm scales,
- relatively long-lived and thus good integrators of long-term stressors or influences, and
- often at the apex of aquatic food webs, and therefore integrate many trophic ecological interactions.

The majority of these points also apply to frogs in wetland and still-water environments that are often found on farms.

The preliminary surveys of fish and frogs described here was part of gathering preliminary information on the types and abundance of aquatic ecosystems on the ARGOS farms. We sought just enough information to assess the workability of more detailed stream and wetland surveys planned as part of the upcoming research. Therefore the objectives of the stream and wetland surveys were to:

1) gain a broad understanding of the aquatic ecosystems present on the participating ARGOS farms, and
2) conduct a rapid assessment of the occurrence of fish, frogs and a crustacean, the freshwater crayfish (*Paranephrops planifrons*) present on the farms.

Techniques available to survey freshwater fish include (a) electro-fishing using specialized backpack units that deliver a low current, high voltage electrical charge to the stream, (b) trapping with various types of set nets, and (c) night spotlighting using high powered lights and hand nets. To meet the needs of the biodiversity surveys, spotlighting and limited trapping were chosen as the most appropriate techniques. The advantages of spotlighting include:

- Spotlight counts are fast and efficient, allowing longer reaches to be sampled than with trapping or electro-fishing.
- Spotlighting is a relatively inexpensive technique that does not require the purchase of expensive electro-fishing equipment. Additionally, field teams must be licensed before being allowed to operate electro-fishing equipment.
- Spotlighting is the least invasive technique of the three, and causes minimal harm to the fish recorded during the survey, with the only contact being minimal handling of any individuals that may be caught in hand nets to confirm species identity.
- Most native fish are nocturnal and consequently, spotlighting provides more information on behaviour and habitat use than either trapping or electro-fishing.

Although spotlighting was chosen as the primary survey technique, there are situations, such as in still water in farm or orchard dams or very slow flowing streams, where other techniques are more appropriate. Consequently, we used small live-traps to survey ponds and dams. These were Gansel Collapsible 'Bait Fish Traps' (Gansel Australia, Milperra NSW), measuring 25 x 25 x 45 cm when extended. They were primarily used in the kiwifruit orchards (see Section 5.2).

4.1 Aquatic surveys on sheep/beef farms

Prior to the first farm visit, known and potential waterways were identified using the Tumonz GIS software and aerial photographs, and their nature and accessibility were then confirmed with the landholder at the time of the survey. Sometimes the farmers identified additional waterways not discernable from the aerial photographs. The most promising sites were then visited in daylight to confirm suitability.

4.1.1 Streams on sheep/beef farms

Stream channels were found on 34 farms (all except the Waimate organic, conventional and converting farms). Of these, Oamaru organic and Waimate IM did not have flowing water in the channels, but they did have remaining pools that were surveyed. Oamaru IM had a channel but no pools remaining.

Streams in rolling hill country (Blenheim, Amberley, Waimate, Oamaru and Gore) tend to be small, slow flowing streams found in paddocks and gully lines. They are typically edged by pasture and have no riparian shading, and have soft sandy or gravelly bottoms. Streams on the Canterbury Plains (Leeston, Methven, Ashburton and Fairlie) are all farm drains or irrigation water races. These are typically long straight reaches, 1-2 metres wide with flat sandy or silty bottoms, and grazed or long pasture along the banks. Most streams flow along roadways beside the boundary fence or along paddock margins. The farms in the three remaining clusters (Banks Peninsula, Outram and Owaka) contain much steeper terrain with greater amounts of native scrub and bush. Consequently, the streams in these clusters are typically small and shaded by native vegetation, with coarser bottoms of cobbles and boulders. They typically contained pools, ripples and rapids which provided more varied habitat for fish.

The wide diversity of stream types present on the ARGOS farms is a key factor contributing to the range of native and introduced species we recorded and highlights the important role agricultural landscapes can play in wider biodiversity conservation.

Upon reaching the survey site, the latitude and longitude of the transect start was recorded using a Garmin eTrex GPS unit, and the same ambient weather conditions as recorded in the bird and bat surveys were taken. Two observers were used in the surveys, each equipped with a pair of hip waders and either a LightForce 100W hand-held spotlight (LightForce, Adelaide, South Australia) and 12 volt, 17-ampHr gel battery (Century Yuasa Industrial Batteries) or a LightForce 30W hand-held spotlight and 12 volt, 7 ampHr gel battery. No colour filters were used. The main observer was the same in all surveys, while the second observer was alternately one of a group of four other field workers. The two observers moved upstream (to avoid disturbing un-surveyed substrate) on opposite stream banks at a slow walking pace, avoided walking in the stream channel wherever possible. Fish were either identified in-stream, or caught in hand nets for identification (Appendix 8.6). We aimed to survey 200-400 m of representative waterways on each farm. The chosen sites were surveyed in the first two hours of darkness, concurrent with the bat surveys (Section 4.1). The average time (± standard deviation) taken to complete each survey was 31 ± 14 minutes. A small number of species (particularly small individuals of several non-migratory galaxiids) cannot be identified in the field, so we must examine them with a microscope. For these species, individuals were euthanased, preserved in 90% ethanol and returned to the laboratory for identification.

Surveys continued until at least 200m of stream had been surveyed[3], at which point the end latitude and longitude were recorded and several physical and environmental characteristics were recorded (see Appendix 8.7). Mean water depth was the average of three measurements taken at equidistant points along the reach surveyed. The mean width was

[3] 200m is sufficient distance to ensure that three-four replicates of each habitat types (e.g. riffles, pools, rapids) will be sampled in a reach, giving a representative sample of species diversity.

determined as the average of the wetted area width at the three survey points. The percentage of pool, riffle, run, rapid, still water and backwater was estimated over the surveyed reach. Following Joy and Death (2003), 'riffles' were defined as areas of fast flowing shallow water with a broken surface, 'pools' as slow flowing deep water with a smooth appearance, and 'runs' as intermediate in character.

The general characteristics of the stream channel were recorded as the percentage (to the nearest 5%) of

1. Over-stream cover: Any vegetation taller than 1m that cast shade over the stream bed. This was usually willows, poplars, manuka/kanuka and other native trees and shrubs.
2. Undercut banks: Sections of earth bank, often topped with long grass, that the stream channel had cut underneath
3. In-stream debris: Any large (>50cm long) material in the stream, usually in the form of branches and logs, in the stream channel. There were often trapped leaves, twigs and small branches associated with the debris.
4. Exposed bed: Sections of the stream channel that were uncovered and dry due to low flow levels.
5. Aquatic macrophytes: Individual plants or beds of water weeds floating in the water column.

The riparian strip (defined as 5 m either side of the stream banks) was recorded as the percentage of riparian cover that was native or exotic forest, willows, pasture, raupo (*Typha orientalis*) and exposed bed. The embeddedness of the stream substrate was also estimated, with a score of 1 indicating fine sand or gravel that was easily moved and 4 indicating bedrock or large cobbles that could not be moved by hand.

A summary of the species observed and the numbers of farms under each farming system on which they occurred are shown in Table 1. The average number of species recorded on each farm was 2.8 (range 0-5 species). Only 2 reaches had no fish of any sort recorded.

Fish species typically associated with streams in rolling hill country (Blenheim, Amberley, Waimate, Oamaru and Gore) were common and upland bullies, longfin and shortfin eels and trout.

Table 1. Summary of aquatic habitat and species occurrence on 37 ARGOS sheep/beef farms, 2004/05.

Common name	Scientific name	Farming system: Organic	IM	Conventional	Converting	Total Farms
Streams						
Number of farms with streams		*11*	*11*	*11*		*33*
Reaches surveyed		*12*	*11*	*12*		*35*
Banded kokopu	*Galaxias fasciatus*	2	1	1		4
Galaxid species	*Galaxias* spp.	1	3	3		7
Brown trout	*Salmo trutta*		1			1
Unknown trout	*Salmo or Oncorhynchus spp.*	1	1	1		3
Common bully	*Gobiomorphus cotidianus*		1	1		2
Giant bully	*Gobiomorphus gobioides*	1	1			2
Longfin eel	*Anguilla dieffenbachii*	4	1	3		8
Shortfin eel	*A. australis*	2	1	2		5
Unknown eel	*Anguilla* spp.		2	2		4
Redfin bully	*Gobiomorphus huttoni*	1				1
Upland bully	*Gobiomorphus breviceps*	2	3	1		6
Torrentfish	*Cheimarrichthys fosteri*		1			1
Unknown bully	*Gobiomorphus* spp.	1	2			3
Inanga	*Galaxias maculatus*	1	1			2
Whitebait	*Galaxias* spp.	2	1	1		4
Unknown fish			1	1		2
No fish seen		1	1			2
Southern bell frog	*Litoria raniformis*	2		1		3
Koura	*Paranephrops planifrons*	2	2	1		5
Total taxa detected in streams		22	23	18		63
Ponds						
Number of farms with ponds		*0*	*2*	*0*	*1*	*4*
Ponds surveyed		*0*	*2*	*2*	*1*	*5*
Fish-trap-nights		*0*	*8*	*0*	*0*	*8*
Dragonfly larvae	*Odonata* spp.		1			1
Water boatman	*Sigara* spp.		2		1	3
Whistling tree frog	*Litoria ewingii*			1	1	2
Southern bell frog	*Litoria raniformis*			1	1	2
Tadpoles	*Litoria* spp.		1			1
Total taxa detected in ponds			4	2	3	9
Grand total of taxa detected		***22***	***27***	***20***	***3***	***72***

Upland bullies, longfin and shortfin eels, torrentfish, whitebait and adult galaxids were found in the Canterbury clusters (Leeston, Methven, Ashburton and Fairlie). Trout were also recorded on the Organic farm in cluster 4 (Leeston), which had a natural stream system with aquatic macrophytes and riparian trees running through it. The remaining records were all in irrigation water races, which characteristically have flat sandy or silty bottoms and little or no riparian shading, or in farm drains. Importantly, in no cases did we observe introduced trout in these habitats, perhaps largely due to the presence of screens on water race intakes, or low oxygen conditions in the case of farm drains. Absence of trout, which prey on native species and compete for resources may allow the persistence of native fish (Townsend 1996). If so, farm drains and irrigation water races may provide important refuge habitat for native species in agricultural landscapes. Slow moving, overgrown and ephemeral lowland streams have already been recognized as key habitat for native mudfish (McDowall, 1990; Hicks & Barrier 1996). Our surveys suggest that they also provide important refugia for a wider range of native species.

Species recorded in the more natural streams of the three remaining clusters (Banks Peninsula, Outram and Owaka) included upland and redfin bullies, banded kokopu, Inanga, longfin eels, brown trout and koura.

Upcoming surveys on the sheep/beef farms will compare the composition, functioning and health of streams on farms with differing farming systems and will increase our understanding of the importance of water races and farm drains for biodiversity and ago-ecosystem processes.

4.1.2 Ponds on sheep/beef farms

Ponds were noted on four sheep/beef farms as part of the surveys (Table 1). They were defined as any man-made, contained body of water. They nearly all had constructed earthen banks[4], and generally had a slow flow into them from a seepage or stream. They ranged in size from 5-25 m across in the surveys. The banks were usually bare earth or grasses and some sedges and they were all situated within open pastures. The locations of the ponds were recorded using Gramin eTrex GPS units and the same habitat variables as used for the streams were recorded. The size of the pond, the surrounding land use and the nature of the riparian strip were noted as for the stream surveys.

In all cases these were small and largely free of macrophytes. Consequently they were also surveyed for fish using spotlighting, but no fish were spotted (Table 1).

Frogs were surveyed at ponds during the fish surveys by listening for calls from any frogs present (no frogs were heard during any of the stream surveys). Two introduced Australian frog species were often encountered on the farms: the whistling tree frog (*Litoria ewingii*), and the southern bell frog (*L. raniformis*). The two species can be easily distinguished by their calls, with the whistling frog having a high pitched incessant call, while the southern bell frog has a deeper more intermittent call. The presence of frogs and a qualitative density estimate ('rare', 'common' or 'abundant' were recorded for each pond. In the majority of cases a visual sighting of the individual was made to confirm the identification made on the basis of heard calls.

Frogs were only observed on 4 of the 37 farms, although we did not conduct an exhaustive search of every pond. They may be present on a few additional farms. Southern bell frogs were heard in low to moderate numbers (2-10 calls heard) in streams on two organic and one conventional sheep/beef farm, and were heard in a pond on the converting organic farm (3 calls from one individual only). Whistling tree frogs were heard in ponds on one conventional and the converting organic farm. Judging from call frequency alone, this

[4] One pond (on the Waimate farm that is currently converting to organic) had straight concrete edges along two sides and earthen banks on the other two sides (it was approximately a 10 x 20 m rectangle in shape).

species was apparently more abundant that the Southern bell frog, with calls from at least 20 individuals heard on both occasions. However, frogs were not widespread or abundant enough for us to recommend further detailed investigations at this stage, at least with respect to the main ARGOS null hypothesis regarding differences between farming systems.

4.2 Aquatic surveys on kiwifruit orchards

The same basic protocols were used for kiwifruit orchard surveys, including the use of equipment, spotlight search patterns, specimen identification and the consistent use of one main observer. All bodies of water within an orchard were surveyed, but the majority of orchards did not have streams running through them, so surveys were only possible on eight orchards. When present, waterways tended to be slower moving and contain more macrophytes than on sheep/beef farms, resulting in a greater reliance on trapping.

Up to 10 traps were placed per orchard at approximately regular intervals along the waterways and/or along the edges of ponds, allowing for sufficient water depth. Traps were set during the afternoon and checked for contents first in the evening of the same day (between 2100 and 0100 hr, by when it was dark) and then the following morning between 0700 and 1000 hr. This frequent checking is needed to minimize escapes and within-trap predation.

A summary of the species observed and the numbers of orchards under each farming system on which they occurred are shown in Table 2. The average number of species recorded on each farm was 3.7 (range 1-6 species).

Data from the fish transects from both the sheep/beef and kiwifruit sectors were entered into a Microsoft Excel template (Appendix 8.10) with each individual observer entering their own data to minimize errors. Entered data were then cross-checked by a second observer (usually the team leader) to ensure accuracy. The template included columns for all site-specific variables (farm, transect number and latitude and longitude, and weather details) as well as all the survey data (see Appendices 8.3, 8.4 and 8.7). All data were entered on PC workstations, and saved in a folder titled “fish surveys” in the “ARGOS summer biodiversity surveys200405” master folder, held at CSAFE at the University of Otago. The original copies of the field data sheets are archived at the Zoology Department, The University of Otago.

4.3 Problems and opportunities with the aquatic surveys

As with the bat surveys, the main consideration with the aquatic surveys was to select suitable survey sites. Time spent with the farmer discussing the survey techniques and possible sites was particularly useful, as individual farmers could direct the survey team to the most appropriate sites (including the best way to access these sites), as well as provide information on species they had observed in their waterways. Many farmers commented on seeing eels, koura, “native trout” and whitebait, and the best places to observe them. They could also provide information on rare or unusual sightings (such as a large eel sighted on the farm track on an Ashburton farm after heavy rain) and on typical flow patterns and characteristics, such as pointing out which waterways dried up over summer, or had limited access from fish species (such as one stream that flowed over a cliff directly into the sea). These comments were noted on the field data sheets and entered into the computer with the survey data.

There were also challenges associated with the surveys themselves, with some individual fish only sighted briefly or not captured to confirm their identity, in which case they were recorded as ‘unknown’. Even when some fish were caught, it was difficult to determine which species they were, particularly for some of the non-migratory galaxiids species. In these cases, digital photos were taken for later identification. In eight cases, reference specimens were collected for species confirmation back at the University of Otago.

Despite these limitations, the stream surveys provided important baseline information on the aquatic ecosystems present on the farms and orchards, as well as a preliminary signal of the diversity of fish and macroinvertebrates present on the ARGOS farms. The data from the surveys have provided a useful resource for focusing and planning further work in stream systems on the ARGOS farms, particularly for future comparisons between sectors and farming systems.

Table 2. Summary of aquatic habitat and species occurrence on 37 ARGOS kiwifruit orchards, 2004/05.

		Farming system			
Common name	Scientific name	Green	Gold	Organic	Total orchards
Streams					
Number of orchards with streams		*2*	*3*	*3*	*8*
Reaches surveyed		*2*	*3*	*3*	*8*
Fish-trap-nights		*16*	*5*	*2*	*23*
Banded Kokopu	*Galaxias fasciatus*	2	1	1	4
Galaxid species	*Galaxias* spp.		1		1
Inanga	*Galaxias maculatus*	1	1		2
Shortfin eel	*A. australis*	2	2	2	6
Unknown eel	*Anguilla* spp.		1	2	3
Mosquito fish	*Gambusia affinis*		1	2	3
Unknown fish			1		1
Southern bell frog	*Litoria raniformis*			1	1
Unknown tadpoles	*Litoria* spp.			1	1
Koura	*Paranephrops planifrons*		1		1
Water boatman	*Sigara* spp.			1	1
Dragonfly larvae	*Odonata* spp.			1	1
Freshwater shrimp	*Paratya curvirostris*	1	1	2	4
Total for streams		6	10	13	29
Ponds					
Number of orchards with ponds		*0*	*1*	*1*	*2*
Ponds surveyed		*0*	*2*	*2*	*4*
Fish-trap-nights		*0*	*20*	*16*	*36*
Shortfin eel	*A. australis*			1	1
Unknown eel	*Anguilla* spp.		1		1
Mosquito fish	*Gambusia affinis*		1		1
Koura	*Paranephrops planifrons*		1		1
Tadpoles	*Litoria* spp.			1	1
Total for ponds		0	3	2	5
Grand total		**6**	**13**	**15**	**34**

Streams with flowing water at the time of the survey that were large enough and accessible enough to survey were present on 33 of the 37 sheep/beef farms. Three more farms (Oamaru) had streams that flowed intermittently throughout the year, giving a total of 33 farms with streams that could be surveyed. We therefore recommend that streams on sheep/beef farms become the subject of more intensified study in the ARGOS project, particularly with regard to the main farming systems null hypothesis. However, the streams vary in their size, structure and nature, necessitating use of several different techniques to survey them in more detail. Spotlighting was an effective technique in many situations, but further surveys may also require increased use of traps or sampling with electric fishing equipment to answer specific questions.

There were far fewer streams or ponds present on the kiwifruit orchards and we do not recommend any further detailed work on aquatic ecosystems in this sector, although follow-up biodiversity surveys may be conducted in 2-4 years to track broader and longer-term patterns.

5. Conclusions and recommendations

The scope and depth of the preliminary biodiversity surveys described here have obviously been severely constrained by the need to complete a rapid reconnaissance of potential focal species in one day per sheep/beef farm and around two-thirds of a day per kiwifruit orchard. There were also teething problems associated with having under-estimated the time required to train the field teams, assess the overall landscape and habitats available on farms that we visited for the first time, and to interact with the farmers. Many of the farmers were naturally curious about what the team proposed to measure and where they proposed to go on their farms. They all offered very useful information, so future surveys should budget more time for such interactions should they be wanted by the farmer. Better standardization of habitat and bird behavioural scores will be possible in future now that one pass over the farms has been completed and the range of habitats has been encountered. Preparation of detailed habitat maps using the ARGOS GIS should minimise these problems in future.

Despite our need to learn how best to apply the sampling protocols and some inefficiency stemming from unfamiliarity with the individual farms and orchards, we believe that the results obtained in this year's pilot run for birds are sufficiently robust to provide the first baselines from which future changes can be compared. The next step for birds will be to measure inter-annual variation in their abundance and the coefficient of variation of the estimates obtained by the different counting methods. This will allow a statistical prediction of whether the sampling is sufficiently reliable to detect gradual increases or declines in bird life on the farms.

This preliminary survey has underscored the workability of stream health surveys to test environmental impacts of different farming systems, but only in sheep/beef farms. Eighty-nine percent of ARGOS sheep/beef farms had streams with accessible and sufficiently long reaches to allow surveys for native fish, stream invertebrate communities and water quality. Similar coverage is likely to be achievable in High Country, Ngāi Tahu and dairy farms within the ARGOS programme. However there were too few streams within orchard boundaries for water quality studies to test whether organic or IM kiwifruit growing had different impacts on stream health. A wider survey of streams in non-ARGOS farms could potentially identify enough orchards of each type with comparable streams, but this would be enormously expensive and time consuming. Stream indicators vary with season, recent weather and flow conditions, so repeated measures coupled with GIS analysis of the habitats within the whole catchment would be needed to have a high probability of detection of any putative differences caused by orchard management. We therefore recommend that stream health not be part of our study of the effects of organic and IM kiwifruit production. This is one example of many to come where the different spatial scales of the farms and orchards precludes monitoring biodiversity in the same way in the different agricultural sectors.

Nevertheless there is a need to support individual growers in the ARGOS programme and to monitor as many habitats as possible as part of a general commitment to supporting farmers' quest for environmental sustainability. This is an early example of many to come where the monitoring and research outputs of the ARGOS programme are best seen as quite distinct agendas which will force staging and prioritization of investment. We therefore recommend that a more thorough and repeated survey of stream health and riparian management is done on the orchards with streams purely for the long-term monitoring agenda. Renewed surveys should be done as soon as the tests of the farming system null hypothesis have been established and embedded in sampling routines. This is likely to be achievable in 2007 or 2008.

Similarly, farm ponds are too infrequent and sporadic for reliable research of differential impacts of farming systems, so we recommend that focus on such habitats reduces to infrequent monitoring commencing in 2007 or 2008 if resources allow.

The potential presence of bats feeding in kiwifruit orchards in the Te Puke and Kaimai region should now be followed up with a small scale study using automated bat detection devices (O'Donnell & Sedgeley, 1994). However, the absence of bats from all but one of our study farms and orchards simplifies our environmental research and monitoring priorities, as bats were the most likely threatened species to occur on ARGOS farms. A further check for rare lizards and plants is advisable, but forthcoming long-term biodiversity monitoring on ARGOS farms can concentrate on indicators of environmental impact and restoration of more common species and agricultural biodiversity without diversion of resources to a few threatened species.

Bird monitoring proved workable, cost effective and obviously of interest to participating farmers, so it should become part of regular biodiversity monitoring and research. Immediate quantification and mapping of the extent and variety of vegetation is the next research priority to link bird abundance to the amount and quality of suitable habitat present. Once the overall swamping effect of variation in habitat can be statistically removed from consideration, we will be better able to test whether organic, IM or conventional farming results in different outcomes for biodiversity in New Zealand's faming landscapes.

Our pilot run led to the following recommendations:

1. Allow at least 2 weeks for training the field teams in the field methodology.
2. Record and formally analyze the trial data during the learning period and have some of such benchmarking done back-to-back by the observers (same place and time to compare their results)
3. Strive for consistency in who does the main identifying and counting – differences between individual observers were obvious and probably affected results.
4. Make sure the field routines rotate the observers between panels to balance out any biases from such individual observers.
5. Replay the sample tapes of bird calls, frogs and bat passes (on bat detector) at regular intervals to help prevent drift in the scores.
6. Mount a short-term study using automatic bat detection systems in Pongakawa and Kaimai clusters in spring and summer 2005/06.
7. Establish regular measures of riparian management, stream health and fish abundance in ARGOS pastoral farms in 2005/06 to assess differential impacts of organic, IM and conventional farming on aquatic ecosystems.
8. Fish sampling in streams should primarily be done by night spotlighting using trained observers. However fish traps or electric-fishing should be considered for streams that are slow-flowing, full of aquatic macrophytes or have low water clarity.
9. Establish infrequent stream ecosystem monitoring in all ARGOS kiwifruit orchards with streams by 2008.
10. Establish infrequent pond ecosystem monitoring in all ARGOS pastoral farms and kiwifruit orchards with ponds by 2008.
11. More structured field surveys and experiments should be mounted as soon as resources allow to test our over-arching hypothesis that farm irrigation canals and drains are important refugia for native fish conservation.

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7. Appendices

Appendix 7.1: Bird Distance Sampling - ARGOS Biodiversity Surveys

Area:__________________ Cloud cover (0-5)________ Wind speed_________
Observer_______________ Date___________ Point/Transect
No.___________

#	Species	Distance	Angle	Habitat	Behav	Male	Female	Unk	Grp size	Comment (seen/heard only?)
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

Start Lat:____________ Start Long:_____________ End Lat:__________
End Long:________ Start time_________ End time__________

Habitat codes: Open paddock, dense grass, tussock, fence, building, individual tree, shelter belt, pond/wetland, stream, riparian vegetation, exotic forest block, gorse, native scrub, native forest

Behaviour: feeding, singing, perching, preening, flying, interaction with same/other species.

Appendix 7.2: Habitat codes used in the sheep/beef bird surveys

Code	Habitat type
C	Crop
CF	Cliff
DG	Dense grass
EV	Exotic vegetation (forest block, scrub, orchard)
IT	Individual tree
MS	Man-made structure (house, farm building, yards, irrigator, powerline)
NV	Native vegetation (bush gully, forest, scrub, tussock)
OP	Open paddock
PP	Ploughed paddock
R	Road (includes farm tracks)
SB	Shelterbelt
WF	Water feature (pond, wetland, stream, riparian vegetation)

Crop: Paddock planted in cereal or brassica crop, such as barley, oats, kale, swedes or rape.

Cliff: Steep or shear rocky or bare dirt face.

Dense grass: long, lightly or ungrazed paddocks, usually closed for hay production.

Exotic vegetation-forest block: Pine, Macracarpa or Eucalyptus plantation grown for timber production (as opposed to linear shelterbelts of the same species).

Exotic vegetation-scrub: Low dense woody vegetation, usually gorse or blackberry.

Exotic vegetation-orchard: Exotic fruit-tree plantation, usually apples, pears or stonefruit.

Individual tree: 1-5 individual trees grouped together in a paddock.

Man-made structure: Buildings or structures on the farm, including the homestead, wool or hay sheds, stock yards, rotary or line irrigators and high tension or domestic powerlines.

Native vegetation-bush gully: gully or ravine containing native scrub (manuka and kanuka) or native forest.

Native vegetation-forest: large (> 2ha) area of native woody vegetation with established canopy and sub-canopy. May be fenced or open to stock,

Native vegetation-scrub: Low, dense native woody vegetation, usually stands of manuka or kanuka, but may have other native species such as lancewood, clematis or horopito, or exotic species such as gorse or blackberry mixed in.

Open paddock: Any currently or recently grazed pasture that had not been closed up for hay, or ploughed or planted for crop production.

Ploughed paddock: Any recently ploughed or planted paddock that was still >90% bare soil (otherwise classified as crop).

Road: any sealed, metal or dirt road on or around the farm.

Shelterbelt: Any planted woody vegetation along a fenceline or other border on the farm. Included pine, macrocarpa, poplar, eucalyptus, and gorse hedges.

Water feature-pond: Small natural or man-made body of discrete still water.

Water feature-wetland: Boggy or swampy area, associated with a stream system and containing long rank grass, sedges and rushes.

Water feature-stream: flowing water in defined stream system.

Water feature-riparian vegetation: long dense grass or woody vegetation within 10 metres of a stream channel.

Appendix 7.3: Habitat codes used in the kiwifruit farm bird surveys

SB: **Shelterbelt** surrounding the orchard

R: **Row** between the kiwifruit vinelines

G: **Grassy** areas in orchard, usually near shelterbelt or in areas outside the vinelines

RG: Bird observed in **row** on **grass** on ground between the vinelines

RV: Bird observed in **row** on the **vine** itself.

VG: Bird observed on **grass** directly under the **vine** (as opposed to RG where the bird was out from under the vine in the row).

Appendix 7.4: Behavioural codes used in bird surveys

Feeding: Bird observed actively foraging, usually on the ground, feeding on seeds in pasture or crop paddocks, or invertebrates in ploughed paddocks or on the wing.

Singing: Bird heard/seen singing by the observer. The bird may have been seen perched on a fence, tree, shelterbelt or other structure, or observed flying past the observer. Birds that were only heard could usually be located to a habitat feature; otherwise their habitat was left blank and they were scored as heard only.

Perching: Bird sighted stationary on a physical feature, such as fence, powerline, tree or shelterbelt.

Preening: Bird observed cleaning its plumage on a habitat feature.

Flying: Bird seen on the wing.

Interaction with same/other species: Two birds within 5 m of each other if stationary, and 10m if flying, usually visibly interacting. This included behaviours such as mutual preening, perching together on a fence or structure, or flying in close formation for same species groups or chasing another bird in mixed species groupings.

Appendix 7.5: Bat sampling data sheet

BAT SAMPLING - ARGOS BIODIVERSITY SURVEYS

Location:				Transect number:			
Observer:				Date:			
Start Latitude				Start Longitude			
End Latitude				End Longitude			
Temperature		Wind speed		Humidity		Cloud cover (0-5)	
Weather (circle)	Fine	Showers	Drizzle	Rain		Insect survey?	
Insects (circle)	Unknown	None	Rare	Occasional	Common		
Site description							
BAT COUNTS							
Start time			End time			Total minutes	
Bat passes							
Species	Time	Latitude	Longitude	Pass type	Habitat	Comment	

(1 km transects, ca. 20 mins/transect)

(Table modified from O'Donnell and Sedgely 2001 DOC Internal Science Series 12)

Notes on the bat survey data sheets

Specific **Insect surveys** were not carried out in the surveys.

Site description described the general characteristics of the habitat on the transect route, and included the presence of features such as exotic shelterbelts, native forest of scrub and riparian vegetation.

For the bat passes, **Species** refers to either short-tailed bats (pass at 28 kHz) or long-tailed bats (40 kHz), **Time** is the time at which the pass was recorded, **Latitude** and **Longitude** are the location of the record, taken from the Garmin GPS, **Pass type** was categorized as a normal ‘navigation pass’ or a ‘feeding buzz’, used to locate prey, and **Habitat** refers to the broad habitat category the bat pass was recorded in, using the same categories as for the bird surveys.

Appendix 7.6: Stream survey data sheet

Location:				Transect number:			
Observer:				Date:			
Start Latitude				Start Longitude			
End Latitude				End Longitude			
Temperature		Wind speed		Humidity		Cloud cover	
Weather (circle)	Fine	Showers	Drizzle	Rain		Insect survey?	
Insects (circle)	Unk	None	Rare	Occasional	Common		
Site description							
Fish surveys							
Start time			End time			Total minutes	
Species	Number	Pool	Run	Riffle	Backwater	Pond	Comment

FISH SAMPLING - ARGOS BIODIVERSITY SURVEYS

Notes on the fish survey data sheets

Species refers to each individual species recorded in the survey, **number** is the total number of individuals sighted, while the categories for **Pool**, **Run**, **Riffle**, **Backwater**, and **Pond** refer to the numbers of each species recorded in each of these habitats.

Riffles were defined as areas of fast shallow water with a broken surface, **pools** as slow flowing, deep water with a smooth appearance, and **runs** as intermediate in character. **Backwaters** were closed-ended areas of the main stream channel with no flow, and **ponds** were larger discrete areas of still water, generally not associated with a flowing stream.

Appendix 7.7: Stream survey habitat data sheet

Sheep/beef Stream Variables
Site:_____________ Date:___________________ Observers:_________________

Latitude	Longitude	Altitude:	
Reach sampled			
Length fished	Mean depth	Mean width	
Temp	Conductivity	PH	
Flow type (%)			
Still	Backwater	Pool	
Run	Riffle	Rapid	
Habitat characteristics (%)			
Over stream cover	Undercut banks	Debris jams	
Exposed bed	Macropyhtes		
Catchment vegetation (%)			
Native forest	Exotic forest	Pasture	
Tussock	Swamp		
Catchment landuse			
Forestry	Native forest	Dairy farming	
Sheep/beef farming	Urban		
Riparian vegetation			
Native	Exotic forest	Willow	
Pasture	Raupo	Exposed bed	
Embededness			

Notes on the stream variables assessment sheet
Surveys continued until at least 200m of stream had been surveyed, at which point the end latitude and longitude were recorded. **Altitude** and **length fished** were determined from the GIS system after the survey had been conducted. **Temperature**, **conductivity** and **pH** were not recorded in the surveys. **Mean** water **depth** was the average of three measurements taken at equidistant points along the reach surveyed, and the **mean width** was the average of the wetted area width at the three survey points. The percentage of **pool**, **riffle**, **run**, **rapid**, **still water** and **backwater** was estimated over the surveyed reach. The characteristics of the stream channel were recorded as the percentage (to the nearest 5%) of over-stream cover, undercut banks, in-stream debris, exposed bed and aquatic macrophytes. **Catchment vegetation** and **catchment landuse** were calculated using ArcMap and aerial photographs after the surveys had been conducted. The riparian strip (defined as 5 m either side of the stream banks) was characterised as the percentage of

riparian cover that was **native** or **exotic forest**, **willows**, **pasture**, **raupo** and **exposed bed**. The **embeddedness** of the stream substrate was also estimated, with a score of 1 indicating fine sand or gravel that was easily moved, and 4 indicating bedrock or large cobbles that could not be moved by hand.

Appendix 7.8: Bird survey sample spreadsheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sect or	Clu ster	Orchard /Farm	Type	Year	Month	Day	Tran sect	Line/5-min count	Obs	Cloud Cover	Wind	Temp	Hum idity	Start Lat	Start Long	End Lat	End Long
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903
S/B	3	3A	A	2005	1	17	7	L	JW	4.75	1.5	23	43	43 46 139	173 06 048	43 46 348	173 05 903

Appendix 7.8 continued

19	20	21	22	23	24	25	26	27	28	29	30
Start Time	End Time	Species	Dist	Angle	Habitat	Vegetation type	Behav	Group size	Sex	Seen/Heard	Comments
10.10 am	11.13 am	goldfinch	42	0	open paddock		fly	1	U	S & H	
10.10 am	11.13 am	redpoll			open paddock		fly	2	U	S & H	
10.10 am	11.13 am	unk seabird	100	45	open paddock		fly	1	U	S	
10.10 am	11.13 am	bellbird	50	80	native scrub	matagauri	sing	1	U	H	
10.10 am	11.13 am	yellowhammer			native scrub	matagauri	sing	2	U	H	
10.10 am	11.13 am	greenfinch			native scrub	matagauri	call	1	U	H	
10.10 am	11.13 am	redpoll			native scrub	matagauri	call	2	U	H	
10.10 am	11.13 am	greenfinch	6	0	native scrub	manuka (dead)	perch	2	U	S & H	
10.10 am	11.13 am	redpoll	30	10	native scrub	manuka	fly	2	U	S & H	
10.10 am	11.13 am	redpoll		90	native scrub	manuka	fly	2	U	S & H	
10.10 am	11.13 am	redpoll			native scrub	manuka	fly	1	U	S & H	
10.10 am	11.13 am	redpoll	46	0	native scrub	manuka	fly	3	U	S & H	
10.10 am	11.13 am	redpoll			native scrub	manuka	fly	2	U	S & H	
10.10 am	11.13 am	yellowhammer			native scrub	manuka	sing	2	U	H	
10.10 am	11.13 am	chaffinch			native scrub	manuka	sing	2	U	H	
10.10 am	11.13 am	redpoll			native scrub	manuka	fly	2	U	S & H	
10.10 am	11.13 am	redpoll		90	native scrub	manuka	fly	1	U	S & H	
10.10 am	11.13 am	redpoll			native scrub	manuka	fly	1	U	S & H	

Appendix 7.9: Bat survey sample datasheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sec tor	Clu ster	Orchard/Farm	Type	Day	Month	Year	Tran sect	Obs	Temp	Wind	Humidity	Cloud Cover	wea ther	Start Lat	Start Long	End Lat	End Long
B		Dunn						S	18.7	0	69	>1	fine				
B		Shepherds Hall		20	1	2005		S	19.7	0	68.8	>1	fine				
B		Walnut		7	1	2005		S	17	0	76	2	fine				
B		Fairfield		7	1	2005		D	20.1	0.9	66.4	5	fine				
B		Wakatu		7	1	2005		S	18.8	1	75.8	3	fine				
B		McBeth		11	1	2005		F	14.9	0.9	71.5	5	fine	41 32.123	173 42.351	41 32.032	173 42.821
B		McBeth		11	1	2005		S	14.9	0.9	71.5	0	fine	31 33.860	173 40.990	41 31.883	173 42.530
B		Squire		13	1	2005		F	14.8	2.3	74	2	fine	41 41.098	174 01.966	41 41.200	174 01.966
B		McKenzie						T	18.5	2	56	0	fine	see map			
B		McKenzie		12	1	2005		S	18.5	2	5.6	0	fine	41 39.197	1763 16.093		
B		Henderson		17	1	2005		S	16.5	11	38.3	0	fine	42 55.479	172 55.551	42 56.273	172 55.544
B		Lismore Downs		17	1	2005		T				0	fine	42 55.868	172 55.542		
B		Eastcott		17	1	2005		T	15.3	18	32.2	0	fine	42 54.635	172 52.307	42 55.101	172 51.987
B		Eastcott		17	1	2005		F	15.7	6	33.5	0	fine	42 55.085	172 51.940	42 54.806	172 51.832
B		Cameron		16	1	2005		S	25.7	7.9	35.6	<1	fine	42 56.827	172 43.533	47 57.362	172 43.552
B		Cameron		16	1	2005		F				2	fine	42 56.977	172 44.305	42 57.424	172 44.257
SB	3	3A	A	17	1	2005	1	J/EO	15.2	1.3	60	0	fine	43 46.697	173 06.125	43 40.454	173 05.?
SB	3	3B	B	19	1	2005	1	MG	14.7	0	52.8	0	fine	43 40.985	173 02.737	43 40.?	?

Appendix 7.9 continued

19 Start Time	20 End Time	21 Species	22 Number	23 Habitat	24 Comments	25 Notes
10.38	11.06				Walked all boundary & internal shelter belts	
9.37	10.04	possum in crypt			Walked all boundary & internal shelter belts	
10.35	11.06				Walked all boundary & internal shelter belts include 75% of non-ARGOS blocks	
9.50	10.50				Walked all boundary & internal shelter belts 2x each frequency	
10.02	10.23				Walked all boundary & internal shelter belts	
10.50	11.30				Forest/field close to wetland ?	
9.57	11.03				Valley floor, pine trees, some natives, walk road, trrack out; follow stream	
9.55	10.20				Along stream and along shelter belt	
10.15	10.40				pine shelter belt. 2 passes 1 at each frequency	
10.21	10.54				walked way s/b plus bit of road. Interference	
10.00	10.35				Walked down centre of property from top to …Rd junction with Pennett Rd, plus detour along s/b base of dam and house	
10.53	11.22				Down road among edge of pine shelter belt, from top of farm along driveway and up to sheds	
11.02	11.15				along shelter belts	
9.58	10.39				shelter belts, willow near stream. Hawthorn & pine	
10.10	10.30				Along shelter belts	
10.16	10.41				uphill along dirt track near open paddocks	
10.28	10.52				valley alongside stream, scattered native bush either side	

Appendix 7.10: Fish survey sample datasheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sector	Cluster	Orchard /Farm	Type	Year	Month	Day	Transect	Obs	Cloud Cover	Wind	Temp	Humidity	weather	Start Lat	Start Long	End Lat	End Long
s/b	3	3A	A	2005	1	17	1	GB/MG	0	1.3	15.2	60	fine	43 46.3822	173 05.9097	43 46.3317	173 05.7914
s/b	3	3A	A	2005	1	17	1	GB/MG	0	1.3	15.2	60	fine	43 46.3822	173 05.9097	43 46.3317	173 05.7914
s/b	3	3A	A	2005	1	17	1	GB/MG	0	1.3	15.2	60	fine	43 46.3822	173 05.9097	43 46.3317	173 05.7914
s/b	3	3A	A	2005	1	17	1	GB/MG	0	1.3	15.2	60	fine	43 46.3822	173 05.9097	43 46.3317	173 05.7914
s/b	3	3A	A	2005	1	17	1	GB/MG	0	1.3	15.2	60	fine	43 46.3822	173 05.9097	43 46.3317	173 05.7914
s/b	3	3B	B	2005	1	19	1	GB/EO	0	0	14.7	52.8	fine	43 41.1117	173 02.7684	43 41.1117	173 02.7571
s/b	3	3B	B	2005	1	19	1	GB/EO	0	0	14.7	52.8	fine	43 41.1117	173 02.7684	43 41.1117	173 02.7571
s/b	3	3B	B	2005	1	19	1	GB/EO	0	0	14.7	52.8	fine	43 41.1117	173 02.7684	43 41.1117	173 02.7571
s/b	3	3C	C	2005	1	18	1	GB/MG	5	1.5	13.1	59.5	lt rain	43 44.9581	173 06.6846	43 44.9207	173 06.7927
s/b	4	4A	A	2004	12	15	1	GB/MG	5	1.3	16	69.7	drizzle	43 47.5071	172 18.8018	43 47.4039	172 18.7417
s/b	4	4A	A	2004	12	15	2	GB/MG	5	1.3	16	69.7	fine	43 48.077	172 17.910	43 48.1003	172 18.0603
s/b	4	4A	A	2004	12	15	2	GB/MG	5	1.3	16	69.7	fine	43 48.077	172 17.910	43 48.1003	172 18.0603
s/b	4	4B	B	2004	12	13	1	GB/EO	4.5	1.8	14.3	66.1	overcast	43 41.6575	172 11.9815	43 41.6195	172 11.932
s/b	4	4B	B	2004	12	13	1	GB/EO	4.5	1.8	14.3	66.1	overcast	43 41.6575	172 11.9815	43 41.6195	172 11.932
s/b	4	4C	C	2004	12	13	1	GB/EO	2	1.3	14.3	61	fine	43 41.4041	172 08.2868	43 41.3471	172 07.9664
s/b	5	5A	A	2004	1	13	1	GB/JW	4	18.2	16.3	49.2	fine	43 34.125	171 42.137	43 34.092	171 42.271

Appendix 7.10 continued

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Start Time	End Time	length fished	mean depth	mean width	Water temp	Conduct ivity	pH	%still	%back-water	%pool	%run	%riffle	%%rapid	Total	%stream cover	% undercut	%debris
10:25	11:15	366	45	80				0	5	30	10	35	20	100	80	0	5
10:25	11:15	366	45	80				0	5	30	10	35	20	100	80	0	5
10:25	11:15	366	45	80				0	5	30	10	35	20	100	80	0	5
10:25	11:15	366	45	80				0	5	30	10	35	20	100	80	0	5
10:25	11:15	366	45	80				0	5	30	10	35	20	100	80	0	5
		840	25	80				0	0	30	50	20	0	100	0	10	10
		840	25	80				0	0	30	50	20	0	100	0	10	10
		840	25	80				0	0	30	50	20	0	100	0	10	10
11:10	11:17	342	15	62				0	0	15	45	40	0	100	15	0	0
9:55	10:40	420															
10:40	11:05	540															
10:40	11:05	540															
10:15	10:45	646	50	160				0	0	5	95	0	0	100	15	0	0
10:15	10:45	646	50	160				0	0	5	95	0	0	100	15	0	0
11:10	11:45	886	55	120				0	0	10	90	0	0	100	0	0	0
10:33	11:02	190						0	5	5	90	0	0	100	60	0	5

Appendix 7.10 continued

37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
%exposed bed	%macro phytes	%native catchment	%exotic catchment	%pasture catchment	%tussock catchment	%swamp catchment	%forestry landuse	%native landuse	%dairy landuse	% sheep landuse	%urban landuse	%native riparian	%exotic riparian	%willow riparian
5	0						0	0	0	100	0	95	0	0
5	0						0	0	0	100	0	95	0	0
5	0						0	0	0	100	0	95	0	0
5	0						0	0	0	100	0	95	0	0
5	0						0	0	0	100	0	95	0	0
15	10						0	0	0	100	0	0	0	0
15	10						0	0	0	100	0	0	0	0
15	10						0	0	0	100	0	0	0	0
15	0						0	0	0	100	0	15	0	0
0	0											0	0	0
0	0											0	0	0
15	20											0	0	0
5	0											0	60	0

Appendix 7.10 continued

52 %pasture riparian	53 %raupo riparian	54 %exposed bed riparian	55 Emb	56 Species	57 Number	58 Habitat	59 Comments	60 Notes
0	0	5	2	long finned eel	7	pool		
0	0	5	2	banded kokopu	5	pool		
0	0	5	2	giant bully	1	run		
0	0	5	2	red finned bully	1	pool		
0	0	5	2	inanga	10	run		
85	0	15	1	long finned eel	3	pool	second order stream . Sampling site on valley floor in paddock with cows	
85	0	15	1	giant bully	30	pool		
85	0	15	1	inanga	30	pool		
70	0	15	2				small sping-fed stream that drops off cliff to sea. No fish recorded or sen by farmer.	
				short finned eel	5	pool	meandering weed-choked stream with dense willows	Need catchment veg
				trout	2	pool	captured juvenile	Need catchment veg
				short finned eel	1	pool		Need catchment veg
100	0	0	1	short finned eel	3	run	water race intake from Raikaia has screens to stop trout entry.	Need catchment veg
100	0	0	1	upland bully	20	run	water race intake from Raikaia has screens to stop trout entry.	Need catchment veg
100	0	15	1	short finned eel	2	run	water race intake from Raikaia has screens to stop trout entry.	Need catchment veg
35	0	5	1	upland bully	6	run	water race - half in open paddock with scattered willows, half in pine plantation	