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Land-Use Experiments in the Loch Laidon Catchment

2011 Report on Stream Water Quality to the Rannoch Trust

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2011 Report on Stream Water Quality to the Rannoch Trust

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

1. This report presents the results from the Stream Water Quality component of the Loch Laidon catchment land-use experiment which commenced in 1992. The experiment was established with the aim of examining the effects of cattle grazing on the aquatic and terrestrial habitats and biota of a moorland area of upland Scotland.

2. The catchment of a small stream, the "Experimental Burn", was fenced and cattle were introduced in a ~three-month summer grazing regime whilst the neighbouring catchment and the "Control Burn" were left ungrazed by cattle.

3. Having established a seven year chemical and biological baseline the experimentally grazed area was enlarged in 2002 to include the Allt Riabhach na Bioraich Burn and cattle stocking densities were raised accordingly. This now augments the study by providing a pre and post grazing data series and a BACI (Before, After, Control, Impact) design.

4. Analysis of water chemistry samples show that levels of nutrients have not increased significantly in the Experimental Burn or the Allt Riabhach na Bioraich Burn relative to the Control Burn. Soluble reactive phosphorus concentrations have risen slightly in both the grazed burns and the Control Burn so would not appear to be responding to the presence of cattle. Of note however are minor increases in the peak summer nitrate levels in the Experimental Burn relative to the Control Burn during the period from 1998 and 2008, and minor increase in potassium levels in the Allt Riabhach na Bioraich Burn relative to the Control Burn since grazing began in 2002.

5. There are signs of slight reductions in inputs of acidifying atmospheric deposition, with a decline in concentrations of non-marine sulphate, and slight declines in nitrate and chloride concentrations that appear to be affecting the grazed and non-grazed streams alike. These declines have coincided with, and been counteracted by, declines in base cation concentrations, and therefore pH levels have not increased significantly in any of the three study streams. This suggests that cattle activity is not ameliorating the effects of catchment acidification.

6. The diatom assemblage in the Experimental Burn has been more variable than that of the other two burns but there is no evidence during time of an increase in species tolerant of increased nutrient concentrations. There are changes in the assemblage in the Allt Riabhach na Bioraich Burn that are similar to changes in the Control Burn. These are therefore unlikely to be related to grazing effects but to other environmental factors common to both streams or catchments. None of the three streams show chemical pH recovery and this is reflected in the diatom species compositions through time.

7. The aquatic macrophytes in the Control Burn and the Allt Riabhach na Bioraich Burn show marked similarities with respect to both the assemblage constituents and the timings of arrivals of new species. There does not

appear to be evidence of impacts from cattle presence, such as reductions in macrophyte cover or increased levels of filamentous algae, in the Allt Riabhach na Bioraich Burn since catchment grazing began.

8. Macroinvertebrate assemblages have shown marked between-year variability, especially in the Experimental Burn. Summary statistics such as the total number of species and certain diversity indices have shown slight declines in the Control Burn and Experimental Burn. These declines have not been apparent in the Allt Riabhach na Bioraich Burn and the indices have therefore risen compared to the Control Burn, especially since 2007. This is inconsistent with cattle having a negative effect on the macroinvertebrates in the Allt Riabhach na Bioraich Burn, and we hypothesise that it may be a result of minor disturbance caused by cattle.

9. The impact of grazing on fish populations was assessed using the BACI design at the Allt Riabhach na Bioraich Burn. There was some evidence of a positive temporal change in the productivity of the experimental grazed site compared to the control site. However, there was insufficient statistical power in available data to determine whether this was due to the grazing, or to a long-term temporal trend independent of the grazing. In order to separate these hypotheses it is suggested that future studies improve the statistical power through the inclusion of multiple reaches within sites and multiple control and experimental sites.

10. Cattle grazing does not therefore appear to be having a negative effect on the chemistry or biology of the experimentally grazed streams at the current density of around 0.17 cattle per hectare, present for the three month late summer grazing period. Signs of grazing effects are very muted, but may be present in potassium, invertebrate and trout fry data from the Allt Riabhach na Bioraich Burn when compared to the Control Burn.

11. A sediment core was taken in August 2009 from a basin in the small bay of Loch Laidon into which the Experimental Burn flows, with the aim of investigating whether an enrichment signal was present in the top sediments laid down since experimental cattle grazing began. Changes in the sediment diatom assemblages do not provide evidence that there has been an increase in nutrients or productivity in the bay since catchment grazing began. The fossil data also show that there does not appear to have been a recovery in the diatom flora consistent with a reduction in acidifying atmospheric inputs to the catchment.

12. With a view to publication in the scientific literature, the authors recommend a full statistical analysis of the complete data-set, using multi-variate techniques to further assess the significance of the trends identified and explore the relationships between the chemical and biological data. This may be an expedient juncture at which to do so, due to the natural break in the experimental time-series resulting from the unforeseen logistical difficulties that occasioned grazing not being possible during the summer of 2010.

13. The Laidon Grazing Experiment has accumulated a remarkable dataset in terms of length, measurement frequency, analytical consistency and spatial resolution. The data-set provides a unique evidence-base to inform the debate not just about upland grazing, its associated ecosystem services, biodiversity and the recovery or otherwise from acidifying atmospheric deposition but also, with the recent addition of physical parameter monitoring, increasingly that concerning climate change. It is thus crucial that the results are published and disseminated in order to contribute to this debate.

14. Given the quality and length of the data-series, and that the site is representative of upland systems common through the Scottish uplands, during the current period of project review the authors strongly recommend that at minimum monitoring is continued at the Control Burn. This will provide a base-line for the continuation of further grazing studies and could also contribute to additional scientific work within the study area, including monitoring the as-yet limited recovery from acidification and future land-use and climate changes.

1 INTRODUCTION

In 1992 the Rannoch Trust established the Loch Laidon catchment land-use experiment in order to investigate the effects of summer cattle grazing on the terrestrial and aquatic upland environment. Situated in Perthshire, Scotland, the study area forms part of Rannoch Moor and falls within a number of designations, including the Rannoch Moor Special Area of Conservation and Site of Special Scientific Interest, the Rannoch Lochs Special Protection Area and the Tayside Local Biodiversity Action Plan.

Allott *et al* (1994) described the project rationale and background whilst progress and data reports (Monteith *et al.* 1995; 1996; 1997; 1999; Shilland *et al.* 2001; 2003; 2004; 2005; 2006; 2007; 2010) as well as a conference proceeding (Shilland *et al.* 2008) have provided reviews of the accumulating chemical and biological datasets. Sediment cores were taken in 1985 and 1995 from Loch Laidon and the results of the subsequent analyses are presented in Patrick and Stevenson (1987), Flower *et al.* (1988) and Flower *et al*. (1996).

The project presented and summarised here comprises both the aquatic monitoring element of the experiment, including data from 1992 to 2010, and the analyses of a sediment core taken from Loch Laidon in August 2009.

This report aims to address two main questions:

Has the presence of cattle had any effects on the chemistry or biology of the study streams compared to the control stream with respect either

1. to nutrient enrichment associated with an increase in nitrogen and phosphorus loads from cattle (eg. Belsky *et al.*, 1999, Hooda *et al*., 2000)
2. to an amelioration of acidity associated with long-term acidification of the loch and its catchment from acid deposition (Flower *et al.* 1988 and 1996)

2 EXPERIMENTAL DESIGN

The study region is shown in Figure 1, and Figure 2 demonstrates the experimental area, stream catchments and sampling locations in more detail. Water chemistry spot samples have been collected at approximately monthly intervals from sites on the Control Burn and Experimental Burn since 1992 (Figure 2, Sites 1 & 2). Biological surveys of fish, aquatic macroinvertebrates, epilithic diatoms and aquatic macrophytes have been undertaken annually at these sites over the same period. A total of 33 cattle (1 bull, 16 cows and 16 calves) were introduced within the 105 ha fenced experimental plot (approximating to 0.31 cattle per hectare: see Figure 2) from July to late September 1993, and an approximately similar three-month grazing period was observed in subsequent years. Stocking levels were reduced by one cow and one calf after 1993.

In the report of Monteith *et al.* (1996) concerns were raised that:

(a) insufficient pre-impact assessment of the Experimental Burn had been carried out before cattle had been introduced,
(b) the Experimental Burn was not sufficiently similar to the Control Burn for rigorous comparisons to be made,
(c) the upper station on the Experimental Burn might be situated at too great an elevation to be sensitive to any change in grazing regime.

Responding to the first two points chemical monitoring began in summer 1995 on a second experimental system, the Allt Riabhach na Bioraich Burn, approximately 500 m further to the east and with physical characteristics more similar to the Control Burn. At this time the Allt Riabhach na Bioraich Burn was outside the fenced area, thus providing a “Before, After, Control, Impact” (BACI) experimental setup. Simultaneously, in response to point (c) a second chemistry sampling site was adopted on the original Experimental Burn, while, due to the long term interest in the acidity status of Loch Laidon and its predicted recovery from acidification, a further sampling site was established on the loch outflow. The additional sampling sites, numbered according to Figure 2, are therefore as follows:

3. A lower station on the Experimental Burn
4. A lower station on the Allt Riabhach na Bioraich Burn
5. An upper station on the Allt Riabhach na Bioraich Burn
6 The Loch Laidon Outflow

One further spot water chemistry sampling point, number seven, was added in September 2000 in a burn within a recently planted area of Woodland Grant Scheme forest, approximately 1.5 km North East of the Allt Riabhach na Bioraich Burn. Since 1996 the Allt Riabhach na Bioraich Burn has also been sampled for epilithic diatoms, aquatic macrophytes, aquatic macroinvertebrates and fish following the pre-existing protocols.

In 2002, having established a seven year pre-impact baseline, the experimentally fenced area was enlarged to 216 ha to include the Allt Riabhach na Bioraich Burn. Accordingly, stocking densities were increased overall, to 40 cattle in 2002 and then reduced slightly to 36 cattle in 2003, approximating to 0.17 cattle per hectare. An area of approximately fifteen ha in the northwest corner of the enlarged experimentally fenced area was burnt in 2002. This inadvertently reduced cattle grazing pressure immediately adjacent to the burns as animals were attracted to this area of fresh plant growth (Thexton, *pers comm*.).

As of the 2007 contractual period, chemical sampling ceased at the upper sampling points on the Experimental Burn and the Allt Riabhach na Bioraich Burn. These are shown as points 2 and 5 respectively on Figure 2. Fish sampling frequency also reduced from annual surveys to three-yearly surveys. Monitoring equipment was installed on the Control and Allt Riabhach na Bioraich Burns to record water temperature and stream water-levels. In order to measure rainfall a tipping rain-gauge was installed next to the Control Burn.

Due to unforeseen logistical problems and the illness of key staff it was not possible to put cattle onto either the old or new experimental areas in the summer of 2010.

Aquatic macroinvertebrates were not surveyed in 1995 nor aquatic macrophytes in 2000. Biological sampling dates are provided in Table 26. Photographs of the survey stretches are shown in Figures 3 to 5.

3 METHODOLOGY AND DATA PRESENTATION

3.1 CHEMISTRY AND BIOLOGY

Chemical and biological sampling methodologies follow those of Allott *et al.* (1994).

Data are held on a central database at the Environmental Change Research Centre (ECRC). This report presents primary data, graphs and summary statistics.

Selected water chemistry variables are presented as time series with values for two or three burns superimposed. Where appropriate, time series of the ratios of values for the Experimental and Control Burns are also overlaid. Common (natural) variability is thus controlled for. Any impact of grazing on water chemistry should be detected as a progressive departure from the normal distribution of the ratio (i.e. any deviation away from a horizontal line). Data are also presented for physical measurements of rainfall, stream temperature and stream height that commenced in November 2007.

Diatom and aquatic macroinvertebrate diagrams show percentage abundances of individual species for each year of sampling. Macroinvertebrate species occurring with a minimum abundance of 1.5% are presented whereas the diatom graphs show species with a minimum abundance of 1%.

The following biotic and diversity indices have been used for macroinvertebrates:

Hill's N1 approximates to the number of abundant species.
Hill's N2 approximates to the number of very abundant species in the sample**.**
Hill's E5 is a measure of the evenness of species occurrences in a sample. E5 approaches zero as a single species becomes more dominant in the community.
Richness (rareftn 100) predicts the expected number of taxa in a sample of 100 individuals.
BMWP is a scoring system for macroinvertebrates based on a scale of 1 to 10 given to each taxonomic family. It provides an indication of water quality by assigning families very sensitive to organic pollution a score of 10, whilst those that thrive in organically polluted systems, such as bloodworms, are assigned a score of 0.
ASPT is the Average Score Per Taxon, based on the BMWP score divided by the number of taxa in the sample. A range of 6.3 to 6.7 is typical for a diverse fauna.

Multivariate statistical methods were applied to the epilithic diatom and aquatic macroinvertebrate data from the Control, Experimental and Allt Riabhach na Bioraich Burns to examine the extent of between year variability and test for the evidence of changes with time. It is necessary to demonstrate trends in the biological data which are unique to the grazed catchments in order to invoke biological responses. Detrended Canonical Correspondence Analysis (DCCA) was used to measure the time-constrained gradient lengths of species so that the most appropriate subsequent analysis could be determined. As this demonstrated very little turnover in species composition, the linear methods of Principal Components Analysis (PCA) and Redundancy Analysis (RDA) were selected. PCA is an indirect gradient approach that provides a sensitive measure of between sample variance in the species assemblage. RDA is a form of PCA in which the components are constrained to be linear combinations of explanatory variables. For the purpose of this study, “time”, coded as the year of sampling was applied as the single explanatory variable. Statistical significance of the results was tested using a restricted version of the Monte Carlo permutation test, running 999 permutations. All analyses were performed using the program CANOCO (ter Braak and Smilauer 1998). For a fuller explanation of the statistical methodologies see Patrick *et al.* (1995).

Aquatic macrophyte data are presented graphically, showing percentage cover of the 50m survey stretch occupied by each species.

Electrofishing surveys were carried out in single reaches in each of the three study catchments. The reaches were approximately 50m in length and marked with stakes such that a static length of stream was fished each year. Fish numbers were estimated from three pass depletion electrofishing based on the maximum likelihood removal method (Borchers *et al*., 2002). In a very small number of instances where depletion was not observed between passes realistic density estimates could not be obtained. In these circumstances a minimum density (total of fish caught) was obtained. For presentation fish numbers were converted to densities by accounting for the area fished. All formal analyses were performed on the fish numbers alone.

Fish densities are plotted for the three sites individually and together. Data are presented by life stage to include fry (0+) and parr (>0+)

Formal analysis of the fish data involved a Before-After-Control-Impact (BACI) design. The log ratio of fish numbers (0+ or >0+) between the Control and Experimental catchments was modelled as a function of year (as a continuous variable) and treatment (as a factor). The term for year allowed for a long-term temporal trend in the relative abundance of fish between sites independent of treatment. The term for treatment allowed for step changes in the data associated with the addition of cattle. Evidence for any change over time was assessed by comparing the model

log ratio ~ year + treatment

with a model in which there is no time effect

log ratio ~ 1

using an F-test. Evidence for a long-term temporal trend or a treatment effect was then assessed using the significance levels of the individual terms. Models were fitted using the GLM function in R (2.12.0).

3.2 SEDIMENT CORE

Since 1985 a series of sediment cores have been taken from Loch Laidon. LAI1 and LAI3 were taken from the deepest part of the Loch in 1985 and were reported on by Patrick and Stevenson (1987) and Flower *et. al.* (1988). In 1995 the Loch was cored again in the deepest area (LAI4), and a comparison made between that record and the earlier core by Flower *et. al*. (1996). These studies largely concentrated on the atmospheric pollution history of the site and demonstrated that the Loch had acidified since the onset of industrial atmospheric pollution in around 1850.

In order to explore the evidence of possible effects of grazing on the lake sediments a core, LAI6, was taken from a basin in the bay on the North side of Loch Laidon into which the Experimental Burn flows. The core was retrieved on 14th August 2009 from 5.5m depth at UK grid reference NN 36950 53936 (red X on Figure 2) using a Renberg gravity-corer. A backup core, LAI7, was also recovered on the same day from 26.9m in the main basin of Loch Laidon at UK grid reference NN 37418 53603. Both cores had undisturbed sediment-water interfaces. Core data presented here are all from LAI6 and include lithostratigraphic analyses of dry weight, loss on ignition, carbonate content, sediment spheroidal carbonaceous particle (SCP) concentrations and a diatom stratigraphy.

The cores were extruded at 0.25 cm intervals down to 15 cm and 0.5 cm intervals thereafter, and any visible stratigraphic changes were noted. The percentage dry weight (%DW) which gives a measure of the water content of the sediment, and percentage loss on ignition (%LOI) which gives a measure of the organic matter content, were determined in the laboratory on samples from LAI6 by standard techniques (Dean 1974). The carbonate content was calculated by returning the crucibles to the furnace for two hours at 950 ^{o}C and then reweighing.

Sediment samples were analysed for SCPs following the method described in Rose (1994). Dried sediment was subjected to sequential chemical attack by mineral acids to remove unwanted fractions leaving a suspension of mainly carbonaceous material and a few persistent minerals in water. SCPs are composed mostly of elemental carbon and are chemically robust. The use of concentrated nitric acid (to remove organic material), hydrofluoric acid (siliceous material) and hydrochloric acid (carbonates and bicarbonates) therefore does them no damage. A known fraction of the resulting suspension was evaporated onto a coverslip and mounted onto a microscope slide. The total number of SCPs on the coverslip were counted using a light microscope at x450 magnification and the sediment concentration calculated in units of 'number of particles per gram dry mass of sediment' (gDM^{-1}). The criteria for SCP identification under the light microscope followed Rose (2008). Analytical blanks and SCP reference material (Rose 2008) were included in each batch of sample digestions. Reference concentrations agreed with the expected values while no SCPs were observed in the blanks. The detection limit for the technique is c. 100 gDM^{-1} and concentrations have an accuracy of c. ± 45 gDM^{-1}.

The dating of the core follows the method described in Rose *et al* (1995) whereby three main features of the SCP profile are used to provide dates: the start of the record, the rapid increase in SCP concentration and the peak in SCP concentration. A later approach using cumulative SCP inventory profiles (Rose and Appleby 2005) is not applicable to LAI6 as the SCP profile appears truncated. However, comparison of the LAI6 SCP profile with a previous radiometrically dated SCP profile from a deep water core from Loch Laidon (LAI4 – 1995) provides a useful additional chronological tool.

Diatoms were obtained for analysis from the sediment samples using standard methods described in Battarbee *et al* (2001). Samples were digested in hydrogen peroxide, washed and mounted on glass coverslips before being counted on a light microscope using phase-contrast optics at a magnification of x1000. Counts were performed on samples from 20 separate levels and concentrated on the topmost sediment layers where any evidence of cattle-grazing effects might expect to be seen. Approximately 400 diatom valves were counted at each level. The count data were then converted into percentages and the stratigraphic diagrams plotted using the program C2 (Juggins 2007). PCA sample scores, that provide a sensitive measure of between sample variance in the species assemblage, were also calculated using the program C2 and Axis 1 and Axis 2 scores are presented alongside the diatom stratigraphy. pH was reconstructed from the diatom data using the same program, running the Weighted Averaging Partial Least Squares method and using pH training set data from the SWAP project (Stevenson *et al.* 1991). Bootstrapping was performed to choose the best Component to use for the reconstruction, and as Component 2 did not improve the model prediction by over 5% Component 1 was chosen and is shown here alongside the diatom percentage abundance stratigraphy.

4 RESULTS

4.1 CHEMISTRY

Chemical data are summarised in Table 5 whilst full chemistry is shown in Table 6 to Table 12. The assessment below concentrates primarily on evidence for trends in the ratios of certain chemical indicators between both the Control and Experimental sites and Control and Allt Riabhach na Bioraich Burns. The chemical determinands presented are those which are considered most likely to change due to the influence of cattle grazing and those indicative of acidification.

4.1.1 COMPARISON OF THE CONTROL AND EXPERIMENTAL BURN

The longest time-series available for chemical comparison is from the upper chemical sampling station on the Experimental Burn. Figure 6 to Figure 12 show comparisons of key determinands, alkalinity, conductivity, nitrate, soluble reactive phosphorus, pH and non-marine sulphate starting in 1992. Due to its position higher up the catchment this sampling station is less likely to respond strongly to grazing effects and most of this section is devoted to comparisons between the Control Burn and the lower chemical sampling station on the Experimental Burn, where sampling commenced in 1995 (Figure 13 to).

Alkalinity (Figure 6 and Figure 15) and conductivity (Figure 7 and Figure 19) show strong seasonal variability in the Control Burn and at both sampling points on the Experimental Burn. The Experimental Burn has greater values for both determinands during the summer months when stream flow is low and the water chemistry is seemingly more groundwater influenced than in the Control Burn (see Shilland *et al*., 2006). A sea-salt event is visible in the Control Burn and Experimental Burn conductivity data in 2005, whereby storm-derived marine ions such as sodium and chloride (Figure 20) were deposited on the catchment, elevating conductivity levels. This event is less visible at the lower Experimental sampling station where summer conductivities are the highest of any in the study. There do not appear to be any trends in the ratios between the Control and Experimental Burn conductivities or alkalinities during the period of experimental grazing.

Concentrations of nitrate (Figure 8, Figure 13 and Figure 14) in both burns show seasonality typical of the nutrient. N mineralization processes and uptake by vegetation during the growing season, which generally result in peak concentrations occurring in early spring. The relationship in peak concentrations between the two streams shows a clear switch after 1998, when values in the Experimental Burn began to be higher than those in the Control Burn. This remained the case until 2008, after when nitrate concentrations have been very low, and very similar, in each stream. Concentrations appear to have fallen both in the Experimental stream and the Control stream during the experimental period, resulting in both decreased nutrients and decreased nitrate acidity.

Soluble reactive phosphorus (SRP) is the biologically available form of phosphorus, and concentrations might be expected to rise in streams with cattle-grazed catchments. SRP concentrations are shown in Figure 9 and Figure 21. Levels are generally low but appear to have risen slightly since 2001 in the Experimental and also the Control Burn, with seasonal maxima usually observed in the summer. The linear trend in the ratio appears to be flat and therefore it would not seem that SRP levels are rising in the Experimental stream relative to the Control stream.

Calcium levels (Figure 16) in the Experimental Burn have correlated strongly with conductivity throughout the study and therefore also show elevated levels in the summer months. Similarly magnesium (Figure 17) and potassium (Figure 18) peaks have generally been higher in the Experimental Burn than the Control Burn, though Experimental Burn potassium peaks have reduced slightly relative to the

Control in more recent samples. This is interesting, as potassium levels might be expected to increase due to the activity of cattle within the grazed catchment (Kurz, O'Reilly, and Tunney 2006b). The heather burning during 2002 shows up as a clear potassium peak in both burns.

pH values (Figure 10 and Figure 22) in both the burns demonstrate seasonality, with differences of over one pH unit between summer highs and winter lows in most years. Whilst the lowest pH, rainfall-driven, acid episodes might not be captured by the sampling methodology, the time-series suggests that there may have been a reduction in pH minima, especially over the last decade. General values have been consistently higher in the Control Burn that at either the upper or lower sampling station on the Experimental Burn. The overall pH values do not appear to show an upward trend in either stream during the experimental period, indeed the pH of the Control Burn appears to have decreased very slightly whilst that in the Experimental Burn has changed less. As a result the pH of the two streams match more closely in the recent sampling years and the H+ ratios between the streams have drawn slightly closer to 1.

Non marine sulphate values show a marked difference between the upper (Figure 11) and lower (Figure 23) sampling stations on the Experimental Burn. Levels at the upper sampling station track those at the Control Burn, and are similar, if usually slightly lower. Both show ongoing reductions in concentrations, especially after 1995, but there is no trend apparent in the ratio between them. At the lower sampling station on the Experimental Burn however, non-marine sulphate levels demonstrate a sequence of very elevated late-summer peaks right through the sampling period, unlike that seen at the upper sampling station or indeed any of the other sampling points throughout the study area. The ratio between the lower Experimental Burn sampling site and the Control Burn shows an increasing trend; while concentrations have been gradually dropping on the Control Burn summer peak concentrations in the lower experiment remain very high despite overall levels reducing slightly.

Labile Aluminium is shown for the upper Experimental Burn (Figure 12), as this is where the biological sampling at this stream also occurs. Labile aluminium is the biologically available form of aluminium, and is generally associated with low pH waters as it is generated when the acid anions sulphate, nitrate or chloride pass through catchment soils without being neutralised. Rosseland *et al.* (1990) considered labile aluminium to be toxic to fish at threshold concentrations of between 25 µg l^{-1} and 75 µg l^{-1} in low pH and low calcium surface waters. Seasonality is again apparent, with both burns experiencing peak values in the summer. Similar patterns of concentrations occur in each stream through time, and whilst peak values have usually been greater in the Control Stream they have only been higher than 25 µg l^{-1} in two samples, one from summer 1993 and another in summer 1995, and potentially damaging peak values thereafter appear to have been reducing through time in the stream. No overall trend is apparent in either stream, nor can a trend be identified in the ratio between them.

4.1.2 COMPARISON OF THE ALLT RIABHACH NA BIORAICH WITH THE CONTROL AND LOWER EXPERIMENTAL BURN

Comparisons of the Allt Riabhach na Bioraich, the Control and the Lower Experimental burns are presented in time series diagrams of alkalinity, conductivity, nitrate, soluble reactive phosphorus and total organic carbon in Figure 24 to Figure 28.

The three-way comparisons clearly show the influence of seasonality on the chemistry of the streams. Unusual events affecting the whole study area can also be seen, such as the climate driven nitrate leaching during the dry period of summer 1995 and the colder, dryer winters of 1996 and 2001. In all three streams nitrate appears to have decreased slightly since sampling began whereas SRP has marginally increased, though at no time at any of the three sampling stations have SRP concentrations gone above the UKTAG recommended Water Framework Directive threshold annual mean value for "High" stream status of 20 $\mu g\ l^{-1}$. (WFD-UKTAG 2008) The similarity through time of values for conductivity, alkalinity and total organic carbon in the Allt Riabhach na Bioraich Burn and the Control Burn demonstrate the greater comparability of the two for experimental purposes. Total organic carbon values are strikingly similar in all three streams and do not show the increasing trend seen at many upland sites in the UK (Kernan *et al.* 2010).

4.1.3 COMPARISON OF THE ALLT RIABHACH NA BIORAICH WITH THE CONTROL BURN

Comparisons of the time series of selected chemical determinands between the Allt Riabhach na Bioraich Burn and the Control Burn are presented in Figure 29 to Figure 40. When appropriate, the ratios of values between the two burns are also shown. The time series start when monitoring commenced at the Control Burn in 1992 and ratios are shown from when sampling began at the Allt Riabhach na Bioraich Burn in the summer of 1995. The figures are marked to show when cattle grazing commenced during the summer of 2002 in the Allt Riabhach na Bioraich Burn catchment. Average daily water temperature and stream height time series for the Control Burn, commencing in November 2007, are illustrated in Figure 41 and Figure 42 and those for the Allt Riabhach na Bioraich Burn in Figure 43 and Figure 44. Figure 45 shows daily mean rainfall amounts since November 2007 for the experimental area. Unfortunately the rain gauge jammed for a period during 2008 and no measurements were obtained.

Alkalinity values (Figure 29) in samples from both streams are very similar and exhibit marked seasonality, with minima occurring during the winter months and maxima in late summer. Conductivities (Figure 30) also correspond very closely between the two burns throughout the study period, and the 2005 sea-salt event discussed above is clearly visible in both time-series as well as in the chloride data (Figure 31). Neither alkalinity nor conductivity show overall trends in either stream, nor trends in the ratios between the streams.

Calcium (Figure 32) and magnesium (Figure 33) concentrations in the Control and Allt Riabhach na Bioraich Burns again demonstrate close synchroneity between the two streams, and are usually higher during the summer. Both determinands have seen slight decreases in each stream since 1995, trends found across all the study sites including the Loch Laidon outflow. As the minor decreases have been largely similar in the two streams there has been no overall change in the ratios between the streams, either during the whole study period or since the 2002 onset of cattle grazing in the catchment. Throughout the study Potassium (Figure 34) has usually been present in slightly higher concentrations in the Allt Riabhach na Bioraich Burn than the Control Burn. Whilst there does not appear to be any overall trend in levels in either stream, the ratio plot suggests that potassium values may have become very slightly higher in the Allt Riabhach na Bioraich Burn relative to the Control Burn after grazing commenced.

Peak nitrate concentrations during the entire study have been consistently higher in the Allt Riabhach na Bioraich Burn than in the Control Burn (Figure 35 and Figure 36). The slight reduction in nitrate levels through time in the Control and Experimental Burns, mentioned above, is also seen in the Allt Riabhach na Bioraich Burn, and concentrations have become slightly more similar to the Control Burn after, rather than before, cattle grazing commenced in the catchment. SRP levels have done the opposite (Figure 37), and appear to have risen very slightly in both burns since slightly before cattle arrived in 2001. However, because the small increase has been of a similar magnitude in the two burns, it does not appear as a trend in the ratio between them.

With respect to pH (Figure 38), the Allt Riabhach na Bioraich Burn compares to the Control Burn very similarly to how the Experimental Burn compares to the Control: it has been slightly more acid than the Control, it shows marked seasonality of around 1 pH unit with higher pH during the summer, it exhibits no overall trend in values through time but does show a minor convergence with the pH values in the Control Burn as that stream has become slightly more acid. Ratios did not change markedly however after the onset of grazing.

Concentrations of non-marine sulphate (Figure 39) in the Allt Riabhach na Bioraich Burn show a similar pattern through time to those in the Control Burn, but have generally tended to be very slightly higher. Both sites demonstrate a significant decrease in values after the mid 1990s after which levels have continued to reduce, though more slowly. Reductions have been broadly coincident in both streams before and after experimental grazing, and there is no trend visible in the ratio between them.

Unlike in the upper Experimental Burn, labile aluminium levels in the Allt Riabhach na Bioraich Burn (Figure 40) have often been higher than those in the Control Burn, especially during summer peaks. This has been the case before and after grazing commenced in the catchment. In most years summer maxima in the Control and Allt Riabhach na Bioraich burns have usually been below the level of 25 µg l^{-1}, at which biological toxicity can become strongly apparent (Rosseland *et al.* 1990), though the latter stream did experience exceptionally high concentrations in the summer of 2003. During the study no general trend, either upwards or downwards, has been found in values from the Allt Riabhach na Bioraich Burn or in the ratio of labile aluminium concentrations between those of the Control Burn.

4.2 BIOLOGY

4.2.1 EPILITHIC DIATOMS

Epilithic diatom data are provided in Table 13 to Table 15, and are illustrated in Figure 46, Figure 47 and Figure 48. Trend test statistics are shown in Table 1. Due to the length of time required for diatom analysis the results discussed here are from samples up to and including 2009.

Three species of diatom have dominated the assemblage during the study period in the Control Burn: *Synedra minuscula, Tabellaria flocculosa* and *Brachysira vitrea.* The proportion of *S. minuscula* has fluctuated somewhat and has seen a large overall decline. Acid-tolerant *T. flocculosa* abundances have been more stable but have also seen a smaller decline. As *S. minuscula* and *T. flocculosa* have become less dominant the relative abundance of *B. vitrea* and several other species has increased. *Eunotia incisa, Frustulia rhomboides* var. s*axonica, Eunotia naegelii* and *Brachysira brebissonii* have all been found at greater abundances in more recent years of the study.

The Experimental Burn diatom species assemblage has been somewhat more variable than that of the Control or Allt Riabhach na Bioraich burns, and there have been occasional years, such as 1996, 1998 and 2003, when this variability has been especially pronounced. *Brachysira vitrea, Frustulia rhomboides* var. *saxonica* and *Tabellaria flocculosa* have generally been the most consistently abundant species present, but have all varied between years. *Peronia fibula* declined after 2000 and two *Eunotia* species, *E. incisa,* and *E. naegelii* have increased. There is no evidence of an increase in diatom species that favour elevated levels of nutrients.

Of the three burns, the Allt Riabhach na Bioraich Burn has largely had the most stable epilithic diatom assemblage over time. The two dominant taxa throughout have been *Tabellaria flocculosa* and *Brachysira vitrea.* Found at very high abundances until 2004*, T. flocculosa* has subsequently declined, and in 2009 for the first time was replaced by the less acid-tolerant *B. vitrea* as the most abundant species. *Eunotia naegelii, Frustulia rhomboides* var. *saxonica* and *Eunotia incisa* have also increased since the drop in *T. flocculosa* proportions. *Synedra minuscula* had higher than usual abundances in 2005 and 2006.

Eigenvalues from the first axis of the PCA (λ_1^{PCA}) are shown in Table 1. These provide the maximum proportion of total between-year variance that can be explained by a single hypothetical linear variable. The table also shows RDA Axis 1 eigenvalues, which give the variance that can be explained by a time trend (λ_1^{RDA}). Variance explained by time at all three sites is not high compared to variance on the first Principal Component. Restricted Monte Carlo permutation tests subsequently demonstrated that there are no trends significant at the 99% level but that time trends at the Control and Allt Riabhach na Bioraich Burns are significant at the 95% level.

Table 1 Diatom trend test statistics

	λ_1^{PCA}	λ_1^{RDA}	$\lambda_1^{RDA}/\lambda_1^{PCA}$	Restricted P Value
Control Burn	0.32	0.14	0.44	0.02
Experimental Burn	0.17	0.07	0.41	0.07
Allt Riabhach na Bioraich Burn	0.30	0.14	0.47	0.04

4.2.2 MACROINVERTEBRATES

Macroinvertebrate data are provided in Table 16 to Table 18 and summary statistics are provided in Table 19 to Table 21. Figure 49, Figure 50 and Figure 51 show the macroinvertebrate data as percentage abundances for more common species. Figures 42, 43 and 44 show selected summary statistics graphically and Figures 45 to 54 show comparisons of macroinvertebrate summary statistics between the Control and two experimental burns.

Typically during the study period the Control Burn's macroinvertebrate assemblage (Figure 49) has been dominated by the detritivorous stonefly *Amphinemura sulcicollis*, the predatory stoneflies *Isoperla grammatical* and *Siphonoperla torrentium* and the beetles *Limnius volckmari* and *Oulimnius* sp. The acid-sensitive mayfly *Baetis rhodani* has also been abundant since 1998, although this species was rarely present in the preceding five years. Relative proportions of the majority of species have been fairly stable since 2007 although greater variability was observed during the earlier period of monitoring. Through time the flattened, stone-clinging mayfly *Heptagenia lateralis* has become less common and the net-spinning caddis *Polycentropus flavomaculatus* more so. Caddis species have however maintained a low proportion of the total assemblage throughout.

Of the three streams the macroinvertebrate assemblage in the Experimental Burn has exhibited the greatest inter-annual variability (Figure 50). Only the non biting midge group Chironomidae have been recorded in consistently high abundances. Mayflies have been largely represented by the Leptophlebiidae, with *Leptophlebia marginata* present at low levels and *L. vespertina* being especially abundant in the last six years of sampling. The latter species benefits from the greater presence of aquatic macrophytes in the Experimental Burn. Stoneflies have made up a much smaller proportion of the assemblage than they do in the other two study streams. Of those present *Amphinemura sulcicolus* has been the most abundant, though it has become slightly less so in recent years whilst there has been a minor increase in *Nemoura cambrica.* Conversely, caddisflies are better represented in the Experimental Burn than the Control or Allt Riabhach na Bioraich Burns, both in terms of numbers of species and relative proportion abundance. Limnephilidae, characteristic of slower flowing environments, have generally been the most abundant of the group. The predatory net-spinning *Plectrocnemia conspersa* and

Polycentropus flavomaculatus have also occurred regularly, with the second species more common in the latter half of the study period. Present in all the Laidon study burns, the water beetle *Oulimnius* sp has reached its highest abundances in the Experimental Burn but levels have reduced somewhat since 2005.

In the Allt Riabhach na Bioraich Burn (Figure 51) the most noticeable change in the macroinvertebrate assemblage has been the increase in abundance of the acid-sensitive, algae eating, mayfly *Baetis rhodani*. Not present at all in 1996 or 1997, it comprised over 20% of the sample in 2009. Mayflies have otherwise been rather poorly represented. Especially prior to the increase in *B. rhodani*, stoneflies often constituted around half of the total relative abundance, with the detritivore *Amphinemura sulcicollis* being frequent throughout and the carnivore *Isoperla grammatical* more common in the first half of monitoring. *Siphonoperla torrentium* occurred mostly during the first five years of the study and *Leuctra inermis* has been present at low levels throughout. Two beetles have been present in the stream at significant abundances; *Limnius volkmari* has occurred at a largely stable level throughout whereas that of the related *Oulimnius* sp. has fluctuated. Whilst a number of caddisfly species have been recorded all have been at low abundances, similar to the Control Burn. There have been occasional years with high abundances of non-biting Chironomidae midges.

Selected summary statistics for the three burns are shown in Figures 42, 43 and 44. As there appear to be downward trends through time in the Total Number of Taxa in both the Control Burn and the Experimental Burn we decided to better explore the relationships of a number of the invertebrate summary statistics between the three different burns. This has been done in a similar manner to that of the chemistry diagrams, by plotting the summary statistic ratios between the Control Burn and Experimental Burn, and Control Burn and Allt Riabhach na Bioraich Burn in Figures 45 to 54.

The Total Number of Taxa have decreased slightly through time in the Control and Experimental Burns (Figure 55). The Experimental Burn has generally had slightly fewer species than the Control Burn but as declines have occurred fairly evenly in both streams there does not appear to be a trend in the ratio between the two. In the Allt Riabhach na Bioraich Burn however (Figure 56), there does not appear to have been a decline in the number of species and thus the ratio between it and the Control Burn shows a slightly increasing trend, especially since 2007, five years after the onset of grazing at the site.

A similar situation occurs for the BMWP scores, which provide an estimate of water quality by allocating species tolerant of organic pollution low scores and species characteristic of low organic pollution levels high scores. Again, values for the Experimental Burn, whilst variable, are consistently lower than those for the Control Burn (Figure 57). Values for the Allt Riabhach na Bioraich Burn increase relative to the Control Burn after around 2006 (Figure 58). These results are to be expected as the BMWP score is sensitive to the total number of species recorded.

The Average Score Per Taxon (ASPT) is a metric that divides the BMWP score by the number of species present, and should therefore remove bias resulting from increased number of species present when representing the changes in water quality through time. When the ASPT ratio between the Control Burn and the Allt Riabhach na Bioraich Burn is plotted (Figure 60) the upwards trend present for Total Number of Taxa and BMWP scores is no longer seen, suggesting that whilst there may be a greater number of species occurring in the Allt Riabhach na Bioraich Burn after 2006/7 the new species have similar water quality preferences to those already present and also those inhabiting the Control Burn. ASPT scores in the Experimental Burn (Figure 59) have almost always been lower than those in the Control Burn, but there is little evidence of an increasing or decreasing trend relative to the Control Burn during the experimental period.

Macroinvertebrate Richness scores (rareftn 100) provide the number of species that would be expected if the sample contained 100 individuals. The patterns found in and between the streams are mostly similar to those seen for Total Number of Taxa and BMWP scores. Over the course of the study period values, and therefore this measure of diversity, have decreased very slightly in the Control and Experimental Burns (Figure 61). The ratio between the two has been variable but shows no trend overall. In the Allt Riabhach na Bioraich Burn rareftn 100 diversity levels have not dropped and the ratio between it and the Control site shows a slight increase (Figure 62).

Hill's N1 diversity score is a measure of the sample that approximates to the number of abundant species it contains. It therefore tends to down-weight rare or vagrant species that can affect the Richness scores. Since 1993 Hill's N1 values have decreased very slightly in the Control Burn but decreased proportionately more in the Experimental Burn and the ratio between the two, despite being variable, shows a minor decline (Figure 63). The difference between the two has been more pronounced since 2006, meaning fewer species have tended to make up a larger proportion of the total assemblage in the Experimental Burn. In common with most of the other macroinvertebrate indices, ASPT excepted, Hill's N1 diversity has risen in the Allt Riabhach na Bioraich Burn relative to the Control Burn (Figure 64). This results from a very slight decline in values from the Control Burn and a slight increase, beginning around 2002, in values from the Allt Riabhach na Bioraich Burn.

Table 2 presents statistical results from the analysis on the macroinvertebrate data. Detrended Canonical Correspondence Analysis gradient lengths were less than four, and thus sufficient to demonstrate the suitability of using the linear Principal Components Analysis for further investigation of the data for all three burns. The variance explained by time relative to variance on the Principal Component is moderately high at all three streams, suggesting that the likelihood of a time trend is also moderately high. Significance testing using restricted permutations suitable for time-series found the RDA time trends at the Control and Experimental Burns to be significant at the 95% but not the 99% level.

Table 2 Macroinvertebrate trend test statistics

	λ_1^{PCA}	λ_1^{RDA}	$\lambda_1^{RDA}/\lambda_1^{PCA}$	**Restricted P Value**
Control Burn	0.27	0.18	0.67	0.04
Experimental Burn	0.30	0.21	0.70	0.04
Allt Riabhach na Bioraich Burn	0.32	0.23	0.72	0.07

4.2.3 AQUATIC MACROPHYTES

Figure 3, Figure 4 and Figure 5 illustrate the macrophyte survey stretches for the three study burns, Table 22, Table 23 and Table 24 summarise the aquatic macrophyte data and Figure 65, Figure 66 and Figure 67 show the results graphically. Due to physical erosion of the restricted survey stretch available, sampling of the Experimental Burn ceased after 1999.

The macrophyte flora of the Control Burn and the Allt Riabhach na Bioraich Burn are very similar, and both are dominated by mosses and liverworts typical of slightly acidic upland streams. The moss *Racomitrium aciculare* grows at low abundances on stones in the splash zone of both streams and the acid-tolerant liverwort *Scapania undulata* has generally been the most abundant submerged species. Another aquatic liverwort, *Masupella emarginata* var *aquatica* has been recorded in both streams, especially towards the beginning and end of the monitoring period, though its cover has been consistently greater in the Control Burn. The diminutive moss *Blindia acuta* has been found in very small amounts in both streams since 2008.

With respect to algae, *Batrachospermum* sp. has occurred sporadically in both burns, filamentous green algae has consistently been present throughout and of note is that *Lemanaea sp.* has recently been found for the first time in both streams.

4.2.4 FISH

Fish density data for 0+ (fry) and >0+ year (parr) age classes for the three study catchments are presented in Table 25 and Figure 68 to Figure 72. The vertical red lines in Figure 71 and Figure 72 indicate the year in which cattle were initially introduced to the Allt Riabhach na Bioraich Burn. The temporal variability of log abundance ratios between the Control and Allt Riabhach na Bioraich burns are shown in Figure 73. Smaller values indicate relatively lower numbers of fish numbers in the Allt Riabhach na Bioraich Burn compared to the Control Burn. Pre- and post- treatment (grazing) data is indicated by black and red symbols respectively.

All three sites show substantial inter-annual variability in the densities of fry and parr. In general terms, fry density (Figure 71) exhibited greater temporal coherence between sites than that observed for parr (Figure 72), possibly reflecting a common pool of mature fish from the loch.

A formal analysis of the effect of cattle grazing was carried out using data from the Control and Allt na Riabhach (Experimental) catchments. Fry log relative abundance changed positively over time ($p = 0.019$). However, neither year nor treatment was significant when the other term was present in the model ($p = 0.81$, $p = 0.135$ respectively) so it is not possible to say whether the temporal change was due to a long-term trend or due to the addition of cattle (or both). In particular, there was no evidence that the addition of cattle changed fry abundance over and above any long-term trend. When year and treatment were fitted on their own however, both were significant ($p = 0.0154$ and 0.004 respectively), with treatment (the addition of cattle) providing a slightly better fit. None of the models for parr contained significant terms, indicating no long-term trend in relative abundance or effect of treatment. However, it should be noted that the parr numbers were very low.

4.3 SEDIMENT CORE

4.3.1 LITHOLOGY

The percentage dry weights (%DW) of the sediment core LAI6 are presented in Figure 74. Figure 75 shows the percentage loss on ignition at 550^0C (%LOI) and Figure 76 demonstrates the percentage loss on ignition at 950^0C, representative of carbonate content.

The core consisted of fine grained black mud, with a very slight lightening of colour below 25cm depth and a slightly more consolidated consistency below 25.5cm. The %DW remains stable at around 10% throughout the profile, very similar to that obtained in the cores LAI1 and LAI3 taken in 1985 and reported in Patrick and Stevenson (1987). The only levels with slightly elevated %DW are around the same depth as the slight colour change between 25cm and 26cm. %LOI is higher towards the surface of the core and lower towards the bottom, indicating that the organic content in the sediments has generally increased through time to the present day. The organic content is between 45% and 50% down the core from the surface to 4.5cm, where it drops to 40%. It is then relatively stable with a gradual decline from 6cm to 18cm, flowed by a dip to ~25% at about 21cm, a return to higher levels of around 35% between 22 and 25cm then a drop to the lowest levels of around 20% from 25.5cm to the bottom of the core, coinciding with the colour change. Carbonate levels are low throughout the core, as would be expected from the sediments of a moderately acid upland loch. The highest level is just less than 7% towards the bottom of the core at 26.5cm depth. Values are low from 0cm to 2cm, then slightly elevated and more variable down to 15cm, at which depth they reduce again, increasing slightly thereafter to the bottom of the profile.

4.3.2 SPHEROIDAL CARBONACEOUS PARTICLES (SCPs) AND DATING

The SCP concentrations for LAI6 from Loch Laidon are shown in Figure 77. A first presence of SCPs occurs at 13.5 – 13.75cm and concentrations increase gradually to 7.5 – 7.75cm when concentrations increase rapidly to a peak concentration of over 9000 gDM^{-1} at 1.75 - 2cm. Concentrations then decline irregularly to the sediment surface. Surface SCP concentrations are very low at c. 900 gDM^{-1}.

If it is assumed that the SCP concentration peak represents the period of maximum deposition then 1.75 - 2cm may be ascribed the date 1978 (± 5) years. This produces a mean sediment accumulation rate for the most recent 31 years of 0.0605 cm yr^{-1} (0.0565 – 0.645 cm yr^{-1}). If this rate is extrapolated below 2 cm, then 1950, usually indicated by a rapid increase in SCP concentration, would be expected to occur at 3.5 – 4cm which would not appear to be the case in LAI6 where the rapid increase appears at a lower depth at 7.5cm.

The SCP concentration profile form LAI6 also appears to be truncated at the lower end. If the rapid increase in concentration is assumed to be c.1950 then, unless there has been a major change in sediment accumulation rate, the SCP profile does not extend back to the mid-19th century as might be expected. Comparing this with the SCP concentration profile from the 1995 deep water core from LAI 4 shows that a similar pattern was also observed in this earlier core. Indeed the chronology of the whole profile is slightly unusual. The SCP peak occurs at c. 1983 which is slightly later than usual, the rapid increase begins a few years earlier than is normal (i.e. c. 1945 instead of c. 1950) and the similar truncated pattern is observed at the bottom of the profile such that the first presence of SCPs occurs between 1905 and 1910. The earlier deep water core also shows an irregular profile in the upper part of the core although not to the extent of LAI 6 and this is probably due to the higher analytical resolution of the most recent core. Similarly, the uppermost concentrations for LAI 6 are significantly lower than those for LAI 4 and probably reflect the continued decline in SCP deposition over the intervening 14 years. In summary, given the difference in sedimentation environments of the two cores, the SCP concentration profiles of the two cores exhibit a good degree of agreement in their temporal trends.

Given this agreement and as LAI 4 was reliably radiometrically dated we therefore have a site specific calibration for LAI 6 and this would seem to offer the best means by which the most recent core can be dated. From the comparison of the two cores it is also interesting to note that the depths for the various features (see Table below) are similar in both cores in lower sediment depths up to the SCP concentration peak when sediment accumulation is more rapid in the deep water core despite there being an additional 14 years of accumulation in LAI 6. This suggests an acceleration in sediment accumulation rate in the deep water core which is not observed in the recent shallow water core.

The comparison between the SCP concentration trends for the two cores provides dating ‘tie-points’ which can be summarised as follows:

Table 3 SCP Comparison Between Core LAI4 and Core LAI6

	LAI 4 (1995)		LAI 6 (2009)
	Depth (cm)	Date	Depth (cm)
Upper peak	3.5	1983 ± 2	1.75 – 2
Rapid increase	8.5	1945 ± 2	7.5 – 7.75
Lower 'peak'	11.75	1920 ± 3	11.5 – 11.75
First presence of SCPs	13.75	1908 ± 4	13.5 – 13.75

Extrapolating between these dates and depths provides a best available chronology for LAI 6 as summarised in Table 4.

Table 4 Chronology for Core LAI6

Sediment depth (cm)	Age (Years)	Date
0	0	2009
1	14 ± 2	1995 ± 2
2	27 ± 2	1982 ± 2
3	34 ± 2	1975 ± 2
4	40± 2	1969 ± 2
5	47 ± 2	1962 ± 2
6	53 ± 2	1956 ± 2
7	60 ± 2	1949 ± 2
8	66 ± 2	1943 ± 2
9	72 ± 3	1937 ± 3
10	78 ± 3	1931 ± 3
11	85 ± 3	1924 ± 3
12	91 ± 3	1918 ± 3
13	97 ± 4	1912 ± 4
14	103 ± 5	1906 ± 5

No dates can be ascribed to sediment depths below 14cm using this approach.

4.3.3 DIATOMS

The full diatom percentage abundance stratigraphy, diatom-based WAPLS pH reconstruction, diatom Axis 1 and Axis 2 PCA scores, the SCP profile and the SCP derived dates from core LAI6 are presented in Figure 78, while Figure 79 shows the surface to 5cm depth section of the diatom percentage abundance stratigraphy in greater detail.

The lowest sample in the core, from 28cm depth, is unusual relative to the rest of the diatom profile due to being dominated by the planktonic species *Cyclotella kuetzingiana,* which is barely present in any of the more recent upper sediments. All the higher levels from the core are dominated by benthic species, the four most common of which are *Tabellaria flocculosa, Frustulia rhomboides* var. *saxonica*, *Brachysira vitrea* and *Eunotia incisa*. Between 22cm and 14cm there are also significant proportions of the slightly acid-intolerant *Achnanthes minutissima*, but this species then disappears from the assemblage as the sediments become more recent. The four most common species show differing trends in abundance up through the core; *T. flocculosa* has very low levels at the bottom of the profile and then increases substantially, constituting approximately 20% of the total assemblage at most depths up to 3cm. The species then declines slightly before increasing to over 25% abundance at 0.75cm and falling back to around 13% in the two most recent samples; *F. rhomboides* var. *saxonica*, occurs at low abundances in most of the lower core depths then subsequently increases from around 10cm to the top of the core, reducing slightly in the very top surface sediment; *B. vitrea* is most abundant below 11cm depth, declining gradually towards the top of the sediment profile; Lastly *E. incisa* has a relatively stable abundance throughout the time-period covered by the core, reducing slightly at the bottom of the core and also between 0.5cm and 1.5cm. *Fragilaria virescens* occurs at around 10% from the bottom of the core to 14cm, then reduces to around 1cm, where abundances go back up. Other species present, that exhibit their highest abundances towards the surface of the core, are *Frustulia rhomboides* in the top 1cm, and *Tabellaria quadriseptata* and *Navicula leptostriata* in the top 4cm.

The diatom pH reconstruction models pH as being highest, at around 5.6, in the bottom sample of the core. This is followed by a decline to 5.5 at 22cm. Between 19 and 12 cm pH levels are steady before a steep decline to below 5.4 at 10cm sediment depth. Very slight recovery can be seen at 2cm but then reconstructed pH declines again in the most recent sediments. The pH reconstruction under-estimates the measured pH by around 0.5 of a pH unit so care should be used when interpreting these results.

With the exception of a very minor change in the topmost surface sediment sample, PCA axis 1 (capturing 58% of total variance) and axis 2 (37% of variance) scores demonstrate that relative to changes in the lower part of the sediment profile there has been little floristic change towards the surface of the core coinciding with the period of grazing.

5 DISCUSSION

Summer grazing cattle are increasingly encountered in the UK uplands. The practice is now encouraged through agricultural funding schemes, being subsidised in Scotland under the Scottish Rural Development Programme Land Management Axis 2 Option Number 11 (Scottish Government 2008), and in England under the Uplands Entry Level Stewardship Code UL18 (Natural England 2010). These incentives concentrate on the perceived benefits of grazing to the terrestrial system, and the terrestrial monitoring component of the Laidon grazing study has been undertaken and reported on by Cresswell Associates (Walters 2006; Cresswell 2008; Pimley 2009a; Pimley 2009b). Their work indeed suggests that grazing the Loch Laidon experimental area has been slightly beneficial to the terrestrial plant diversity and earthworm abundance.

In contrast to the terrestrial environment however, the effects of cattle presence and grazing on nearby aquatic systems have often been seen as less positive (eg.

Belsky, Matzke, and Uselman 1999; Heathwaite and Johnes 1996; Hooda *et al.* 2000; Kauffman and Krueger 1984; McDowell and Wilcock 2008), largely due to the negative effects of excess nutrient enrichment at high stocking densities. Cattle can increase nutrient levels by excreting directly into streams, degrading stream banks and by compacting topsoils, which can result in less infiltration and more overland flow allowing for greater nutrient loss (Kurz, O'Reilly, and Tunney 2006a; Walker *et al.* 2009).

Considering the potential for nutrient enrichment occurring within the grazed streams of the Laidon Grazing Experiment we have uncovered little evidence for it from either the chemical and biological stream monitoring or the sediment core from Loch Laidon. Streamwater chemistry mostly reveals minor changes in nutrients that seem common to all the studied sampling stations, whether grazed or ungrazed. This is seen in slight overall reductions in nitrate levels and minor increases in peak concentrations of Soluble Reactive Phosphorous. A slight downward trend in nitrate has also been observed at the Allt na Coire nan Con, the closest site to the experimental area in the UK Acid Waters Monitoring Network (Kernan *et al.* 2010). Similar to the Rannoch streams, the UKAWMN has also seen declines in calcium and magnesium concentrations at many sites, a predicted response to the reduction in acid inputs due to decreased emissions.

Previous reports noted the change in the nitrate ratio between the Control and Experimental Burns around 1998, when concentrations swapped to being characteristically slightly higher in the latter. This relationship has persisted, even as levels have lowered in both streams during more recent years. There is little evidence however of a similar change in the ratio of nitrate levels between the Control Burn and the Allt Riabhach na Bioraich Burn once grazing commenced. Estimates of the amount of nitrogen produced by cattle vary significantly (ADAS 2007; Bussink 1994; DEFRA 2009; Jarvis, Hatch, and Roberts 1989), and depend on many variables such as the size of cow and quality of fodder. Even at the higher end of estimates however it seems unlikely that the amount of nitrogen produced by the experimental cattle in the current regime exceeds that arriving as atmospheric deposition in the study area, about 10kg hectare^{-1} year^{-1} (Sutton *et al.* 2004). Moreover the cattle are present on the study site during summer, when the biological uptake of nitrogen is at its greatest. SRP concentrations have often tended to peak during the summer months, but as this also occurs at the ungrazed Control Burn, and relative levels do not appear to be changing between the burns, it seems unlikely that concentrations reflect cattle effects.

The nutrient potassium is also excreted by cows, and unlike nitrogen or SRP, concentrations do seem to have risen somewhat in the Allt Riabhach na Bioraich Burn relative to the Control Burn since cattle grazing began in 2002. Interestingly levels in the Experimental Burn have become more similar to the Control Burn over the same period, indicating either that processes other than cattle are controlling concentrations, or, if cattle are responsible, perhaps that their activity moved away from the Experimental catchment towards the Allt Riabhach na Bioraich catchment once it was made available.

As well as nitrate, chloride and non-marine sulphate are the other main acid anions. Non-marine sulphate shows a decline in all the study streams over the monitoring period, and an absence of trends in the ratios between the grazed streams and the Control Burn suggests that cattle are not affecting concentrations. The difference in late summer non-marine sulphate levels between the upper and lower chemistry sampling stations on the Experimental Burn is likely to be as a result of the very peaty nature of the soils in the stream's lower catchment. During the waterlogged winter months sulphate is reduced to sulphide and retained in the peat. When water levels drop in the summer months the sulphide is reoxidised to sulphate, and in autumn as water levels start to rise again the sulphate is released into the stream, causing the very high peak concentrations seen in the lower Experimental Burn at that time of year. Chloride levels have dropped very slightly in all three streams, but ratios between the grazed and ungrazed burns do not demonstrate trends and, similar to non-marine sulphate, chloride concentrations seem not to be affected by the presence of cattle.

pH levels do not show signs of major recovery at any of the three streams in the monitoring programme, though there may be evidence that biologically important pH minima have become less acid over time. Decreases in acid anions, especially non-marine sulphate, appear to have been largely balanced by the declines in concentrations of base cations such as calcium, magnesium and to a lesser extent sodium. Biologically available labile aluminium has reached levels likely to be toxic to biota (~ 25 g l^{-1}) only very infrequently, in two samples from the Control Burn early in the study period and two samples from the Allt Riabhach na Bioraich Burn, in 1996 and 2003. Though the sampling methodology may not capture all the aluminium peaks, it seems they are reducing slightly in the Control and upper Experimental burns and are becoming less likely to be controlling abundances of individuals or species within the biological study groups. A lack of trends in the aluminium ratios between the grazed and ungrazed streams suggests that cattle are not responsible for any effects in the grazed burns.

The diatom assemblage in the Experimental Burn has been more variable than that of the other two burns but there is no evidence of an increase in species tolerant of increased nutrient concentrations. There are changes in the Allt Riabhach na Bioraich Burn that seemingly suggest the diatom assemblage changed significantly within three years of the onset of cattle grazing: declining *Tabellaria flocculosa*, increasing *Brachysira vitrea* as well as smaller increases in *Eunotia naegelii, Frustulia rhomboides* var. *saxonica* and *Eunotia incisa*. All of these changes have been seen in the Control Burn as well however, where there has also been a similar pattern of declining *Tabellaria flocculosa*, increasing *Brachysira vitrea* and smaller increases in *Eunotia naegelii, Frustulia rhomboides* var. *saxonica* and *Eunotia incisa*. Trend test statistics also demonstrate the similarities between the streams. In combination with the fact that the species more abundant in the second half of monitoring are not indicative of elevated nutrients, this suggests that the observed changes can not be ascribed to changes in the grazing regime at the Allt Riabhach na Bioraich Burn but to changes in other environmental factors common to both streams or catchments, such as reduced labile aluminium maxima or less severe acid episodes.

Despite the Control Burn and the Allt Riabhach na Bioraich Burn having broadly more similar aquatic macroinvertebrate assemblages the summary statistics of the Control and Experimental Burns resemble each other more closely through time.

Both have experienced slight decreases in Total Number of Taxa, BMWP scores, Richness scores and Hill's N1 scores, with the Experimental Burn usually recording lower values for each index for any given year. The two streams both exhibit similar PCA and RDA statistics suggesting time-trends may be present at a level of confidence greater than 95%. This synchronicity between the burns suggests non grazing-induced effects are driving changes in the assemblages at both sites.

In the Allt Riabhach na Bioraich Burn however the Total Number of Taxa, BMWP scores, Richness scores and Hill's N1 scores have remained stable or even increased slightly, especially since 2007, and therefore show clear increases relative to the Control Burn. Increased numbers of species, diversity and BMWP scores, that suggest a reduction in organic pollution, are not consistent with cattle grazing having a negative effect on the macroinvertebrate assemblage of the Allt Riabhach na Bioraich Burn. Care must be taken when interpreting overall trends here however, as the trend test statistics are not significant at the 95% level. Braccia and Voshell (2007) found that in streams subjected to various grazing intensities, total invertebrate richness rose marginally in lightly rotationally-grazed streams relative to ungrazed streams, but then lowered significantly as catchment cattle densities increased further. They hypothesise that this may be due to small amounts of extra nutrients plus low levels of extra disturbance being positive for invertebrate richness before the well documented (eg Belsky *et al.* 1999; Kauffman and Krueger 1984; Magbanua *et al.* 2010; Scrimgeour and Kendall 2003; Wohl and Carline 1996) negative effects of higher cattle stocking densities start to influence the assemblage. If such factors are conditioning the invertebrates in the Allt Riabhach na Bioraich Burn then it might be expected to find similar processes apparent in the longer time-series of the grazed Experimental Burn. This however, is not seen in the data, and may be for reasons similar to those possibly conditioning the potassium concentrations, namely cattle moving away from the Experimental Burn catchment once the grazed area was expanded to include the Allt Riabhach na Bioraich Burn catchment.

The aquatic macrophytes in the Control Burn and the Allt Riabhach na Bioraich Burn show marked similarities with respect to both the assemblage constituents and the timings of arrivals of new species. Total cover percentages have been higher in the Control Burn in every year apart from 2006, probably reflecting the higher proportion of large boulders in that stream which provide a substrate less prone to destructive movement at higher flows. There does not appear to be evidence of impacts from cattle presence, such as reductions in macrophyte cover or increased levels of filamentous algae, in the Allt Riabhach na Bioraich Burn since catchment grazing began. The recent appearance of the clear-water alga *Lemanaea* indicates that water quality in the stream is unlikely to be deteriorating (Thirb and Benson-Evans 1985).

Unlike some of the other biological study groups in the project, fish are mobile and use different habitats at different stages in their life cycle. As such they are dependant on catchment-scale processes rather than those at microhabitat or reach-scale. As well as reflecting the environmental conditions within individual streams, fish numbers reflect conditions, including productivity, within the larger Loch Laidon system. Adult fish will spend at least part of their life cycle within the Loch itself, and are not resident in, or necessarily faithful to, the study streams where they hatched. As such it is difficult to demonstrate the effect of local changes, when processes at larger scales may be equally or more important.

Fry numbers were more robust to analysis than the very limited data available for parr. Furthermore, because fry are known to migrate only short distances from redds they are likely to be more representative of local conditions, where spawner numbers are not limiting. The Fry data suggested a positive temporal trend in the productivity of the Allt Riabhach na Bioraich Burn compared to the Control Burn. Unfortunately there is insufficient statistical evidence to separate possible hypotheses: (1) that cattle grazing through nutrient enrichment increased stream-water productivity leading to increased local fry numbers, (2) that there is a long term increase in productivity in the experimental stream due to factors independent of cattle grazing.

The sediment core LAI6, taken from the bay in Loch Laidon into which the Experimental Burn flows, demonstrates good agreement with previous cores, LAI1, LAI3 and LAI4, taken from the main basin of the loch (Flower *et al.* 1988; Flower *et al.* 1996; Patrick and Stevenson 1987). This provides evidence of the replicability of the techniques, and allows us to be relatively confident of an undisturbed stratigraphy and therefore also in the dating chronology. Despite being taken in a potentially different sedimentation environment, the lithostratigraphic, and Speroidal Carbonaceous Particle profiles revealed sufficient similarity to allow cross-dating calibration with the radiometrically dated core LAI4, taken in 1995. The dates thus obtained suggest that accumulation rates in the bay are slightly lower than those found in the main loch basin.

With respect to the diatoms in the sediment core, the relative abundances and species compositions match well with the 1985 and 1995 cores. The major decline at low depth in planktonic *Cyclotella kuetzinghiana*, the minor decline in *Brachysira vitrea* towards the surface and a broad increase in abundance of *Frustulia rhomboides* var. *saxonica* are similar to changes seen previously in the cores from the main basin of Loch Laidon. Proportional changes of *Tabellaria flocculosa* and *Eunotia incisa* in LAI6 are more similar to the 1995 core LAI4 than the 1985 core. *Frustulia rhomboides* increases in the top two levels but, like the other species slightly more abundant in the core period coincident with catchment grazing it is not a diatom characteristic of elevated nutrient levels, and in general the assemblage is ecologically stable across the period both before and after grazing commenced and does not show signs of increased nutrient levels or loch productivity.

Similar to the 1985 and 1995 cores the diatom-reconstructed pH does not show a recovery signal. It seems that there is little evidence from the diatom assemblages in the uppermost sediment layers that there has been a response to reductions in acidifying atmospheric pollutants as evidenced by the decreases in sulphate concentrations in the stream data, and species more characteristic of higher pH, such as *Achnanthes minutissima* and *Brachysira vitrea* have not returned to the abundances at the top of the core they exhibited before pH decline further down the profile.

Diatom PCA axis 1 scores seem in large part to echo the reconstructed pH profile and may represent the effects on the diatom assemblage of acidification. Both PCA axis 1 and PCA axis 2 scores are stable across the transition from no grazing to grazing in the sediments, and change much more significantly in lower parts of the profile. This suggests that the diatom flora is responding primarily to environmental variables other than those associated with catchment cattle grazing, or that if there is a signal from the experimentally grazed streams draining into the coring bay, that it is masked by other processes controlling the sediment diatom assemblage.

In summary, the chemistry and biology of the study streams do not demonstrate that cattle, under the current grazing regime and densities, are having a major effect on the experimentally grazed streams relative to the Control stream. Levels of nutrients have not increased significantly in the Experimental Burn or the Allt Riabhach na Bioraich Burn relative to the Control Burn. Of note however are the minor increases in the peak summer nitrate levels in the Experimental Burn relative to the Control Burn during the period from 1998 and 2008, and the minor increase in potassium levels in the Allt Riabhach na Bioraich Burn relative to the Control Burn since grazing began in 2002. There are signs of slight reductions in inputs of acidifying atmospheric deposition, with a decline in concentrations of non-marine sulphate, and slight declines in nitrate and chloride concentrations that appear to be affecting the grazed and non-grazed streams in relatively equal measure. These declines have coincided with declines in base cation concentrations, and pH levels have not increased significantly in any of the three study streams. This suggests that cattle are not ameliorating the effects of catchment acidification through their activities. There is some limited evidence of a decrease in acidity, registered mainly through a reduction in aluminium maxima and pH minima, but as these are seen in the Control as well as experimental streams these are more likely to be related to regional trends in acid deposition rather than to the effect of cattle grazing.

Given the muted chemical differences between the streams, it is unsurprising that there is also little clear evidence for major grazing-induced biological trends. This does however indicate that grazing is not having a negative effect on the stream biology. The diatom and macrophyte assemblages and abundances do not seem to show differences between streams that can be ascribed to grazing effects. There is the possibility that invertebrates and fish are reacting positively to grazing in the Allt Riabhach na Bioraich Burn, with elevated levels of some invertebrate diversity indices and trout fry densities relative to the Control Burn since grazing commenced in 2002. The exact mechanisms for these changes require further investigation however. Similar to the slightly raised relative levels of potassium, the reason these effects have not been seen in the Experimental Burn may possibly be that with the expansion in 2002 of the total grazed area, and the subsequent preference of the cattle to congregate in the Allt Riabhach na Bioraich catchment, grazing effects have lessened in the Experimental Burn catchment.

In the core LAI6 the diatom assemblage does not provide evidence that there has been an increase in nutrients or overall productivity in the bay in Loch Laidon into which the Experimental Burn flows since catchment grazing began. The fossil data also show that there does not appear to have been a recovery in the diatom flora consistent with a reduction in acidifying atmospheric pollutants.

In conclusion, the Laidon Grazing Experiment has accumulated a remarkable dataset in terms of length, measurement frequency, analytical consistency and spatial resolution. The data-set provides a unique evidence-base to inform the debate not just about upland grazing, its associated ecosystem services and the recovery or otherwise from acidifying atmospheric deposition but also, with the recent addition of physical parameter monitoring, increasingly that concerning climate change. With a view to publication in the scientific literature, the authors recommend a full statistical analysis of the complete data-set, using multi-variate techniques to further assess the significance of the trends identified and explore the relationships between the chemical and biological data. This may be an expedient point at which to do so due to the natural break in the experimental time-series, conditioned by the unforeseen logistical difficulties that resulted in grazing not being possible during the summer of 2010.

Given the quality and length of the data-series, and that the site is representative of upland systems common through the Scottish uplands, during the current period of project review the authors strongly recommend that at minimum monitoring is continued at the Control Burn. This will provide a base-line for the continuation of further grazing studies and could also contribute to additional scientific work within the study area, including monitoring the as-yet limited recovery from acidification and future land-use and climate change.

6 ACKNOWLEDGEMENTS

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8 FIGURES

Figure 1 The Loch Laidon catchment indicating the boundaries of Rannoch Moor NNR and SSSI.

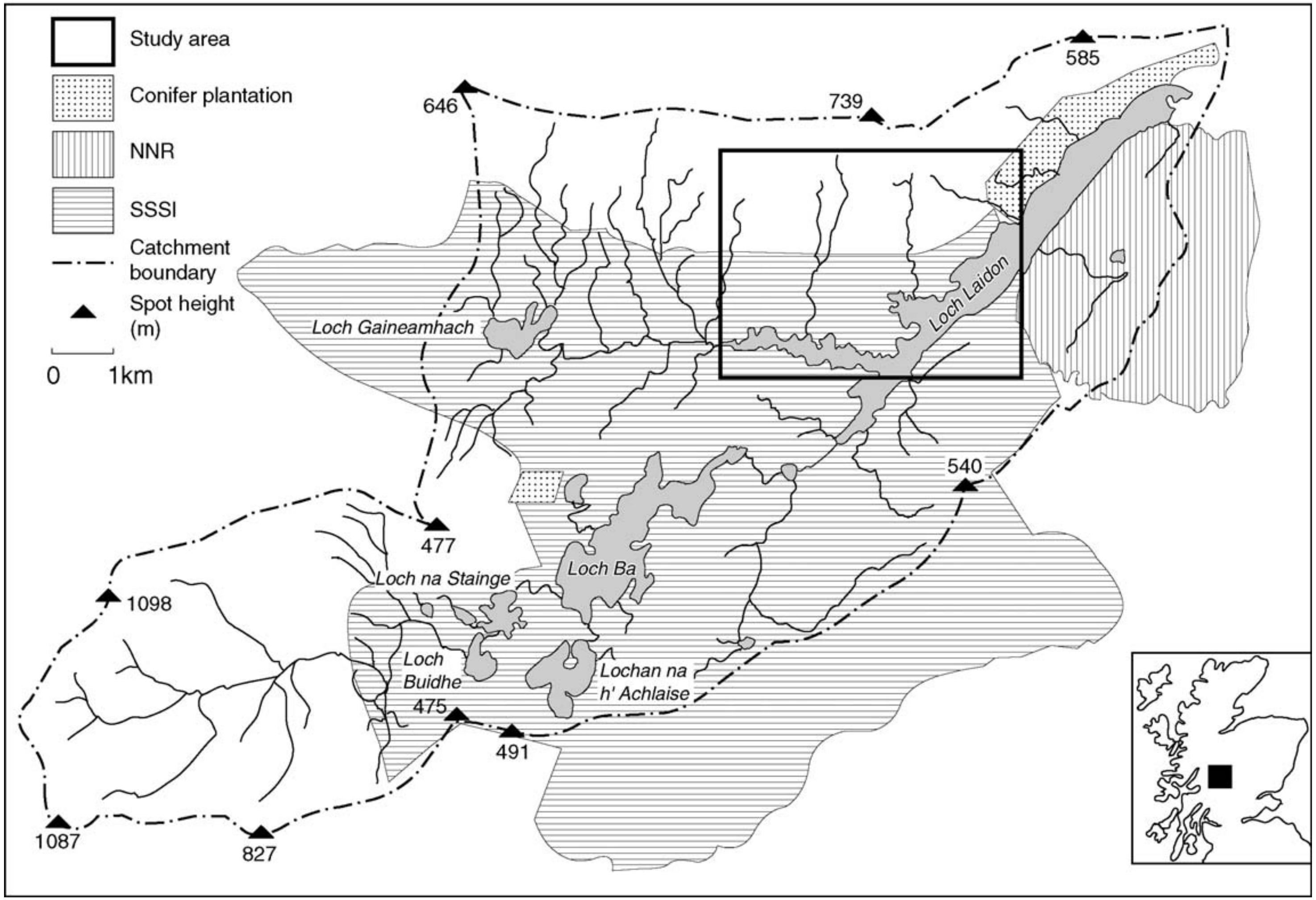
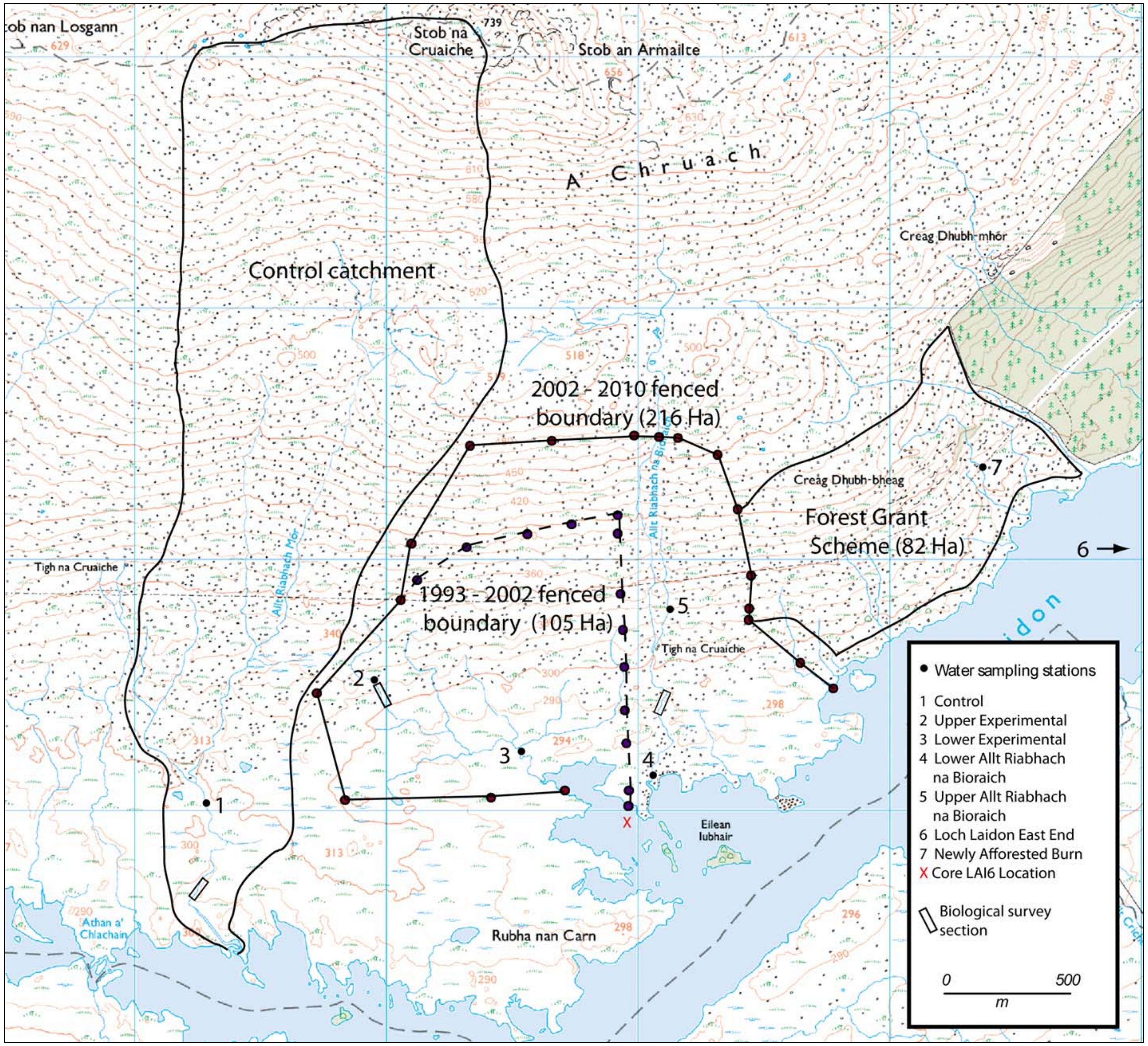


Figure 2 Loch Laidon study area.



Background map © Crown Copyright/database right 2011. An Ordnance Survey/EDINA supplied service.

Figure 3 Control Burn 2010

Figure 4 Experimental Burn 2010

Figure 5 Allt Riabhach na Bioraich Burn 2009

Figure 6 The ratio of alkalinity and its temporal variability in spot samples between the Experimental and Control Burns, August 1992 – April 2010.

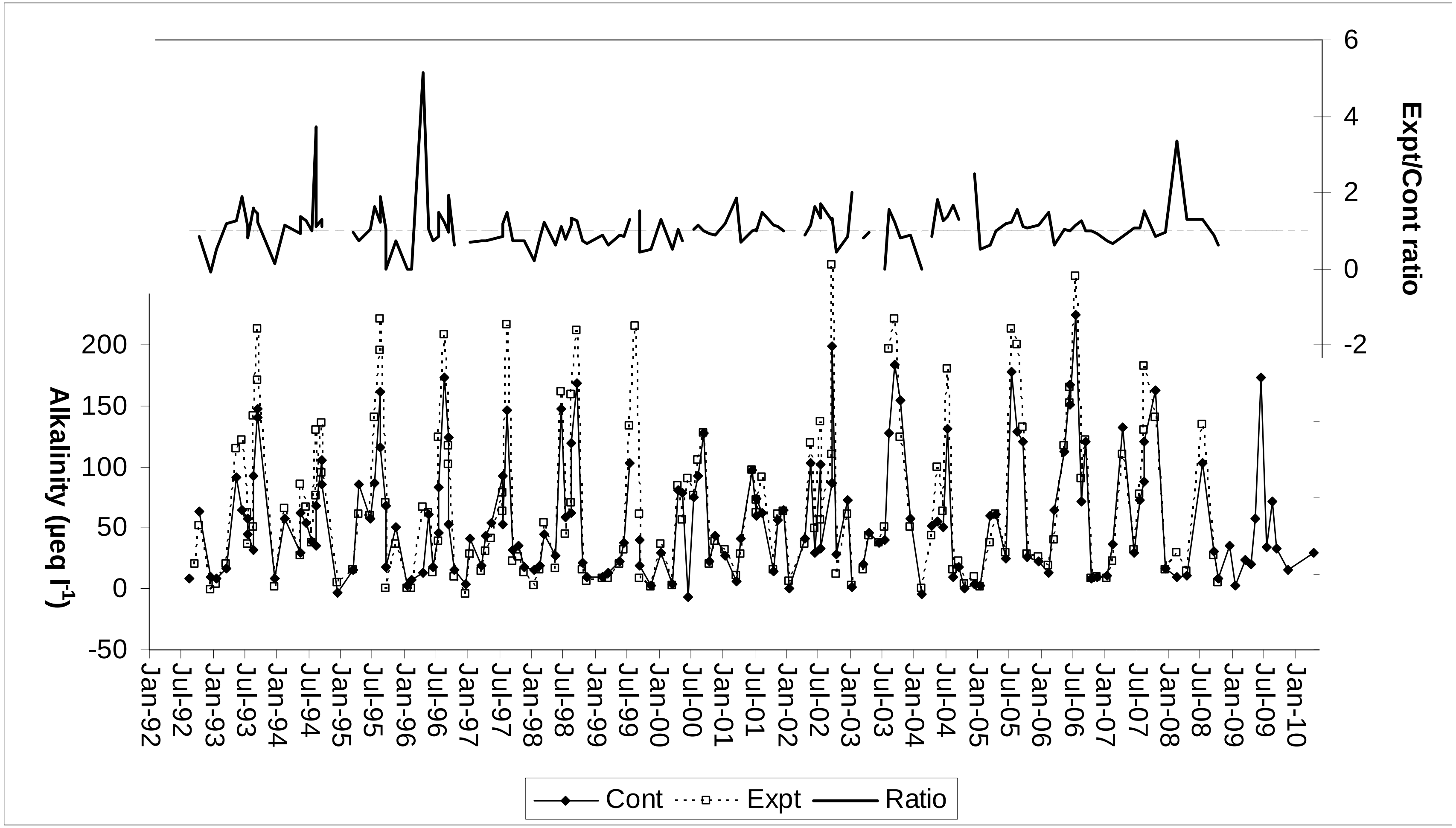


Figure 7 The ratio of conductivity and its temporal variability in spot samples between the Experimental and Control Burns, August 1992 – April 2010.

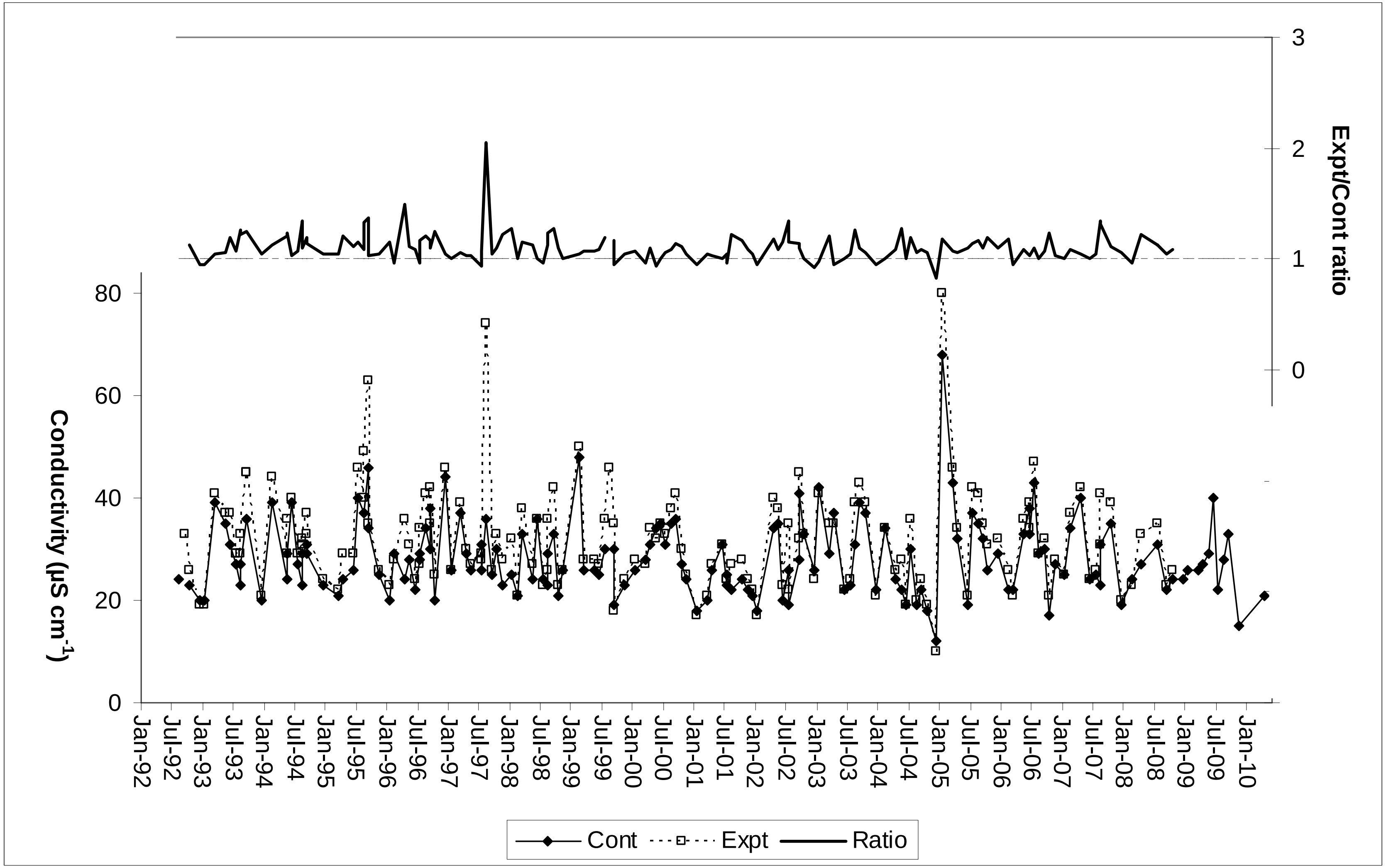


Figure 8 Temporal variability of nitrate in spot samples from the Experimental and Control Burns, August 1992- April 2010.

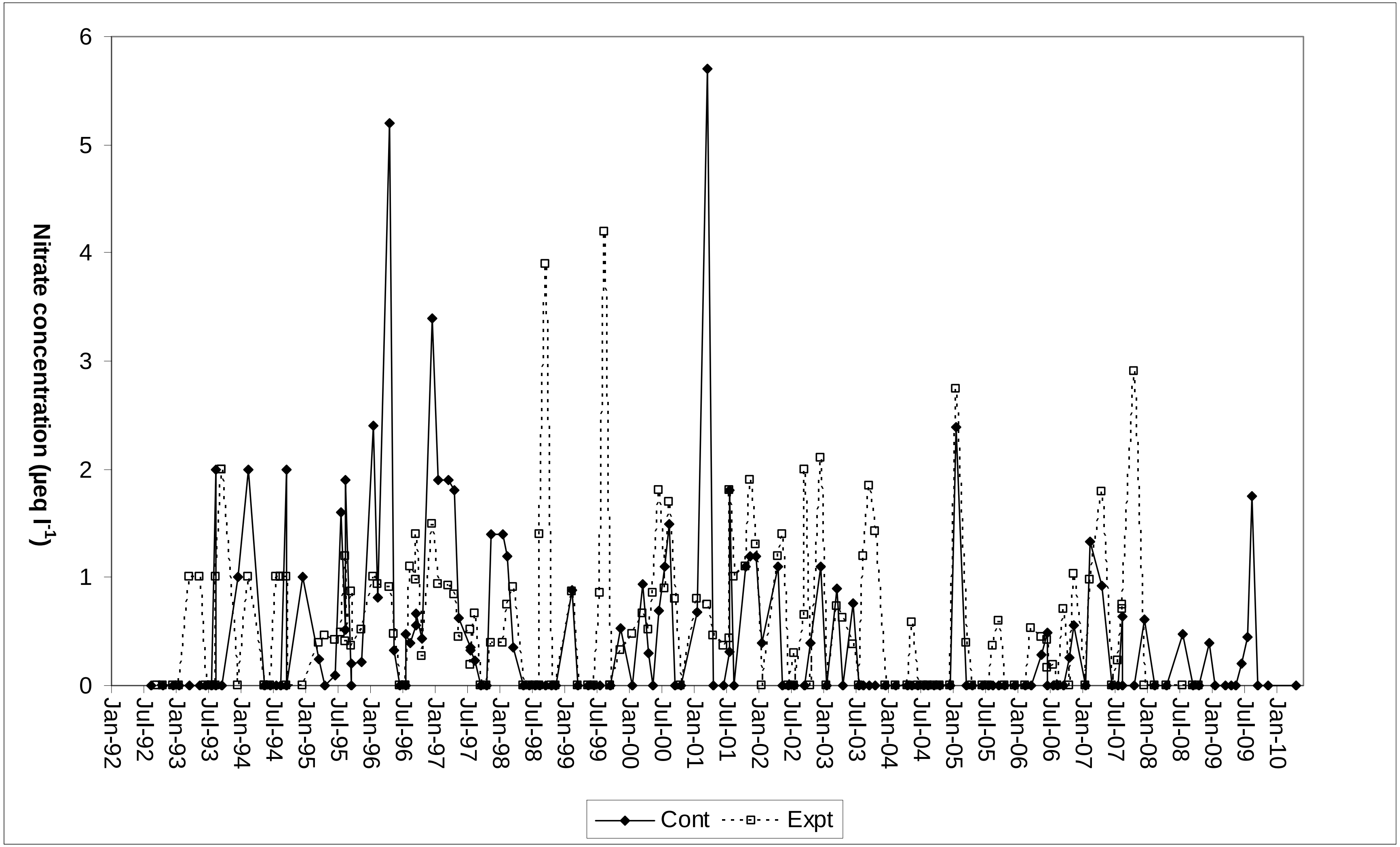


Figure 9 Temporal variability of soluble reactive phosphorus in spot samples from the Experimental and Control Burns, August 1992- April 2010.

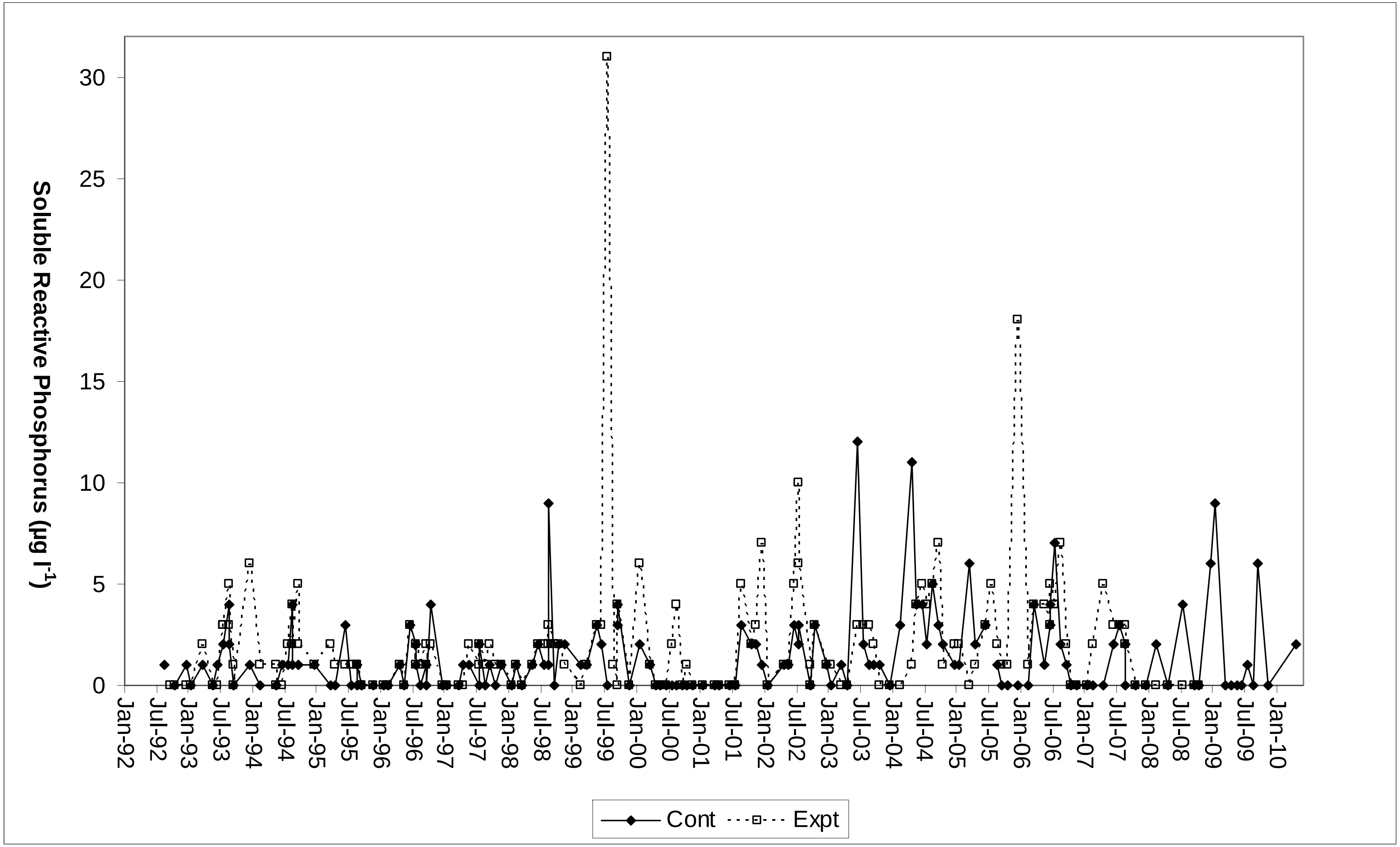


Figure 10 The ratio of H+ concentration and the temporal variability of pH in spot samples between the Experimental and Control Burns, August 1992- April 2010.

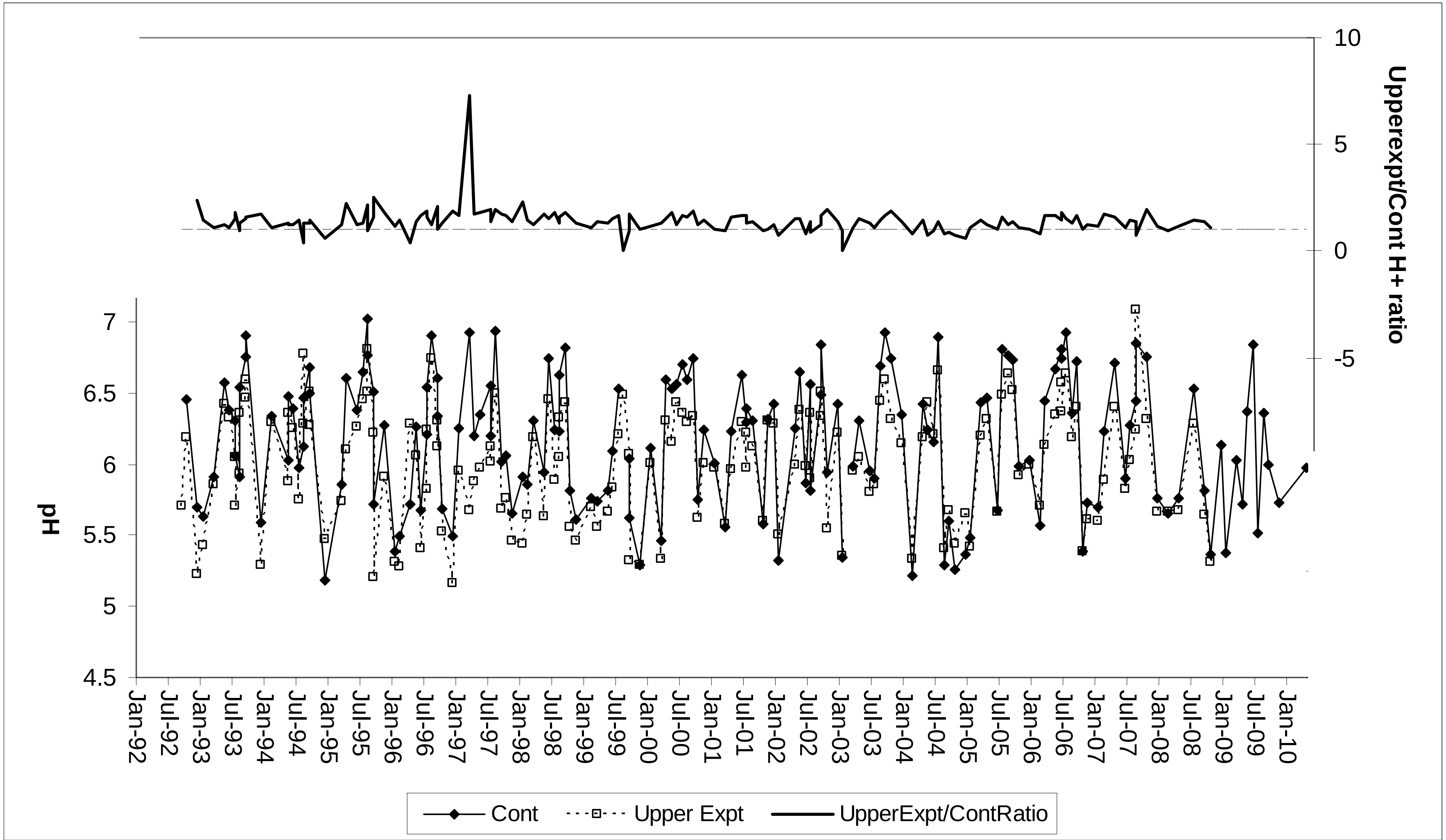


Figure 11 The ratio of non-marine sulphate and its temporal variability in spot samples between the Experimental and Control Burns, August 1992- April 2010.

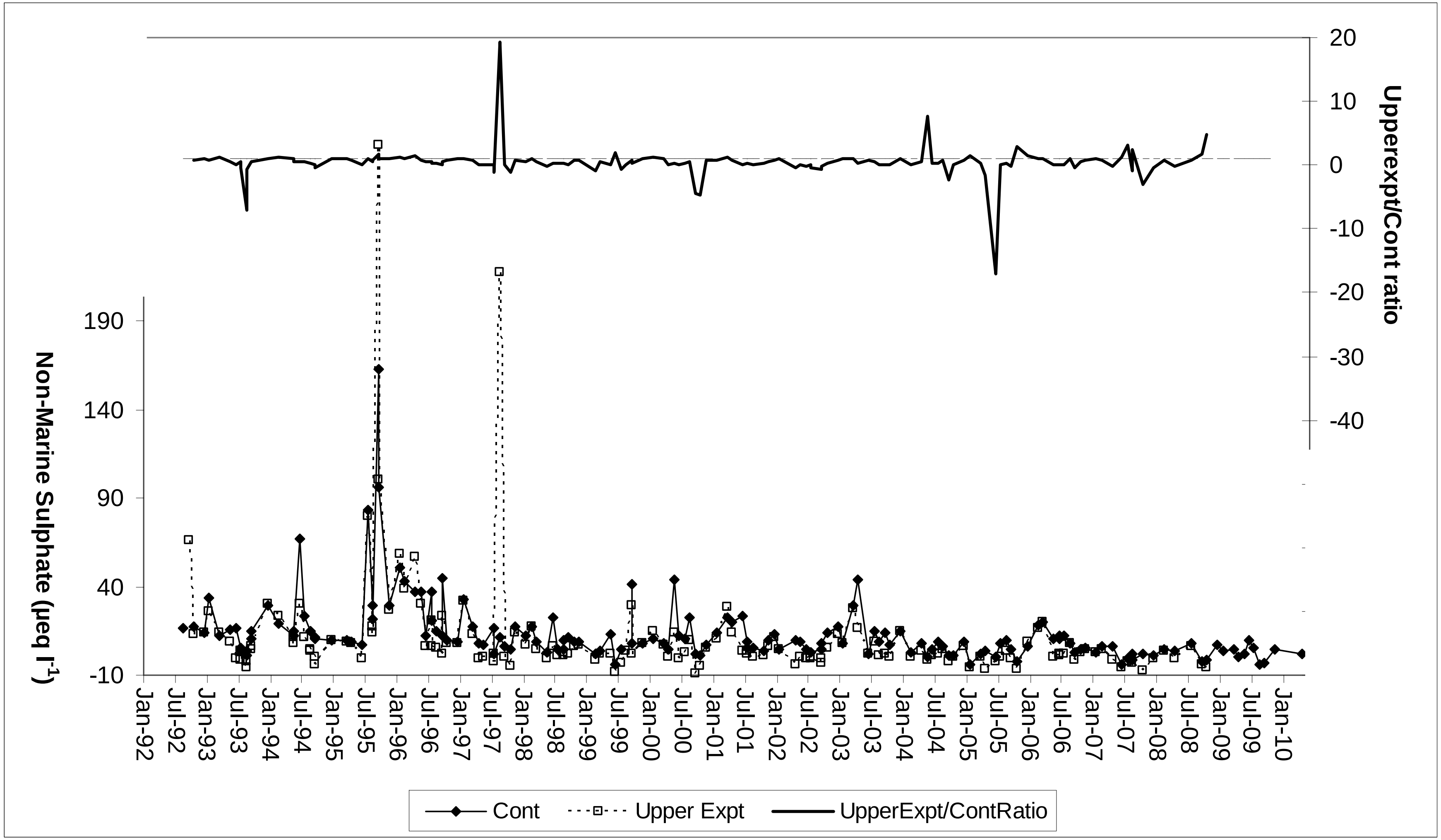


Figure 12 The ratio of labile aluminium and the temporal variability in spot samples between the Experimental and Control Burns August 1992 – April 2010.

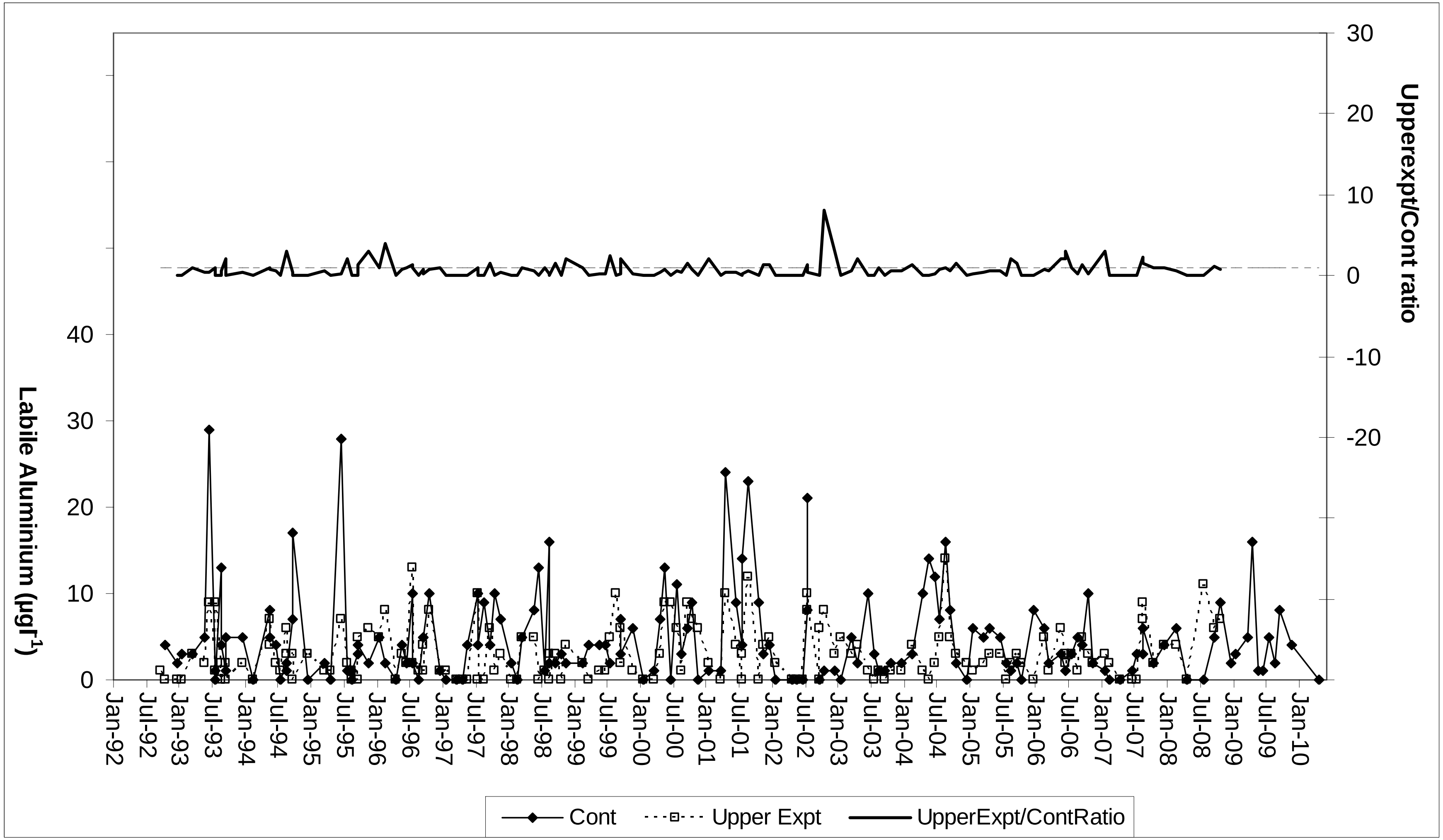
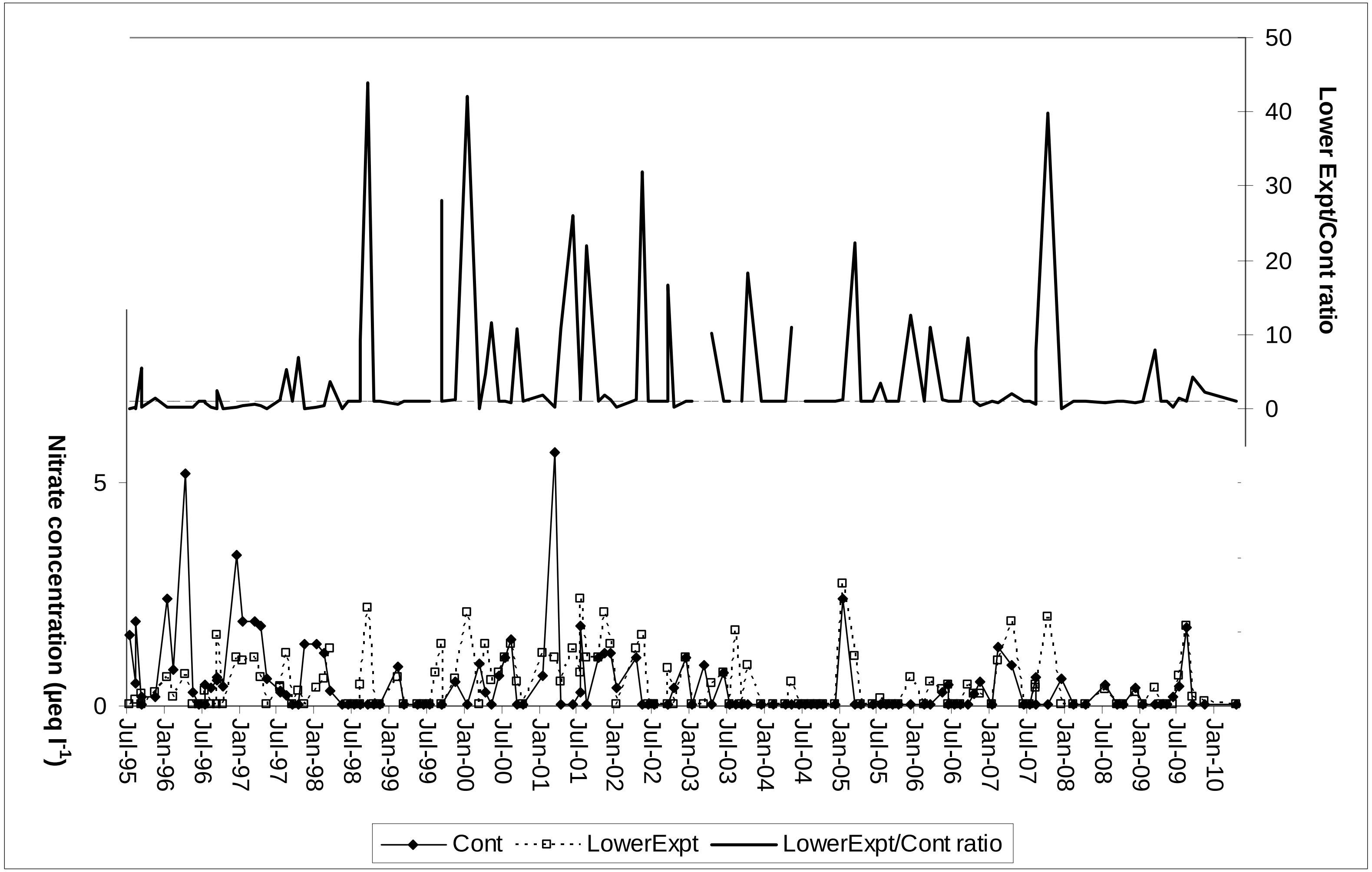


Figure 13 The ratio of nitrate and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.



N.B. 0 values converted to half nitrate detection limit for ratio calculations.

Figure 14 The temporal variability of nitrate in spot samples and the difference between the Control and Experimental Burn (Lower site) June 1995 – April 2010.

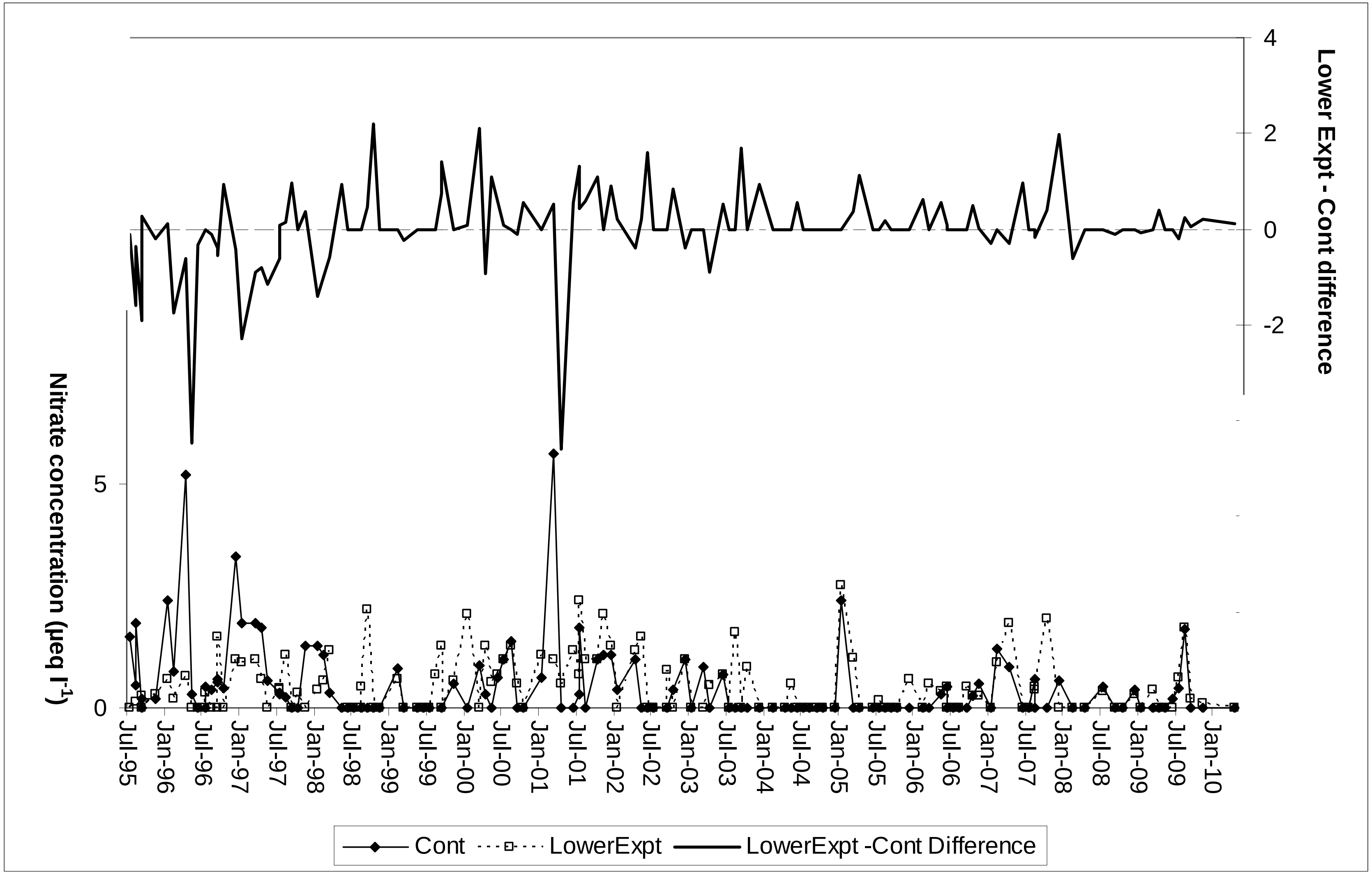


Figure 15 The ratio of alkalinity and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.

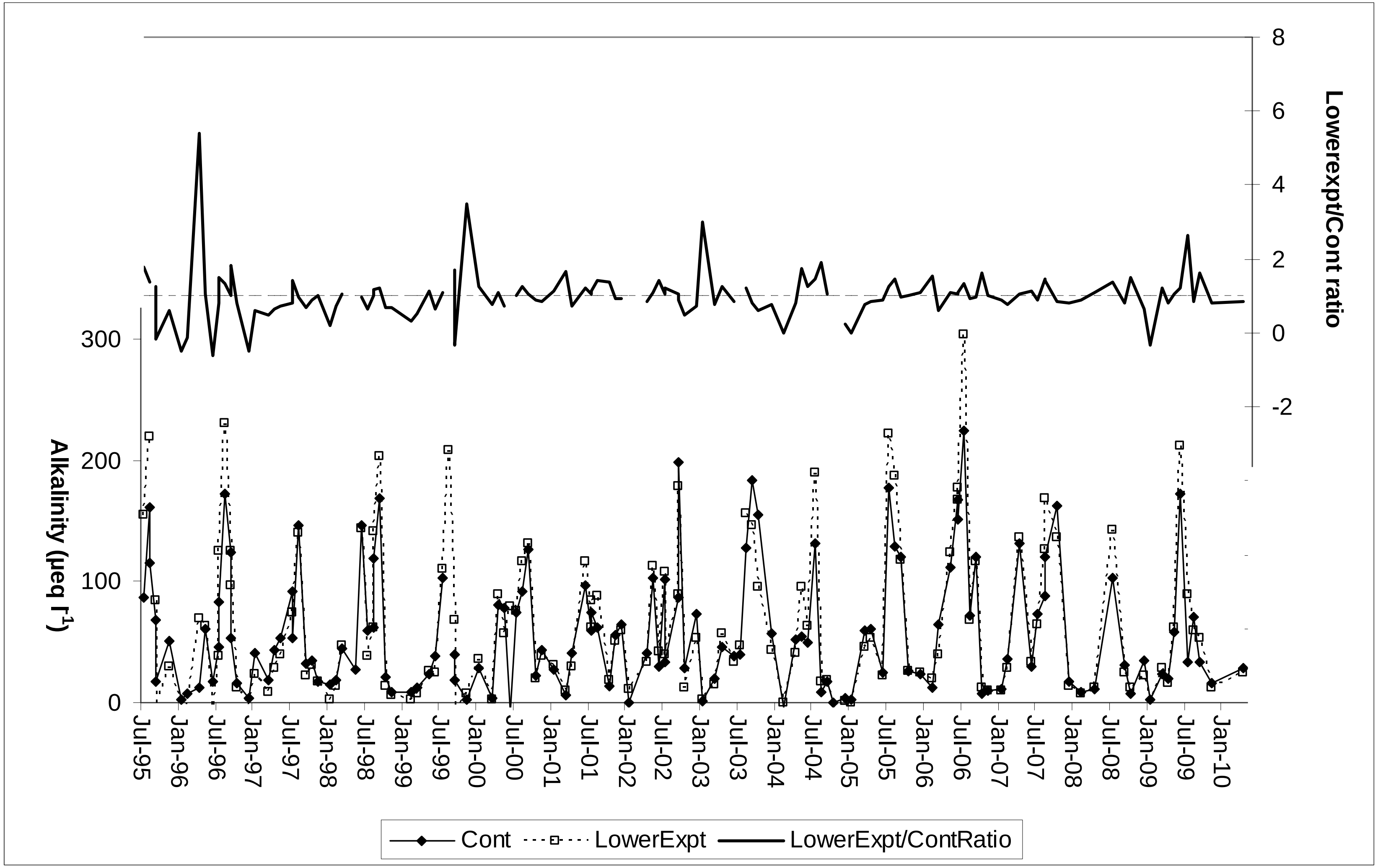


Figure 16 The ratio of calcium and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.

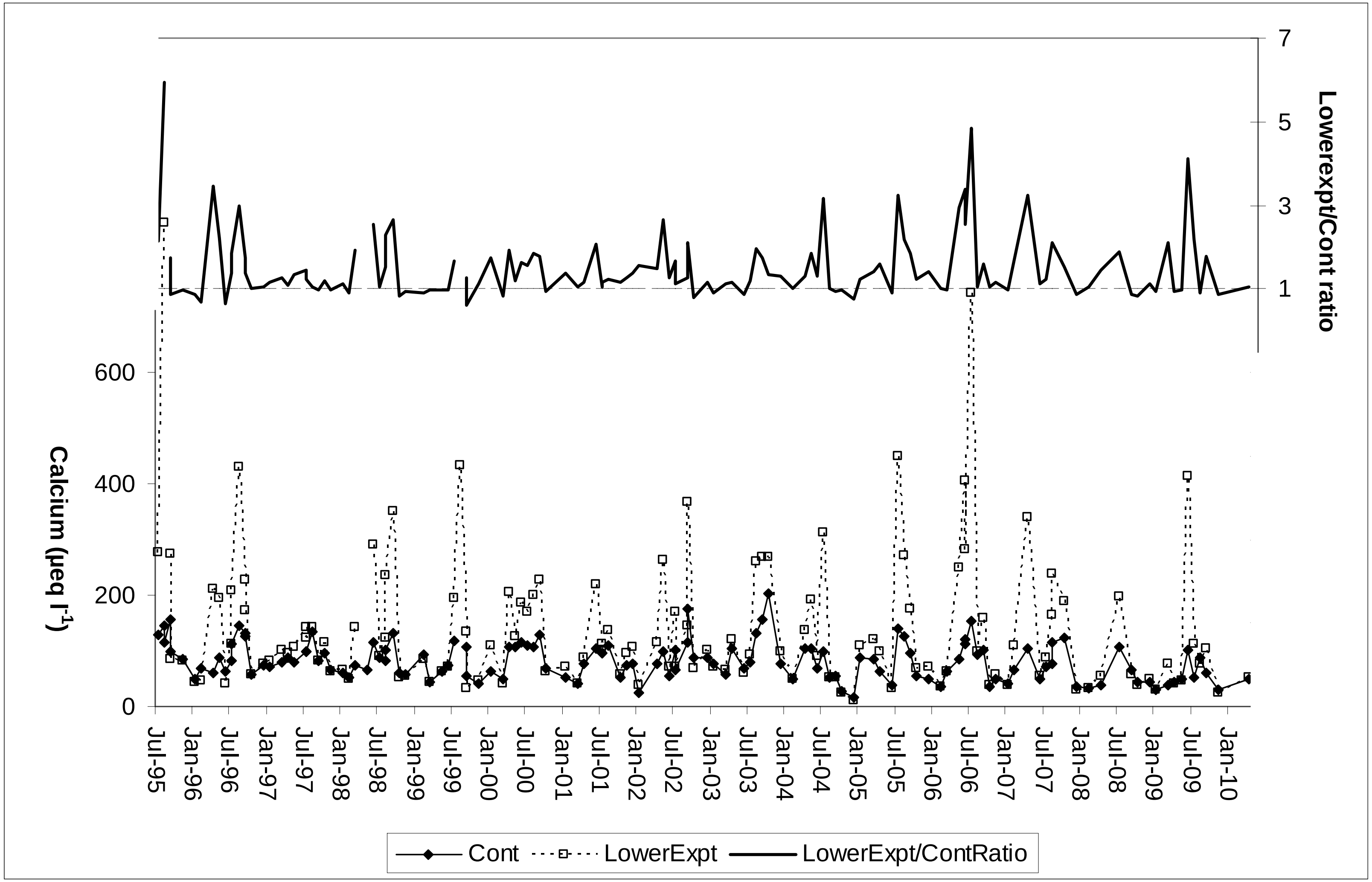


Figure 17 The ratio of magnesium and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.

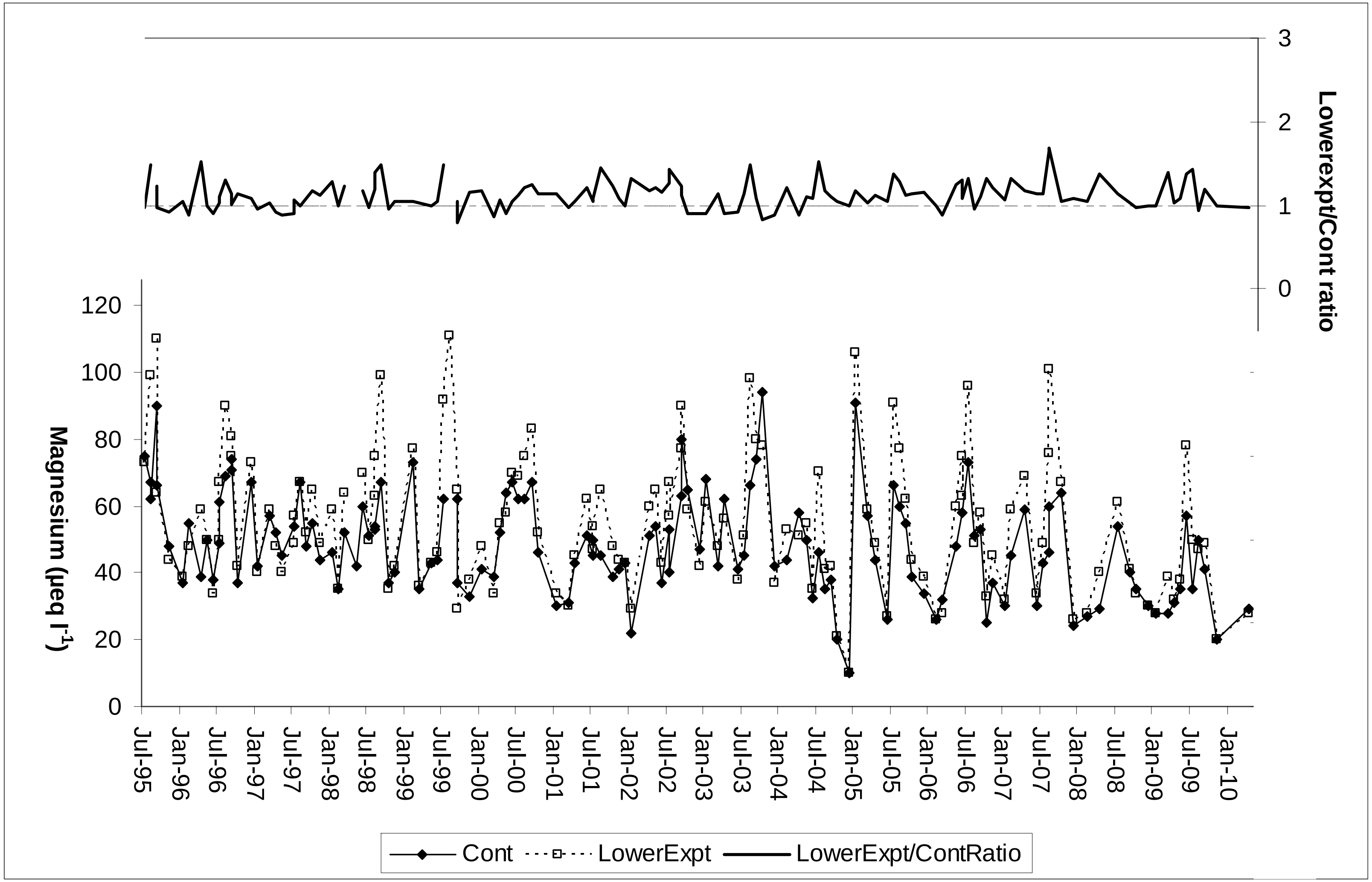


Figure 18 The ratio of potassium and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.

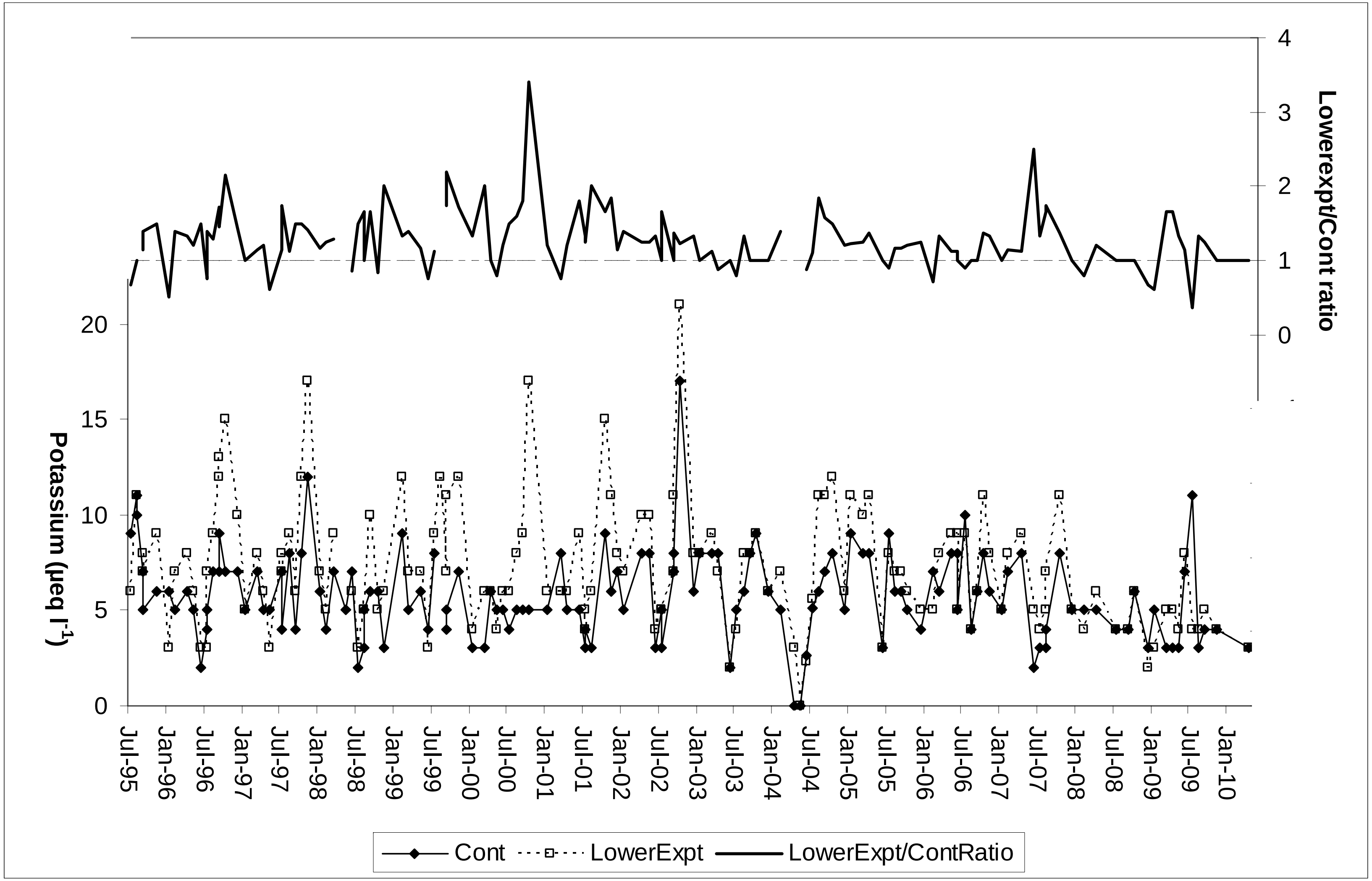


Figure 19 The ratio of conductivity and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.

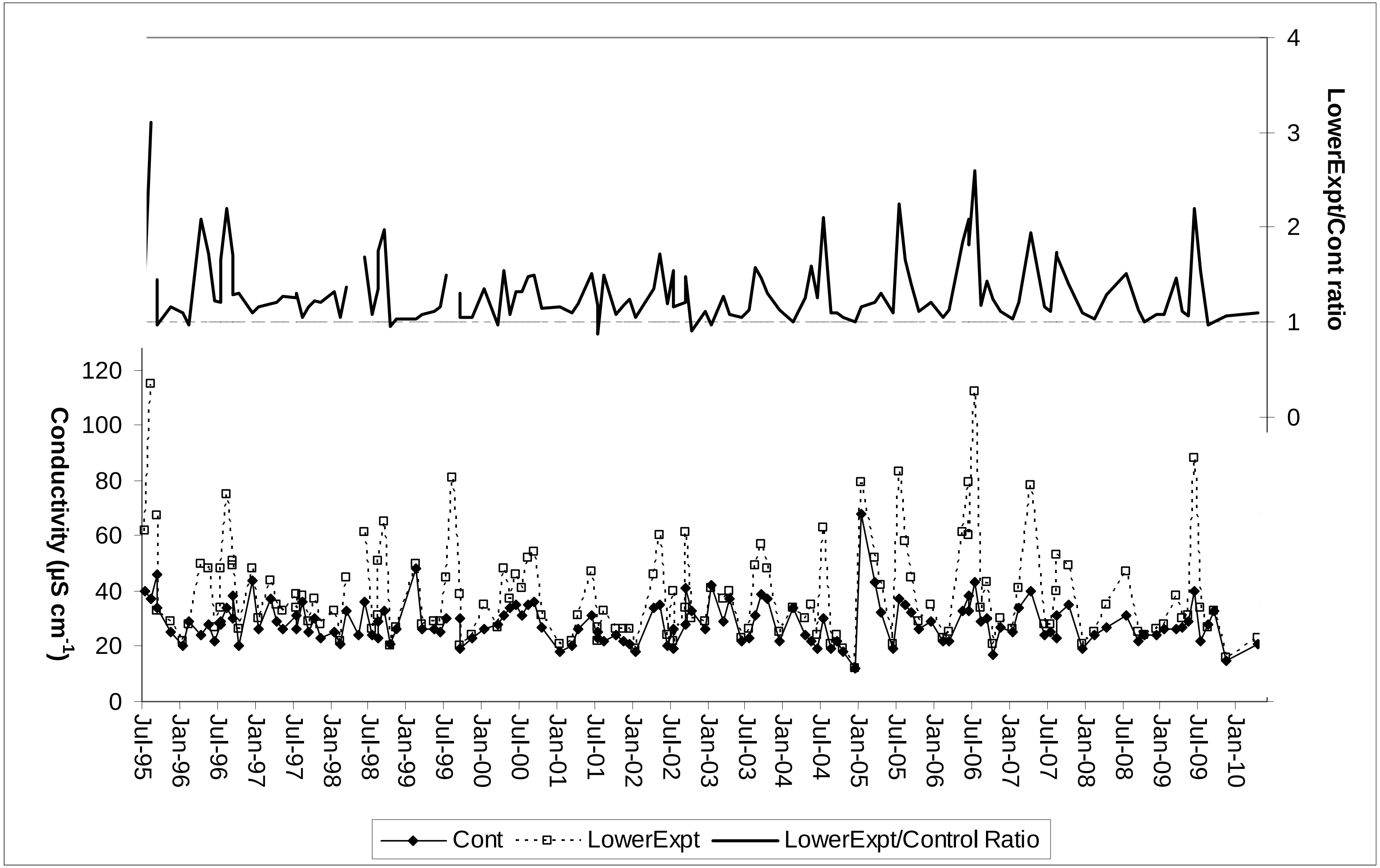


Figure 20 The ratio of chloride and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.

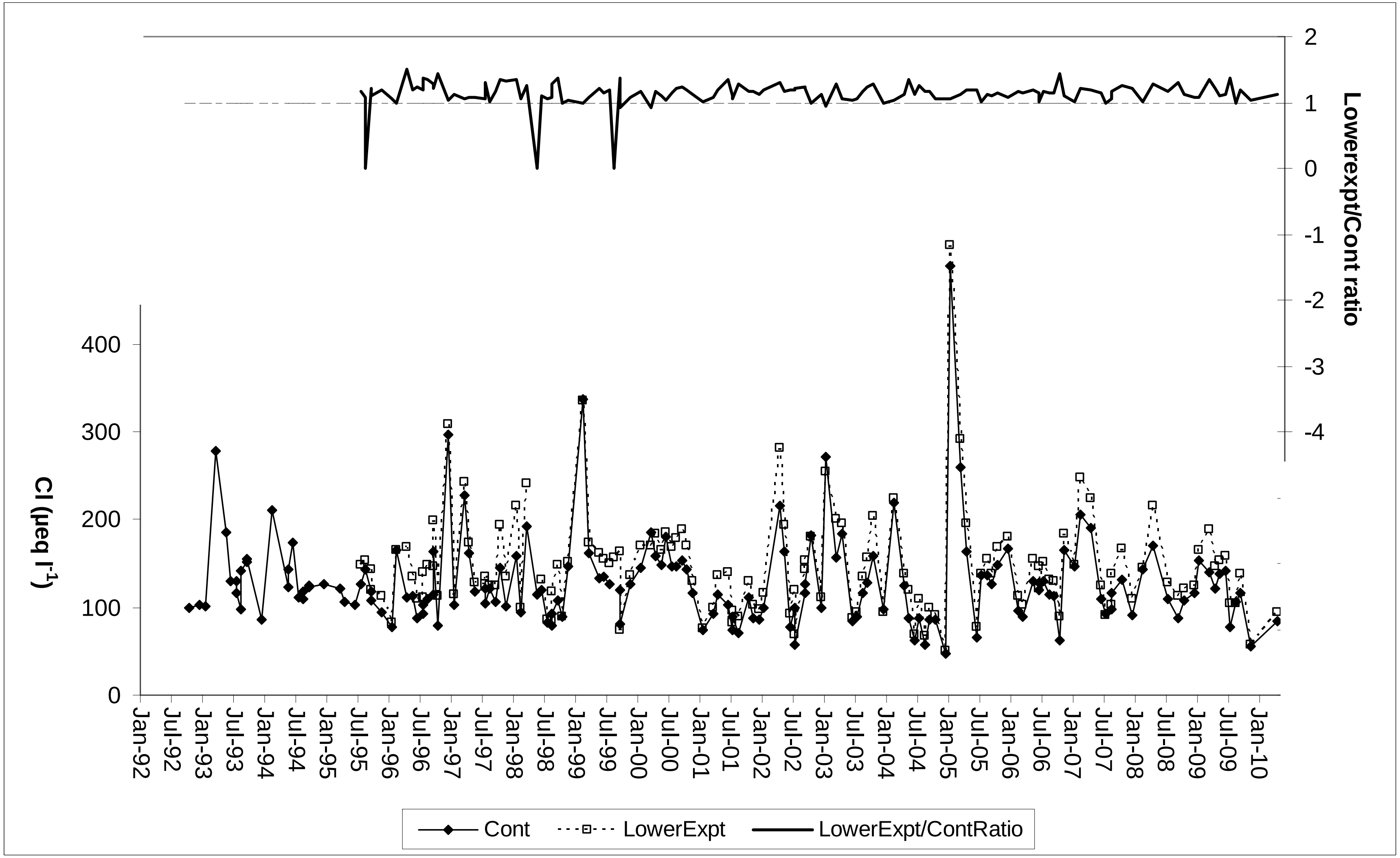
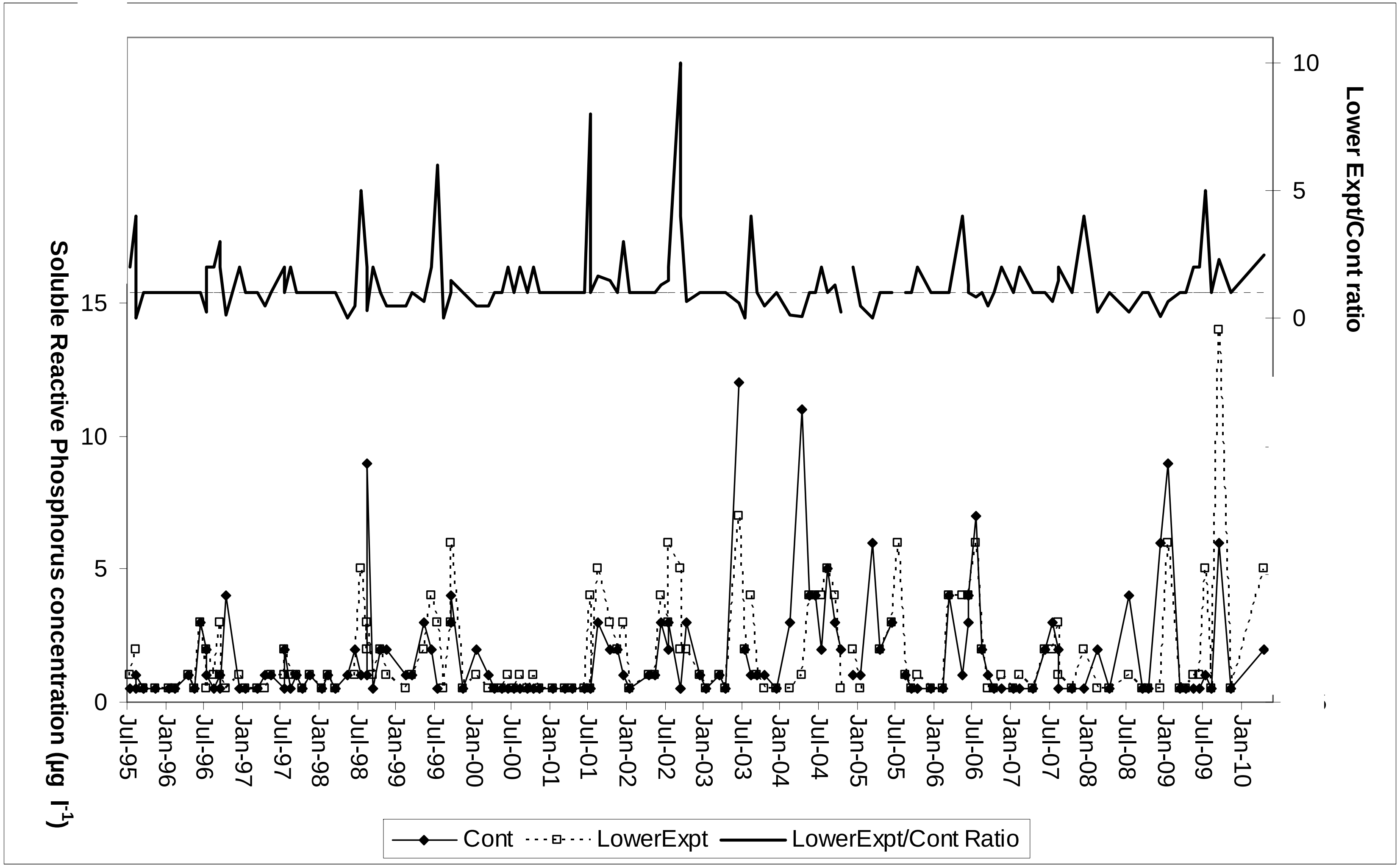
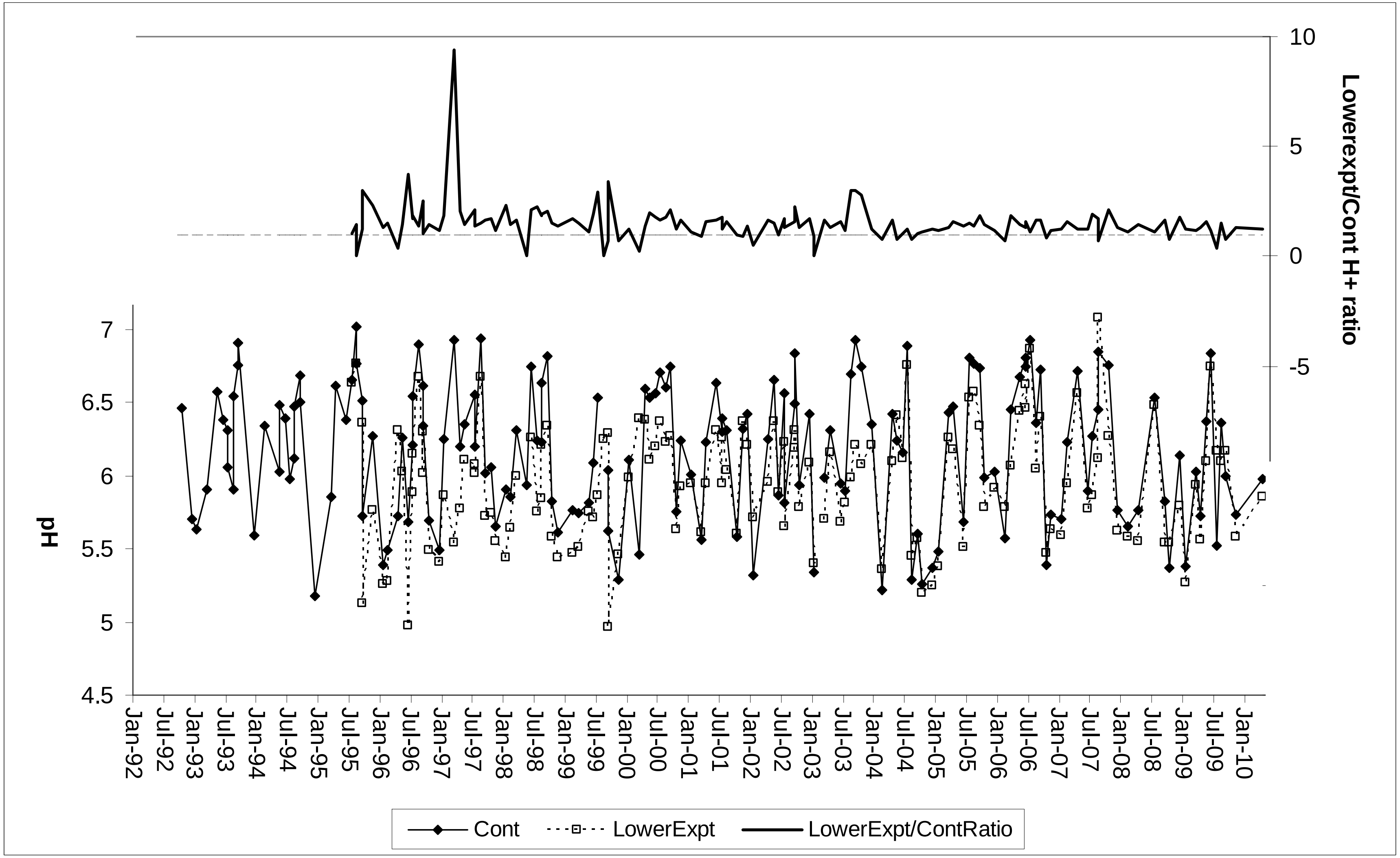


Figure 21 The ratio of soluble reactive phosphorus and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.



N.B. “0” values converted to half SRP detection limit for ratio calculations.

Figure 22 The ratio of H+ concentration and the temporal variability of pH in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.



- 59 -

Figure 23 The ratio of non-marine sulphate and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – April 2010.

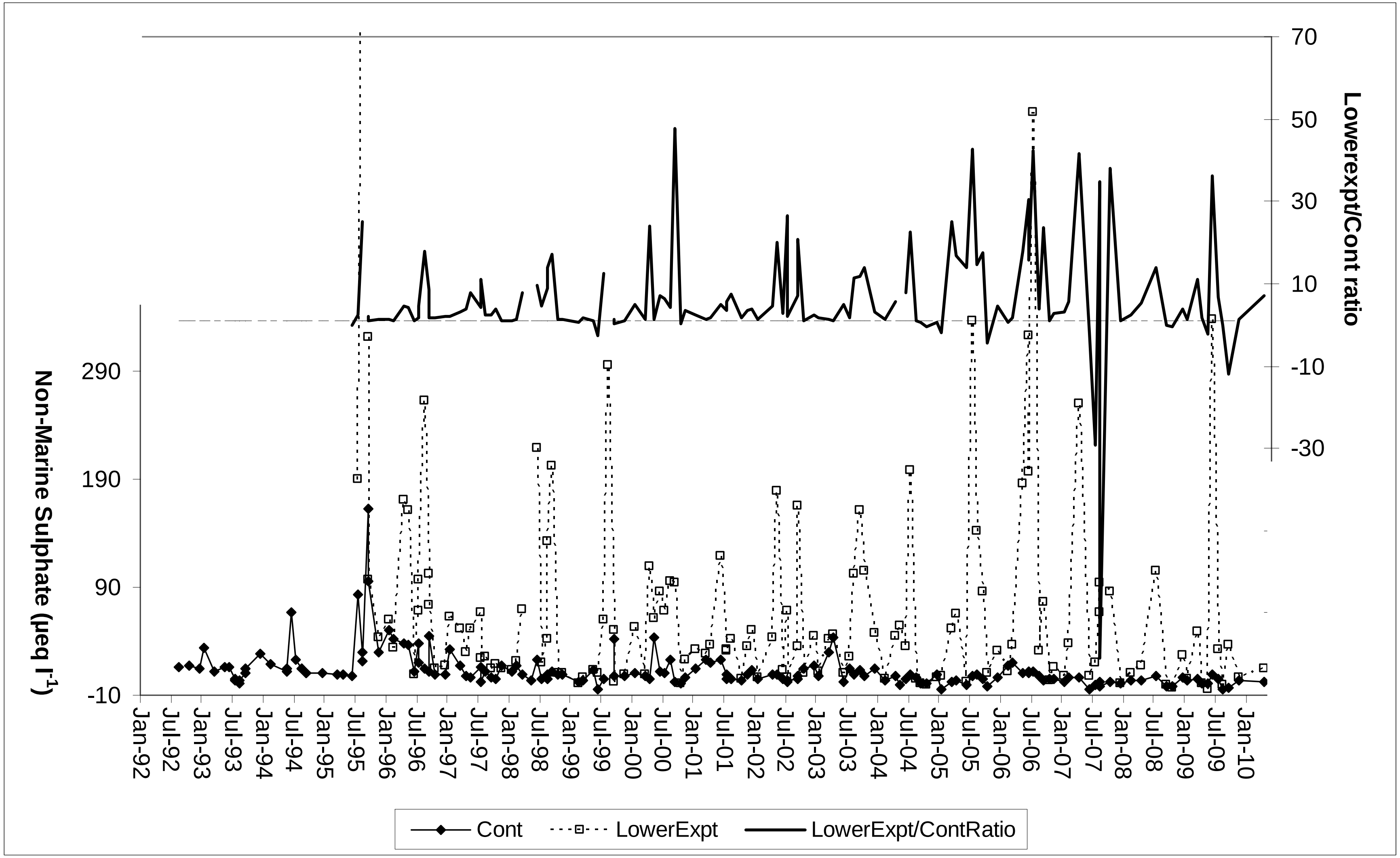


Figure 24 A comparison of alkalinity in spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – April 2010.

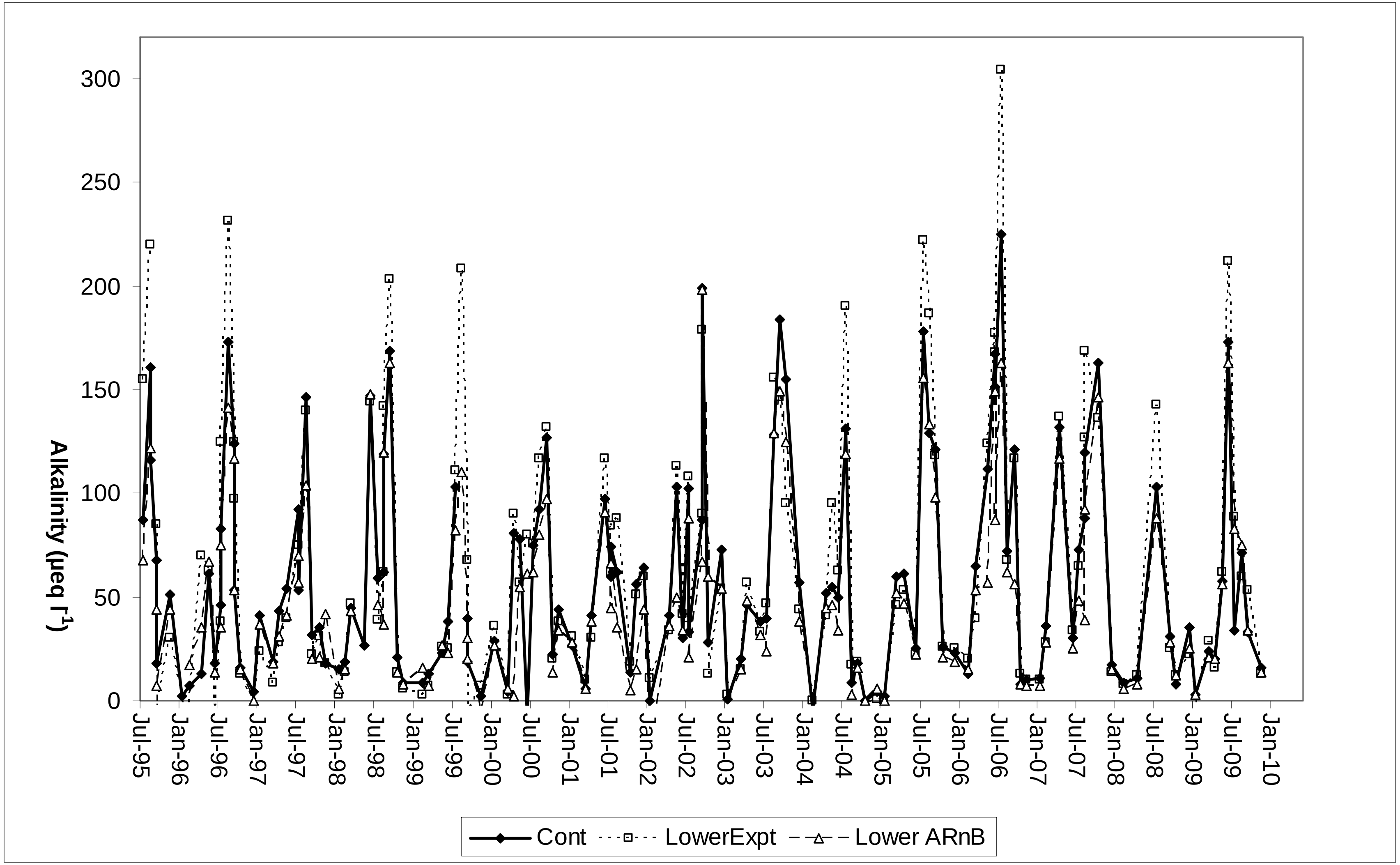


Figure 25 A comparison of conductivity of spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – April 2010.

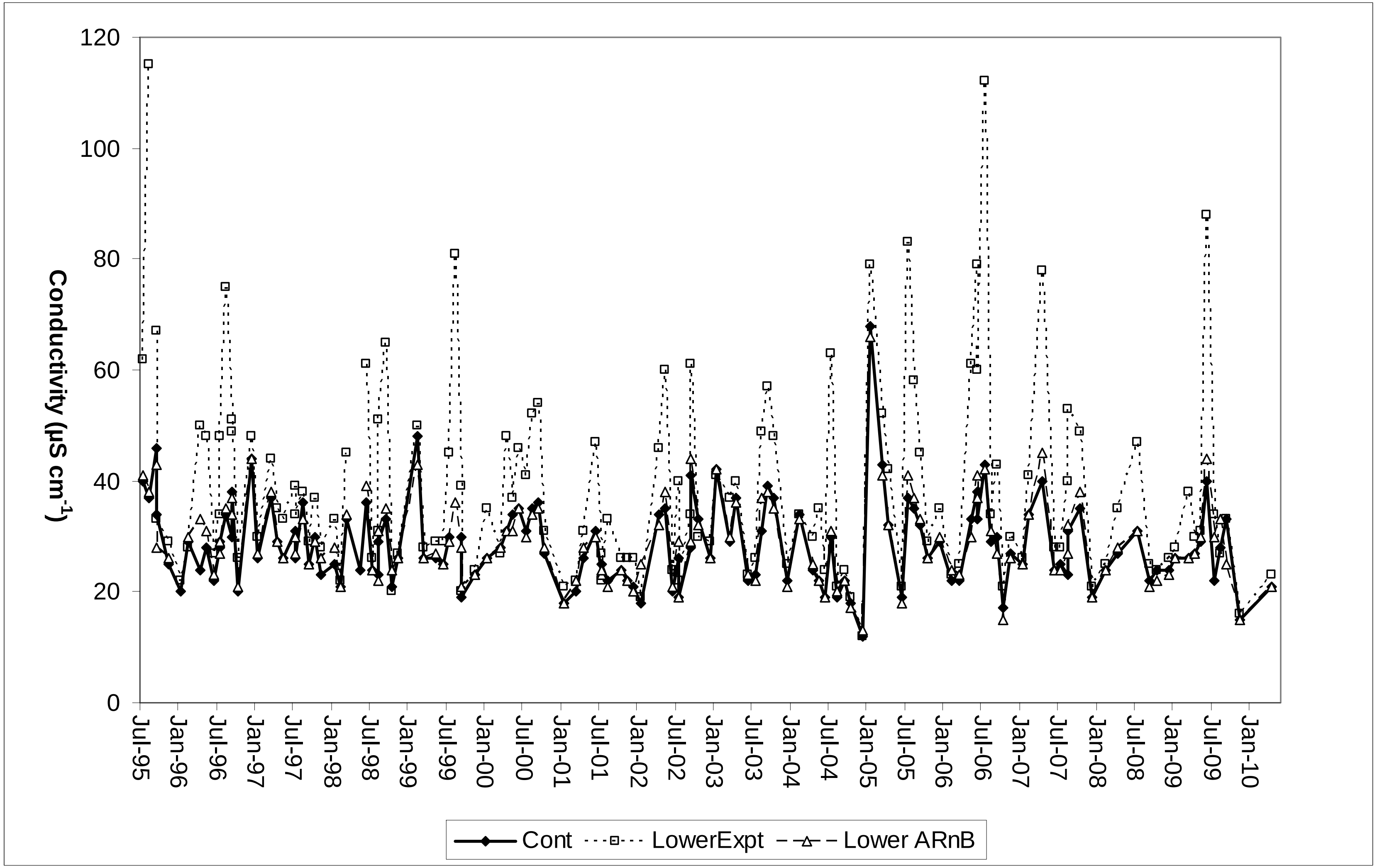


Figure 26 A comparison of nitrate concentrations of spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – April 2010.

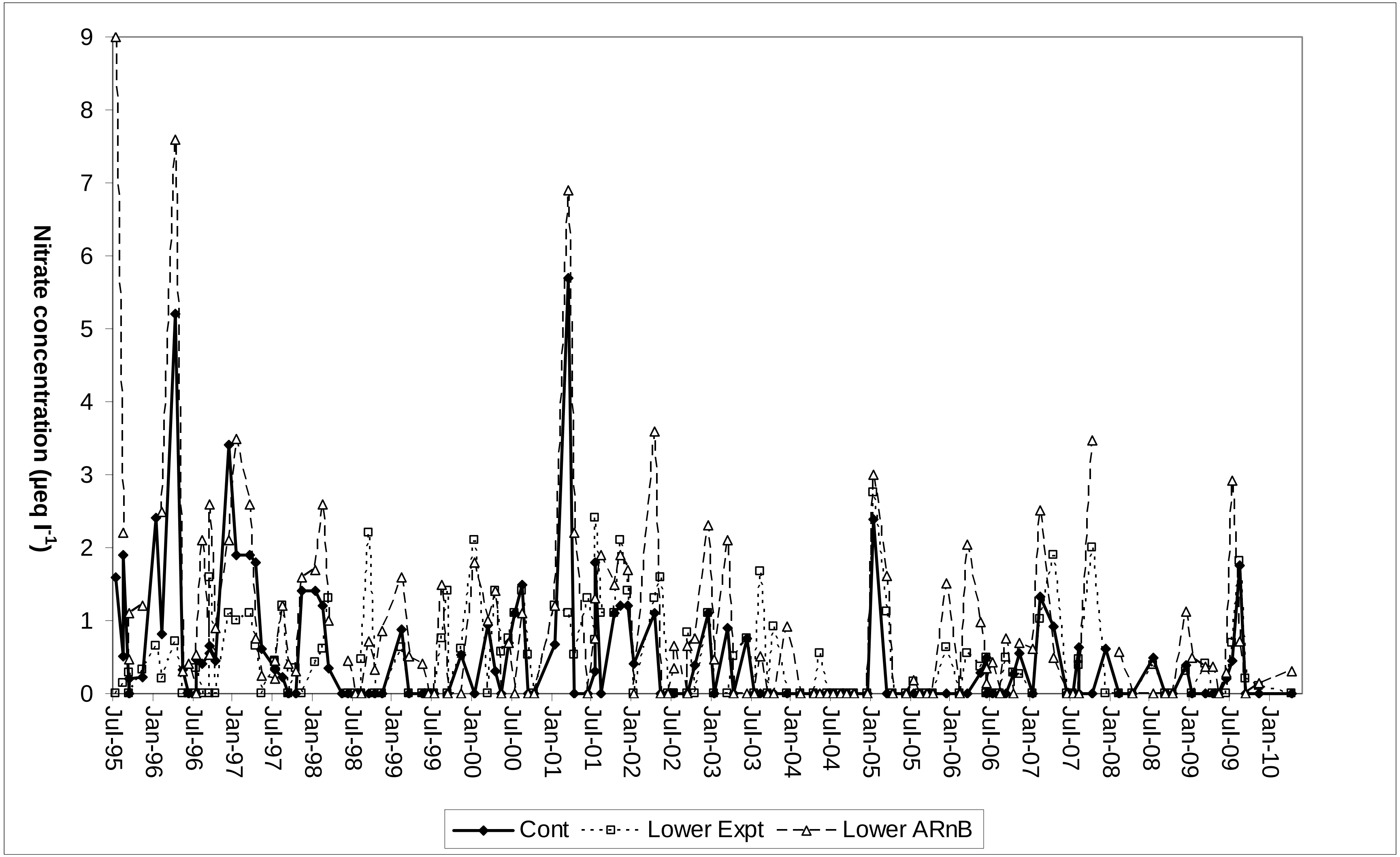


Figure 27 A comparison of soluble reactive phosphorus concentrations of spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – April 2010.

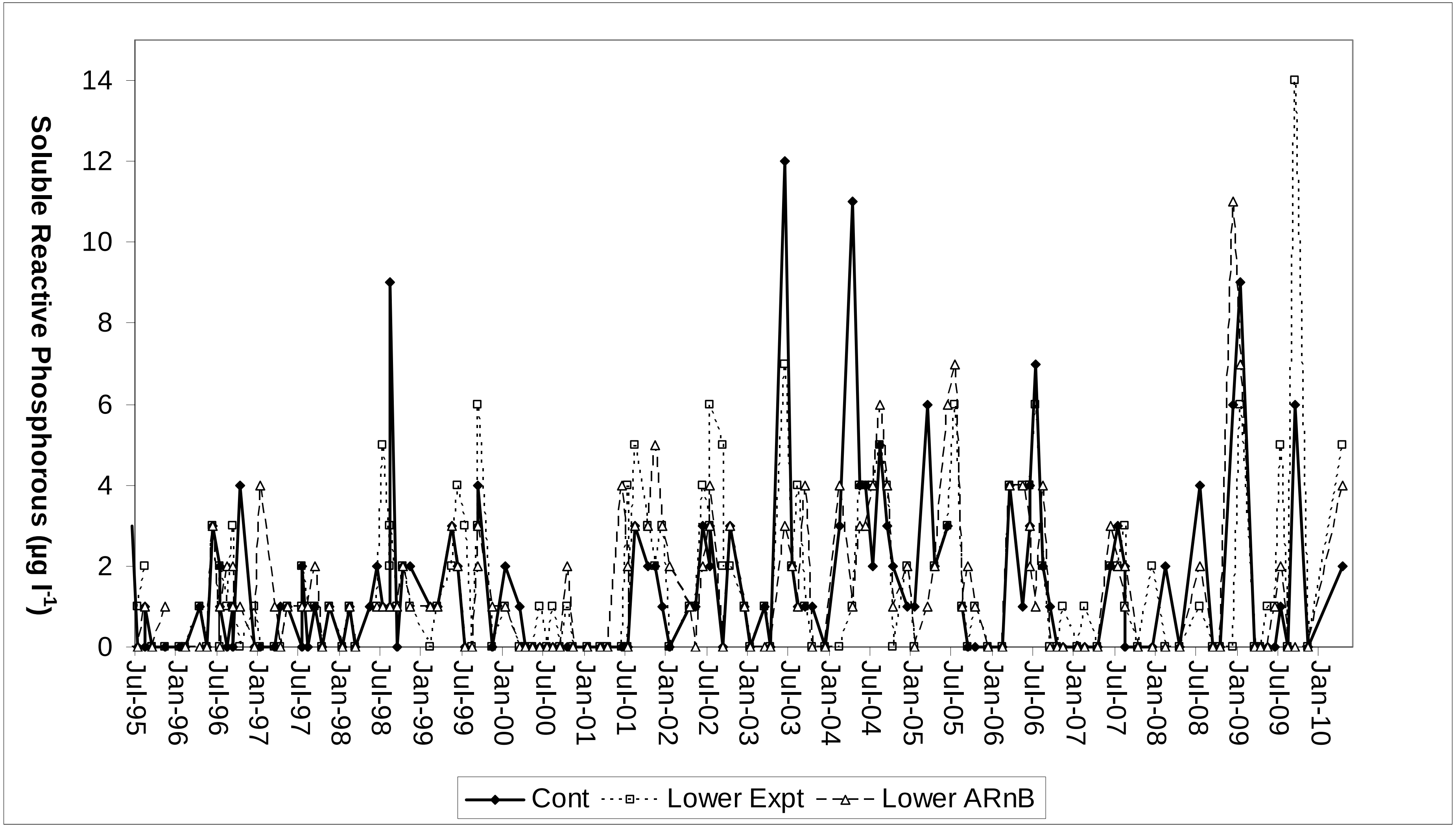


Figure 28 A comparison of total organic carbon concentrations of spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – April 2010.

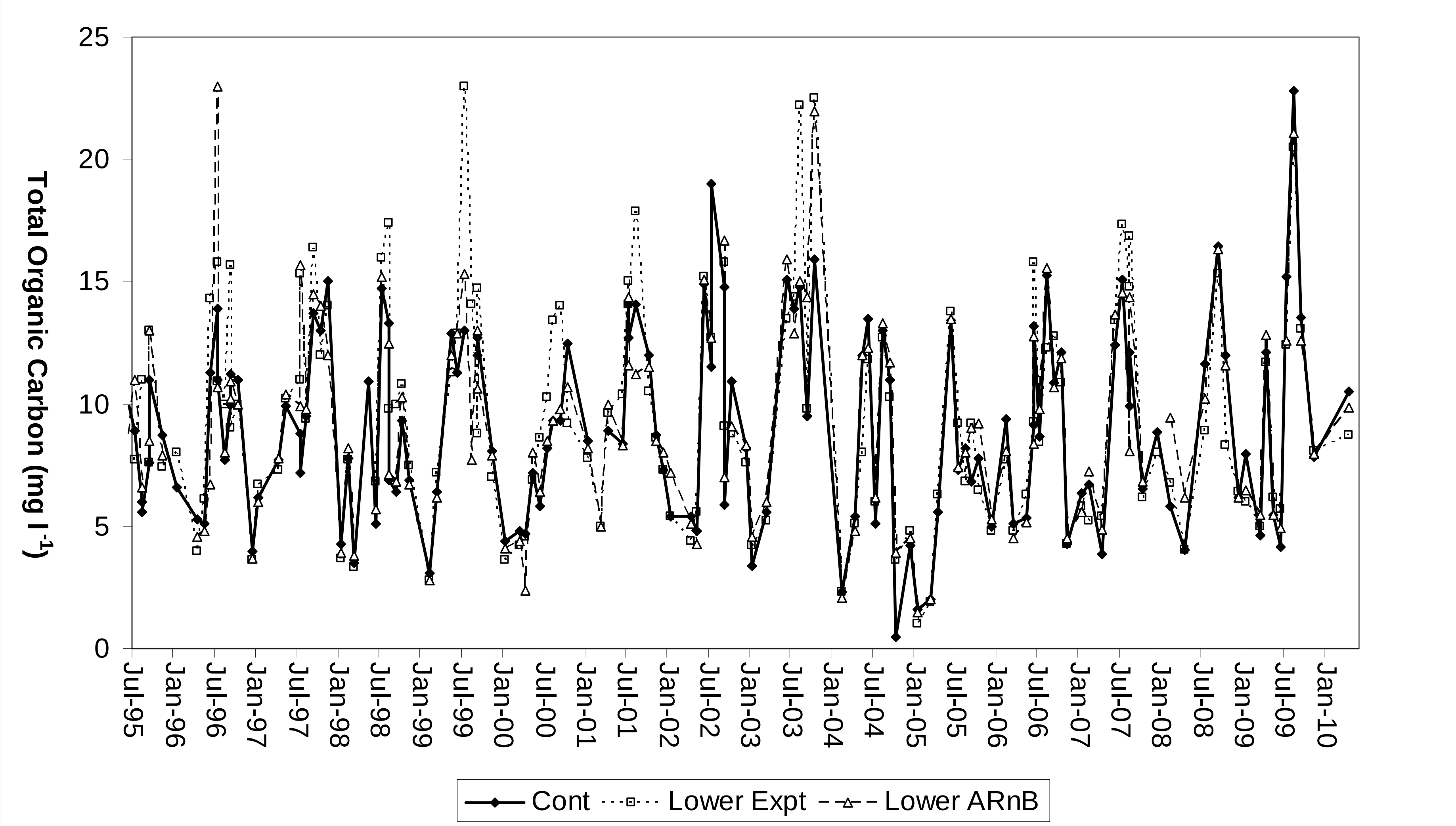


Figure 29 The ratio of alkalinity and its temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

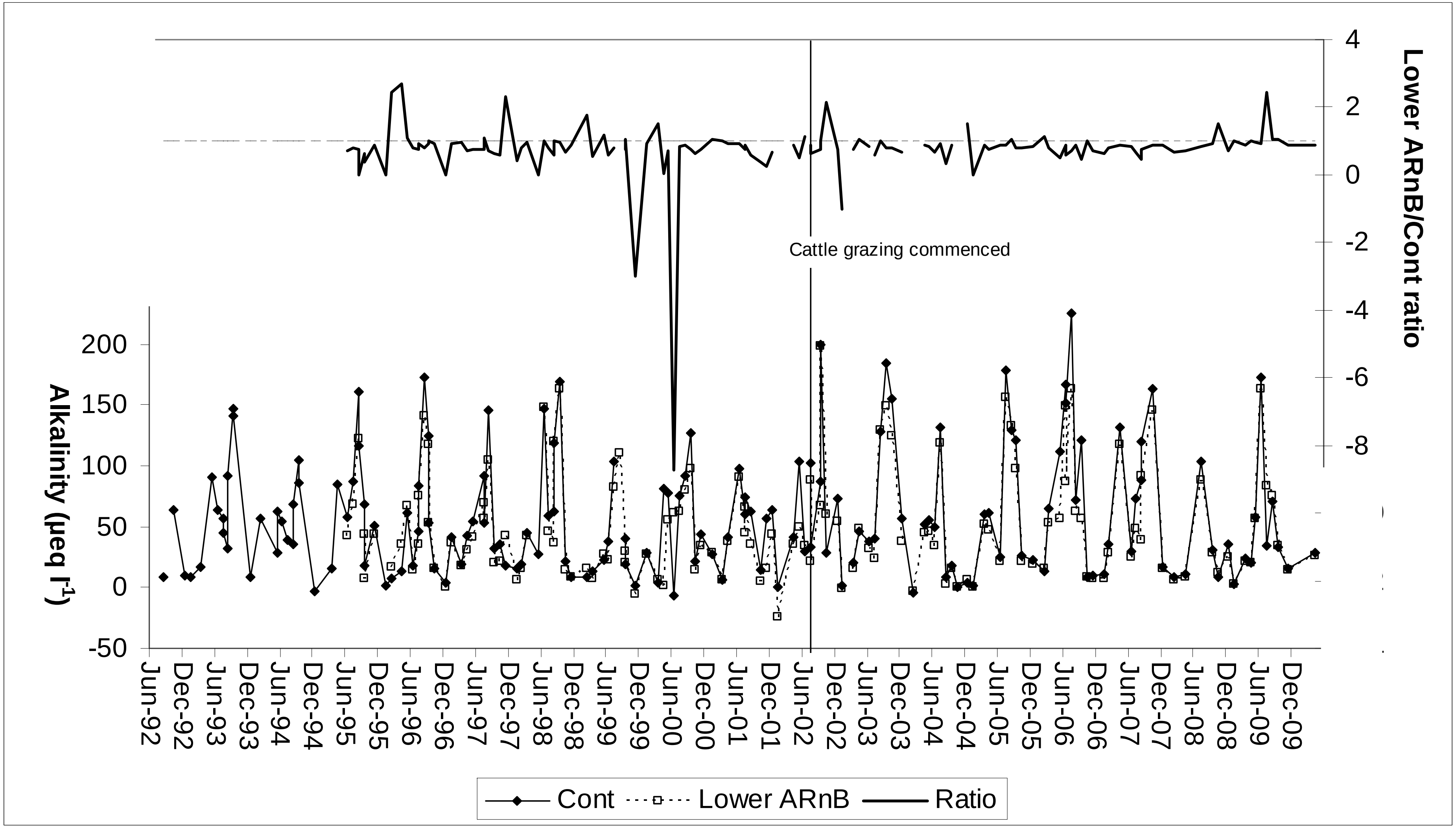


Figure 30 The ratio of conductivity and its temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

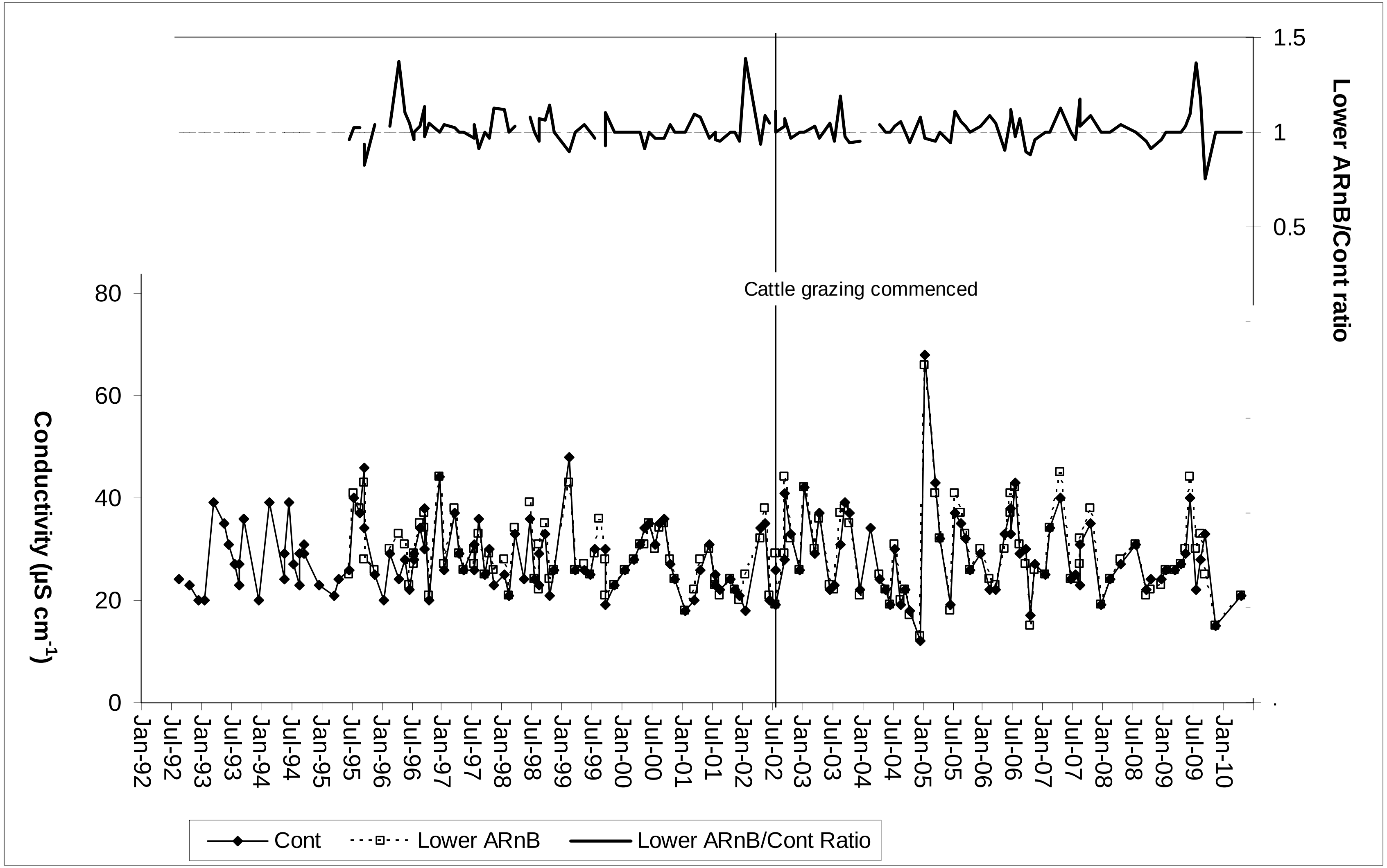


Figure 31 The ratio of chloride and its temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

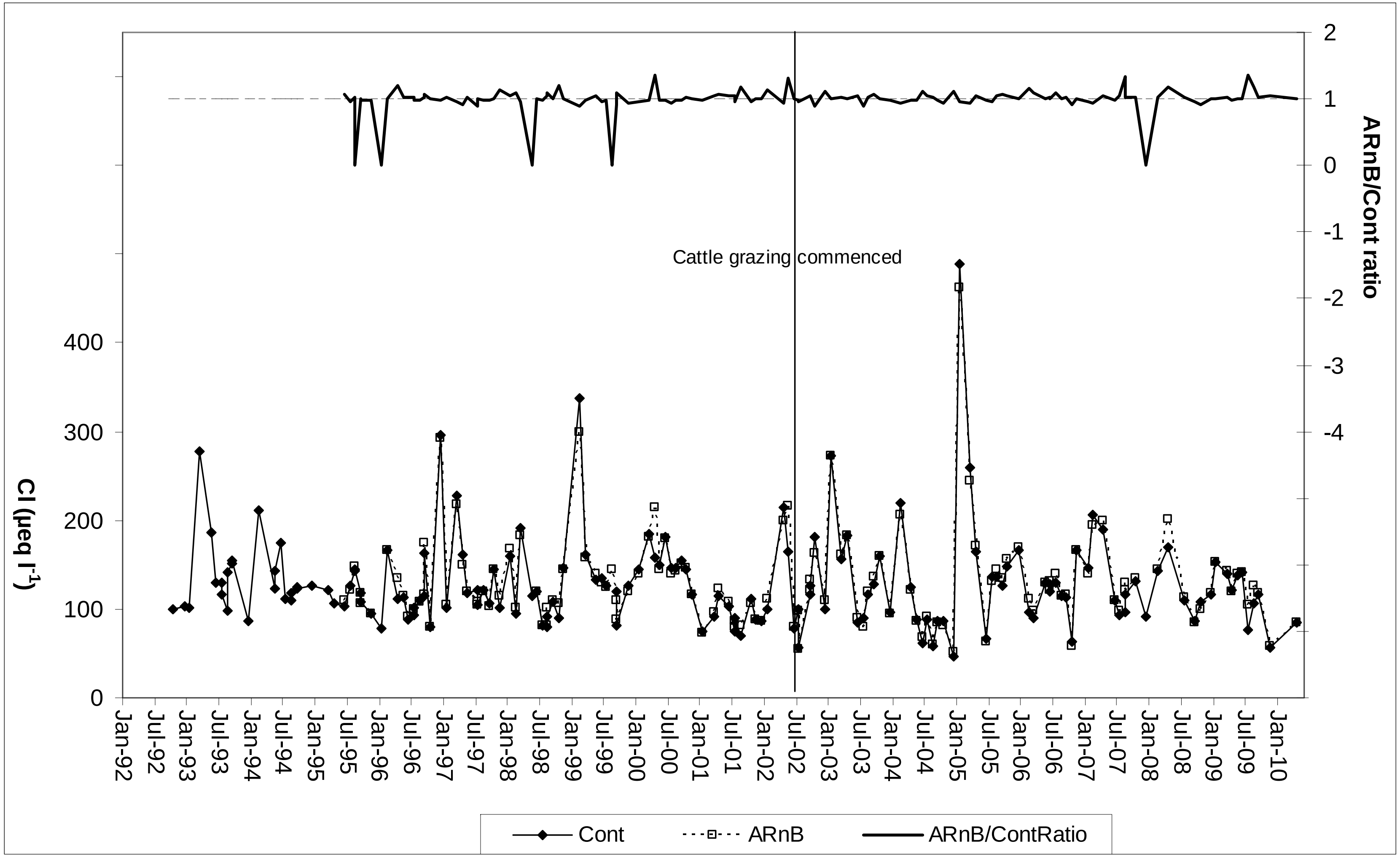


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Figure 32 The ratio of calcium and its temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

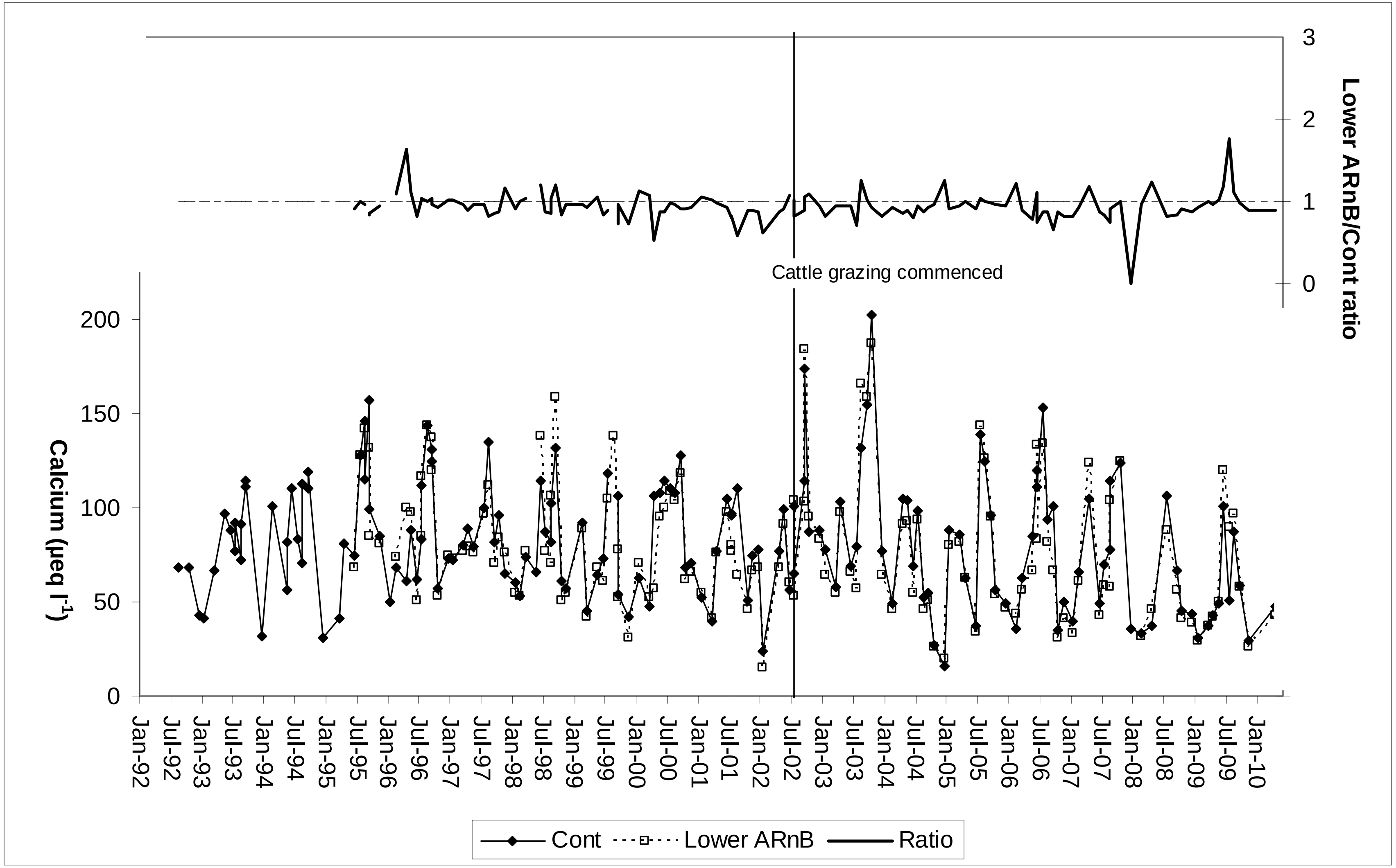


Figure 33 The ratio of magnesium and its temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

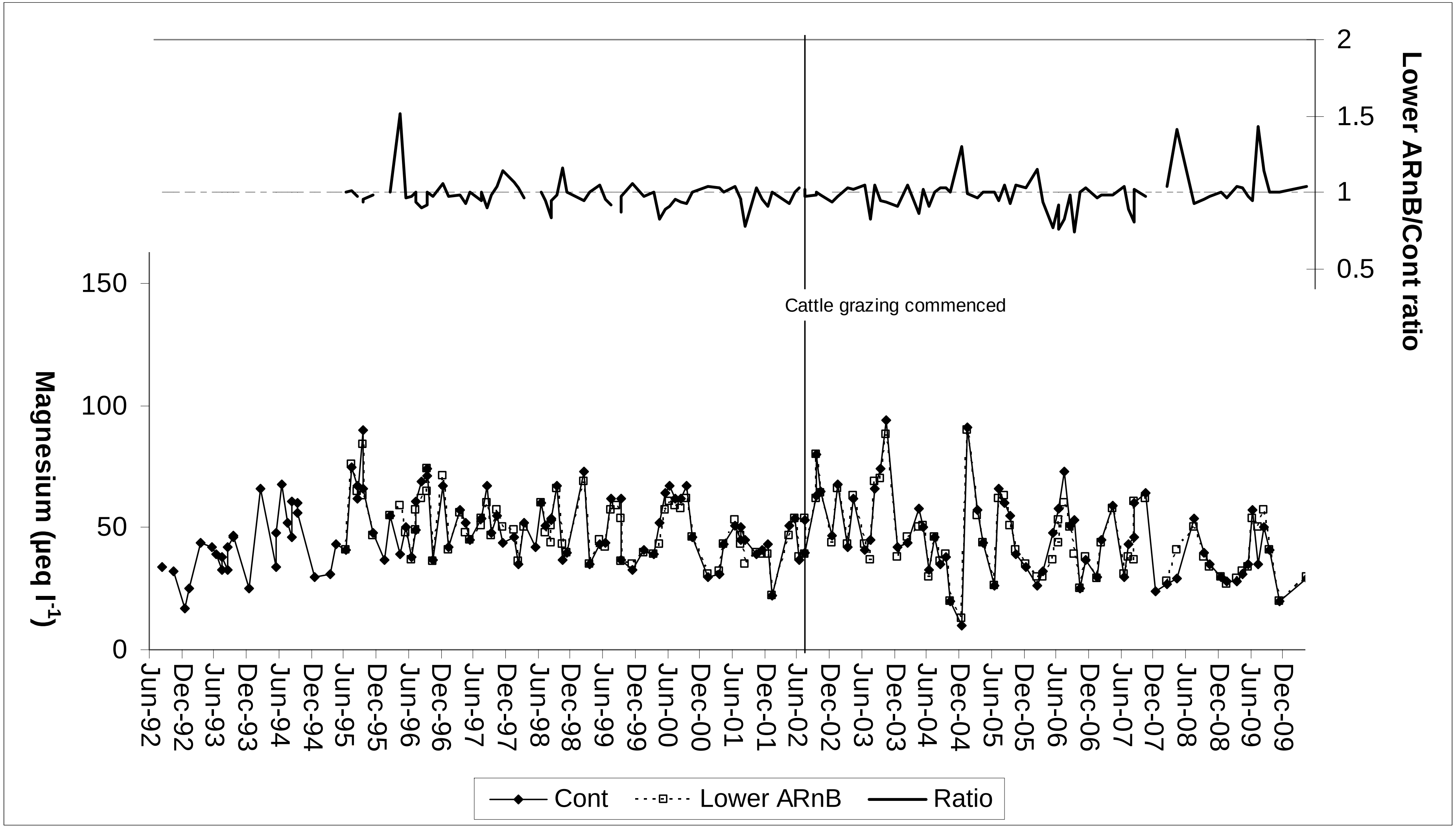


Figure 34 The ratio of potassium and its temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

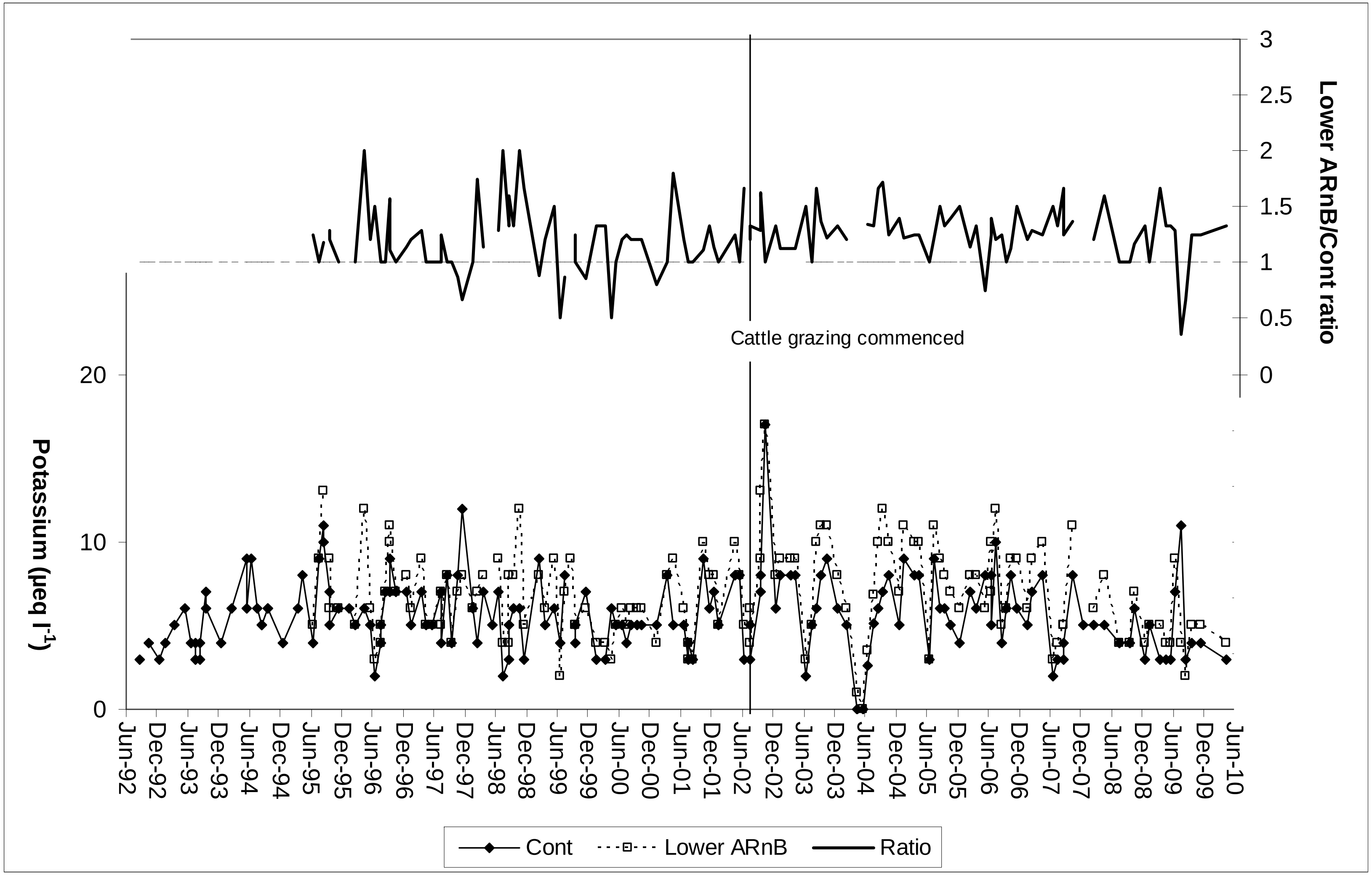
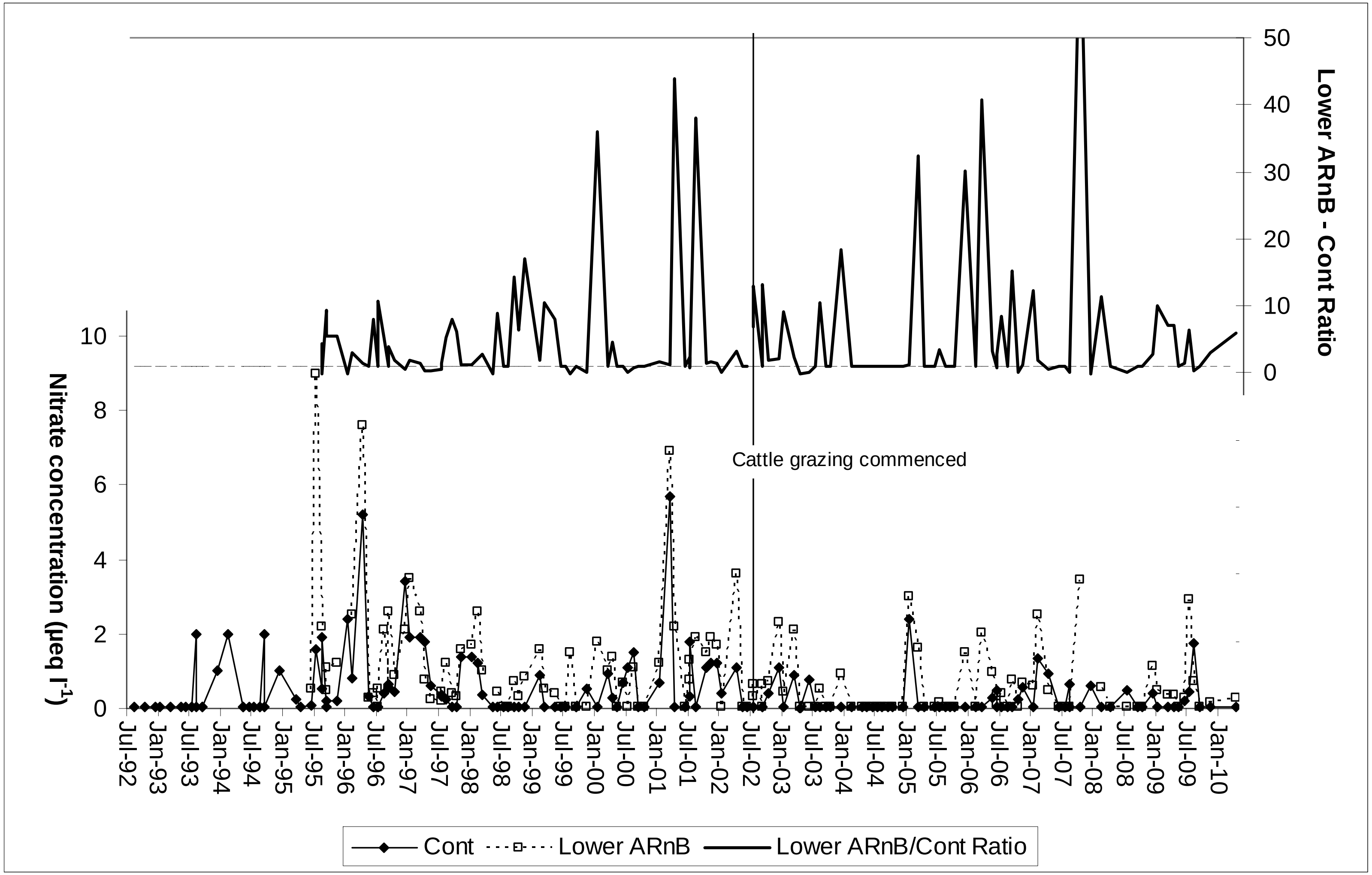


Figure 35 The ratio of nitrate and its temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.



N.B. 0 values converted to half nitrate detection limit for ratio calculations.

Figure 36 The temporal variability of nitrate in spot samples and the difference between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

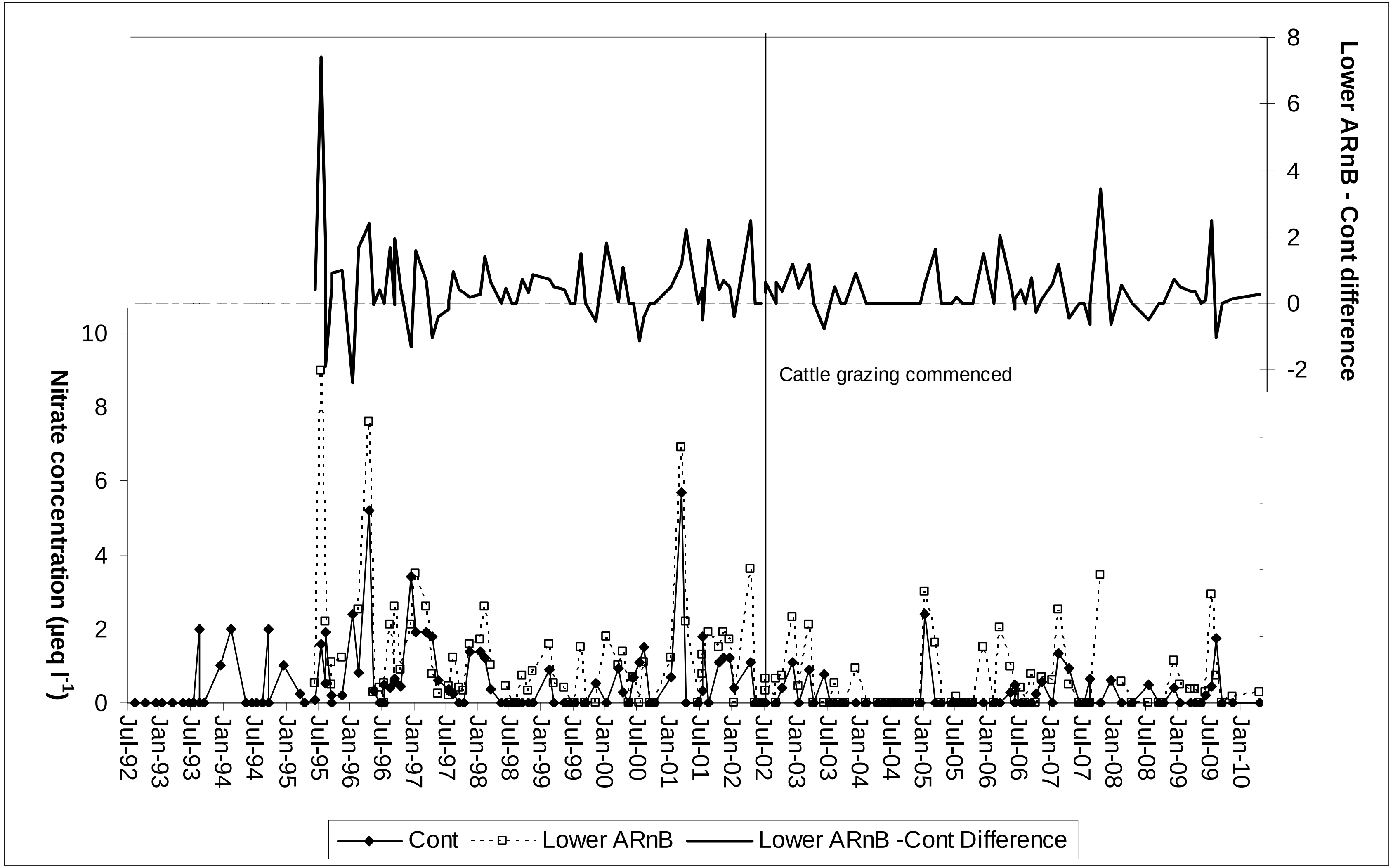
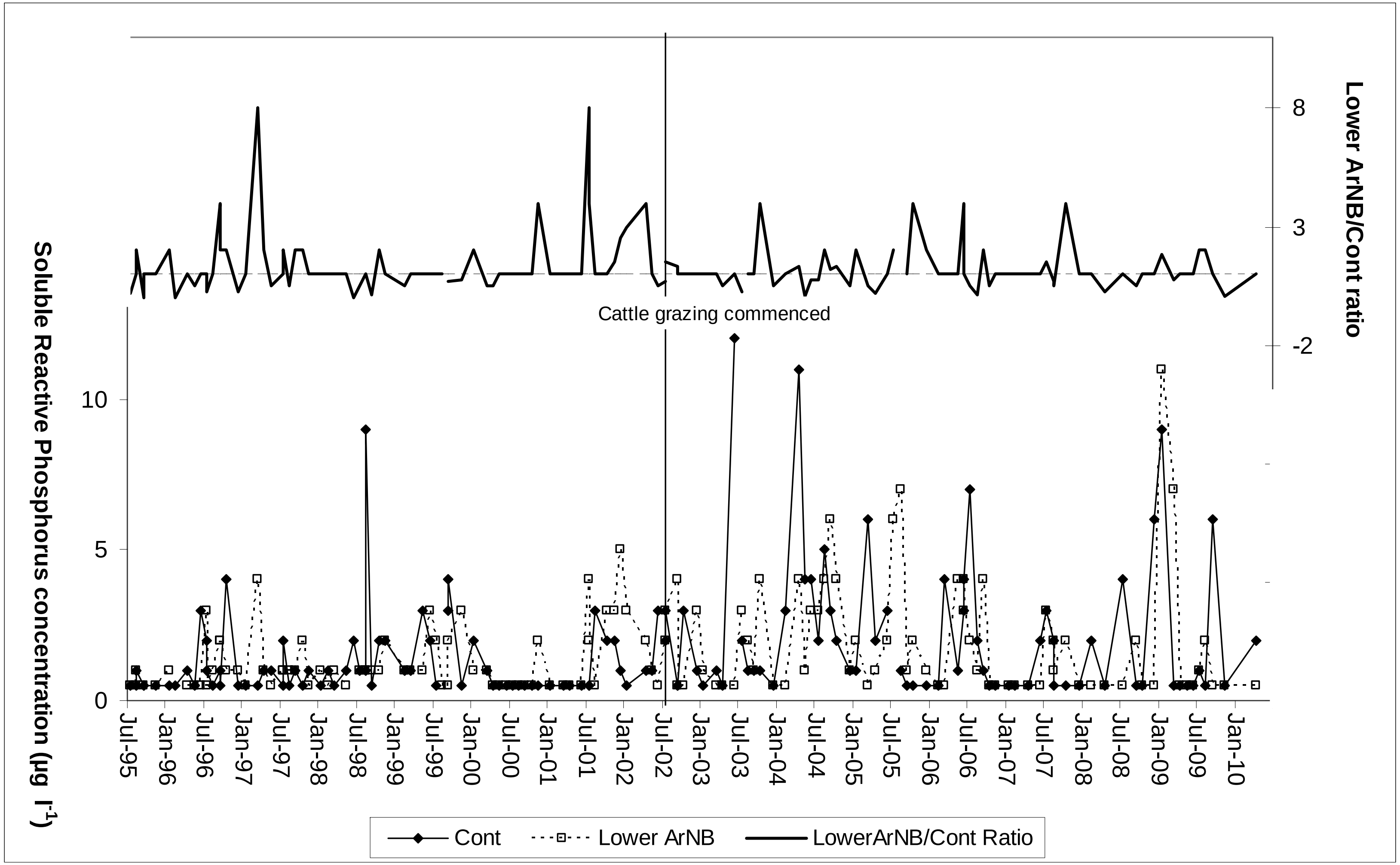


Figure 37 The ratio of soluble reactive phosphorus and its temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.



N.B. 0 values converted to half nitrate detection limit for ratio calculations.

Figure 38 The ratio of H+ concentration and the temporal variability of pH in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

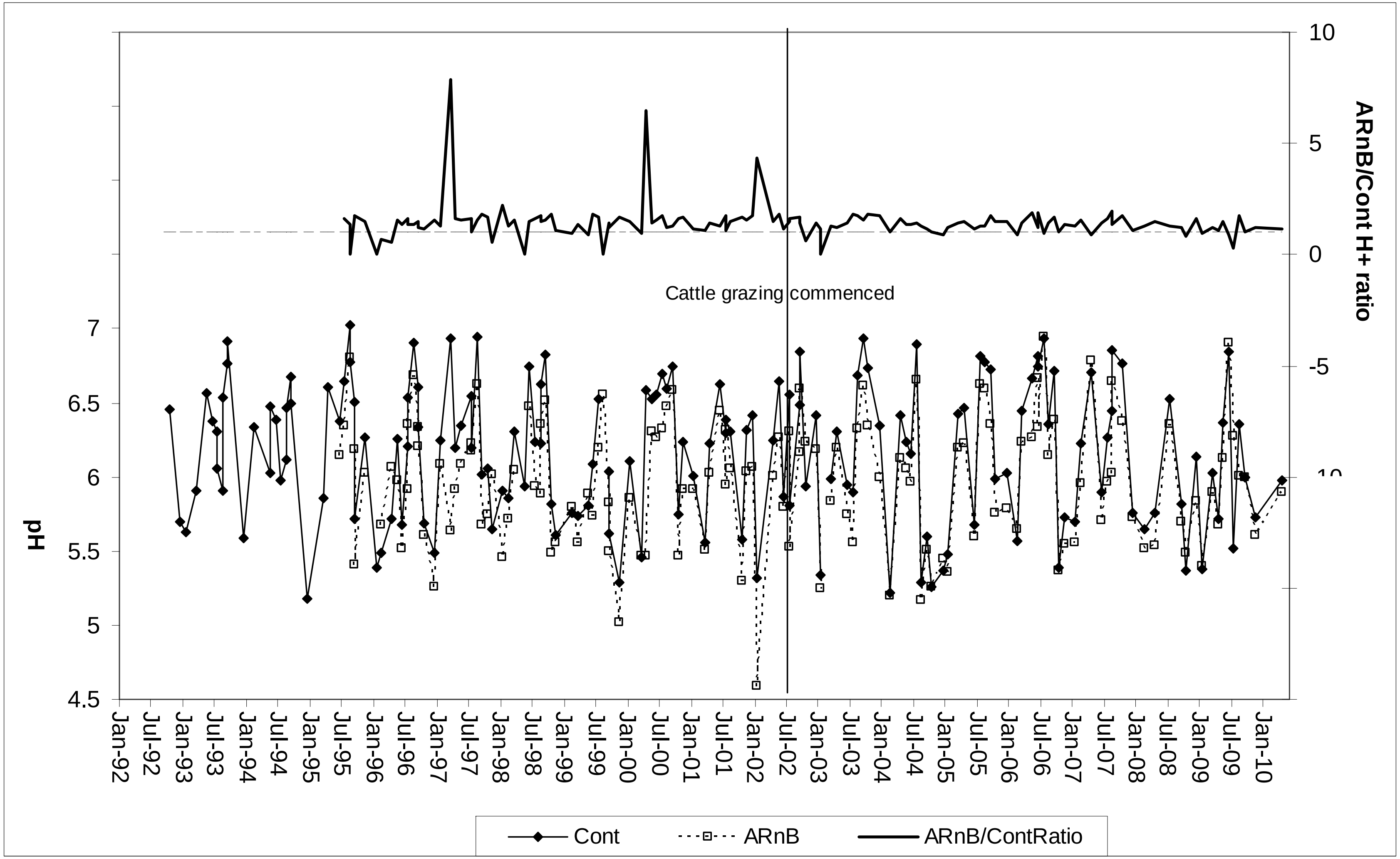


Figure 39 The ratio of non-marine sulphate and its temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

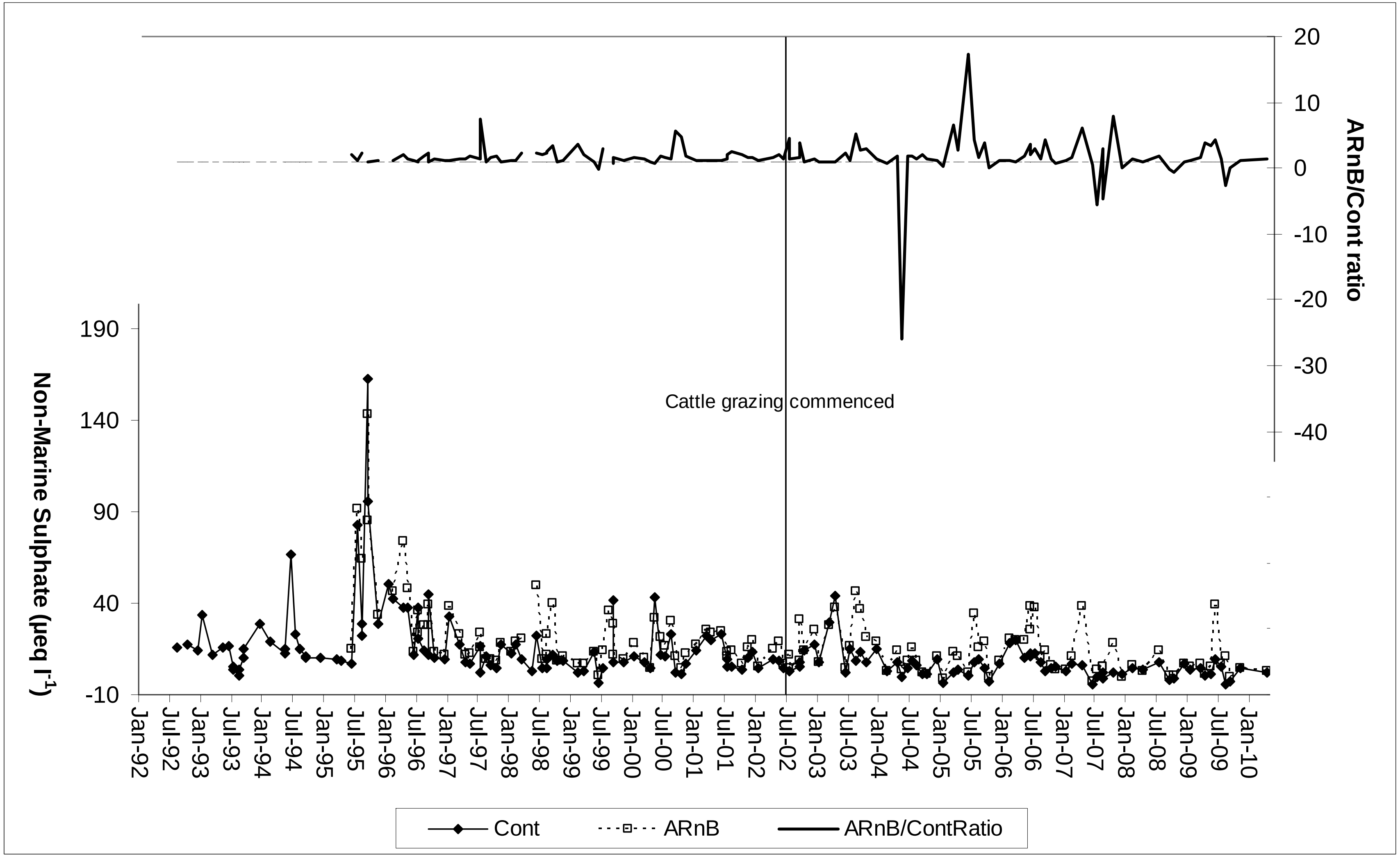


Figure 40 The ratio of labile aluminium and the temporal variability in spot samples between the Control and Allt Riabhach na Bioraich (Lower site) June 1995 – April 2010.

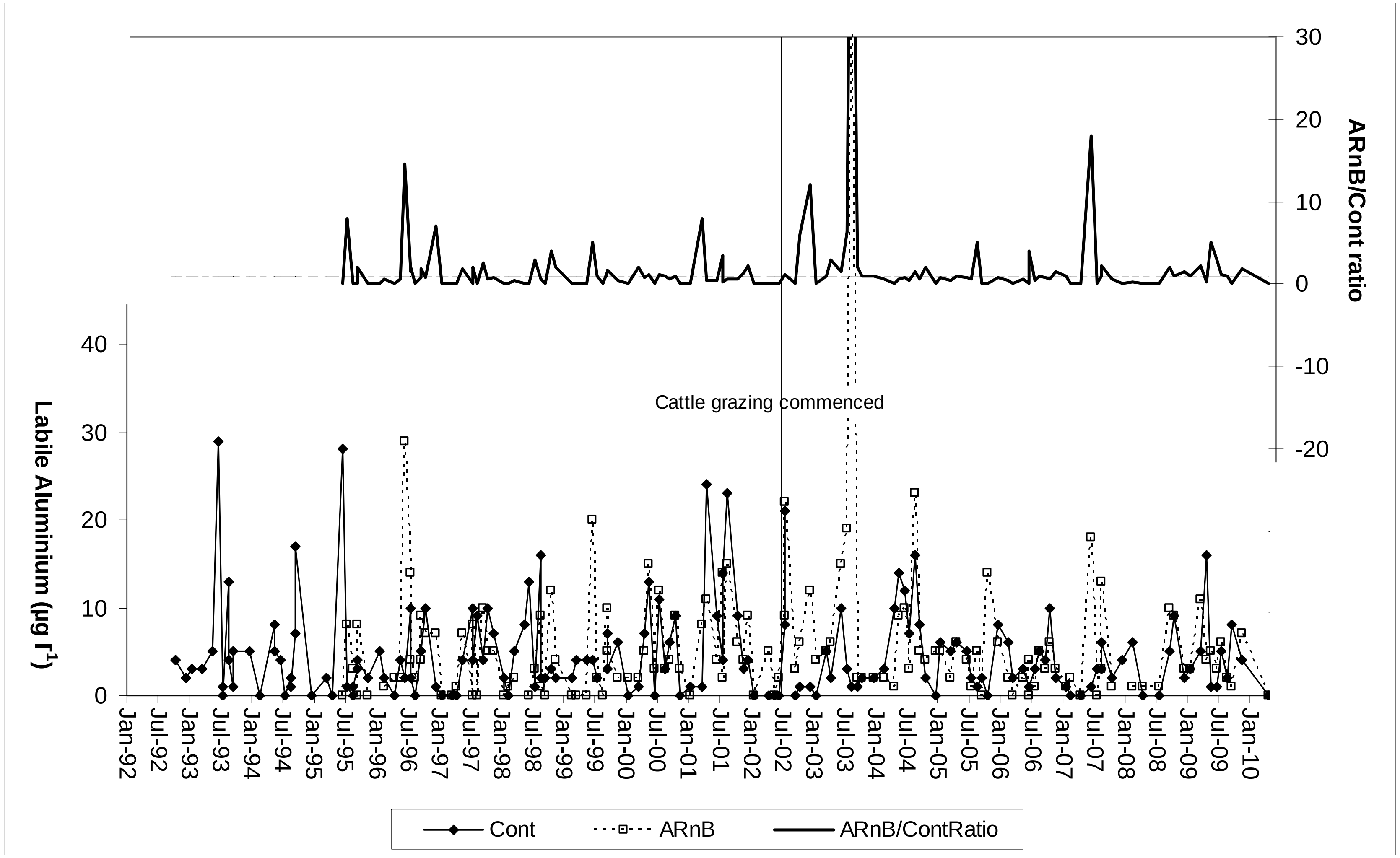


Figure 41 Control Stream Average Daily Temperature (^{0}C) November 2007 – August 2010

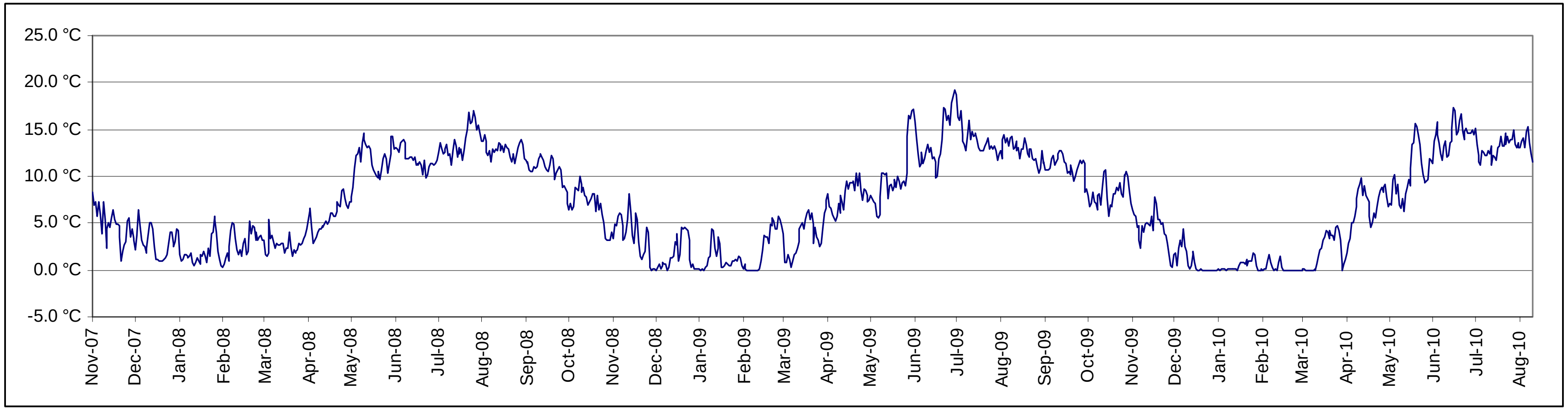


Figure 42 Control Stream Average Daily Height (mm) November 2007 – August 2010

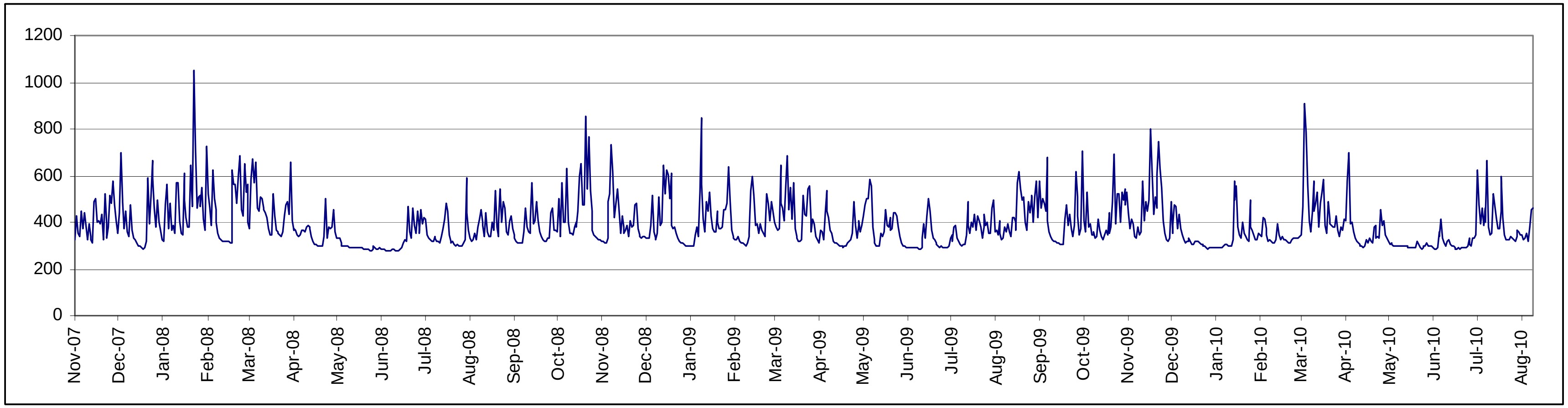


Figure 43 Allt Riabhach na Bioraich Stream Average Daily Temperature (^{0}C) November 2007 – August 2010

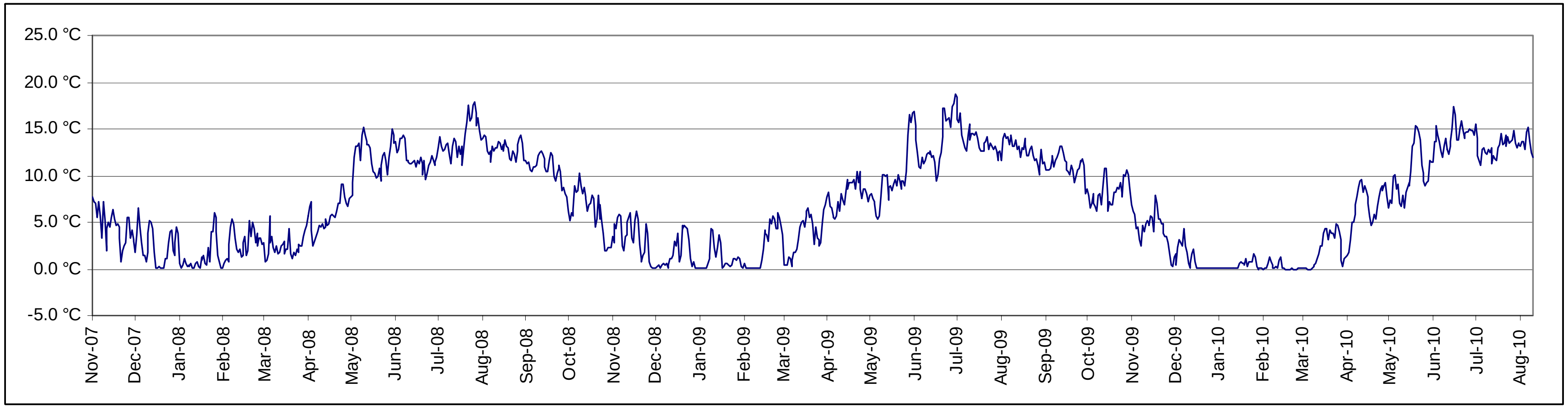


Figure 44 Allt Riabhach na Bioraich Stream Average Daily Height (mm) November 2007 – August 2010

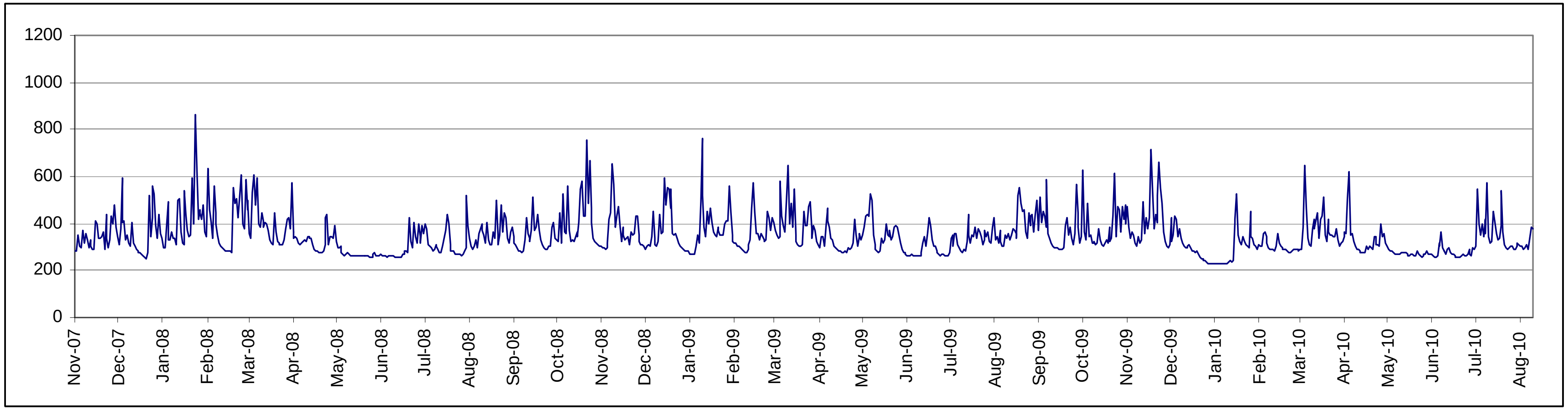
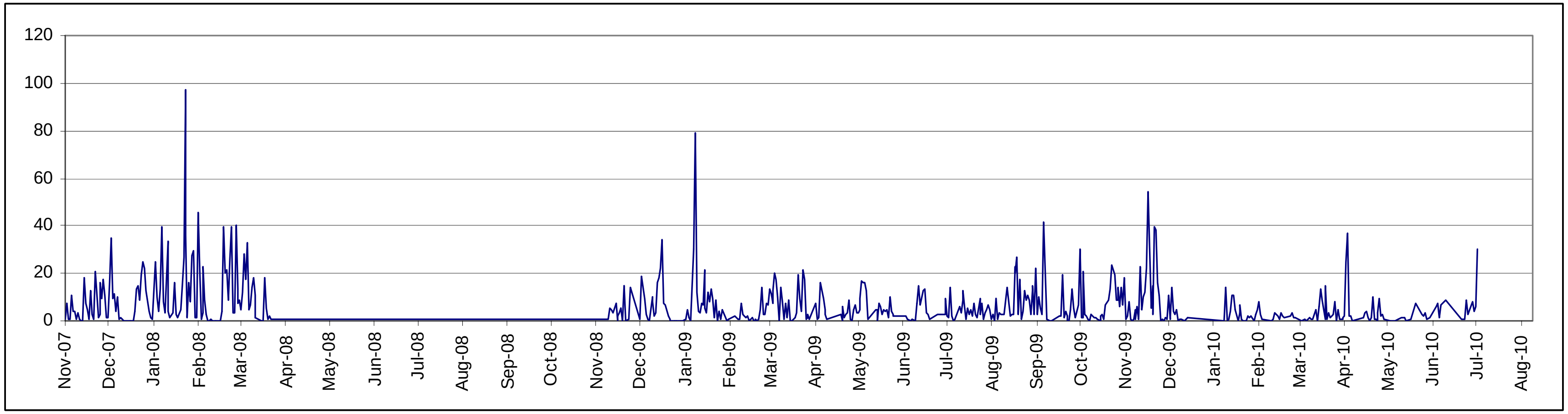


Figure 45 Laidon Experimental Area Daily Rainfall Totals (mm) November 2007 – August 2010


120
100
80
60
40
20
0
Nov-07
Dec-07
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Nov-08
Dec-08
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May-09
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Aug-09
Sep-09
Oct-09
Nov-09
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Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10

Figure 46 Control Burn diatom percentage abundances

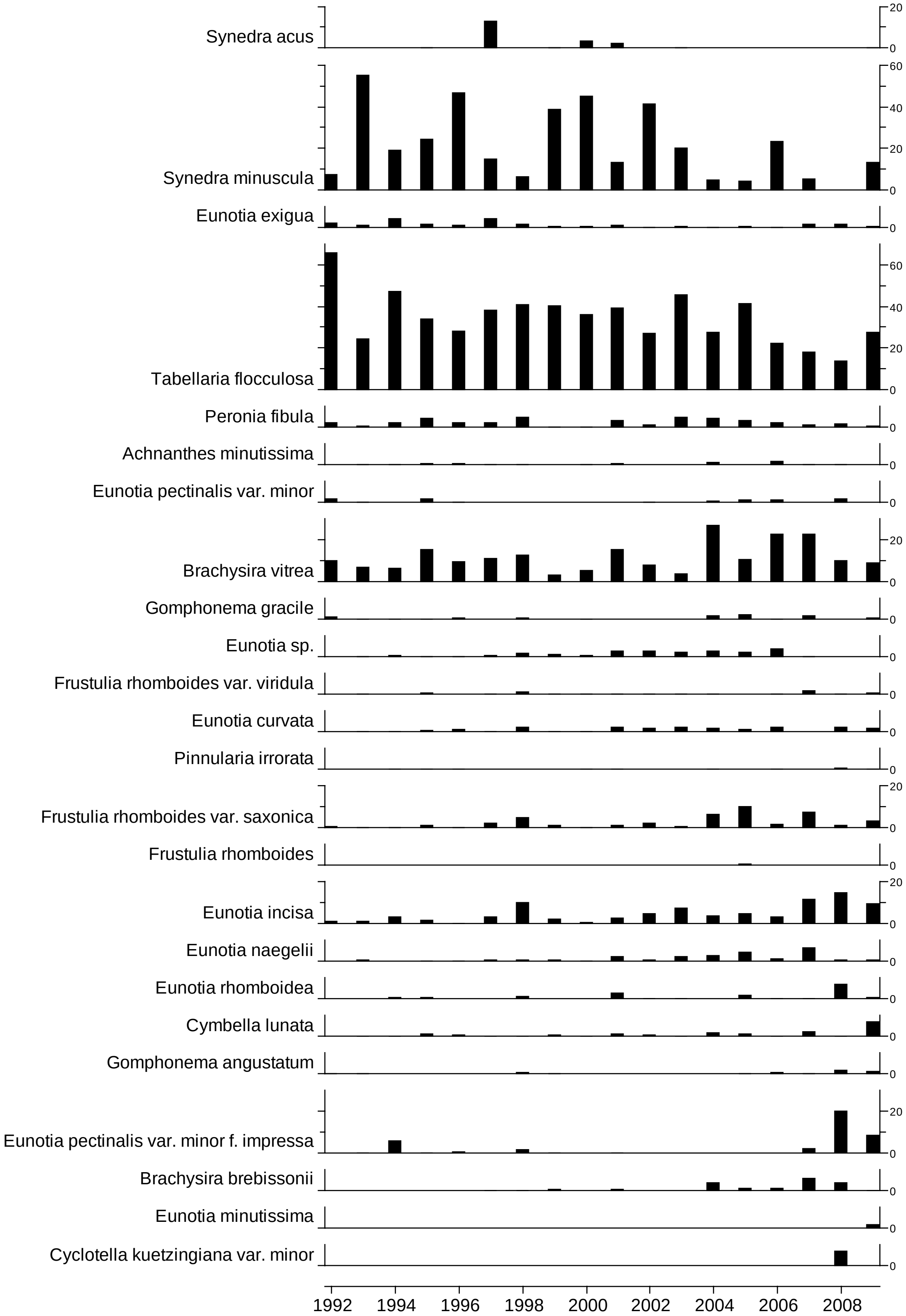


Figure 47 Experimental Burn diatom percentage abundances

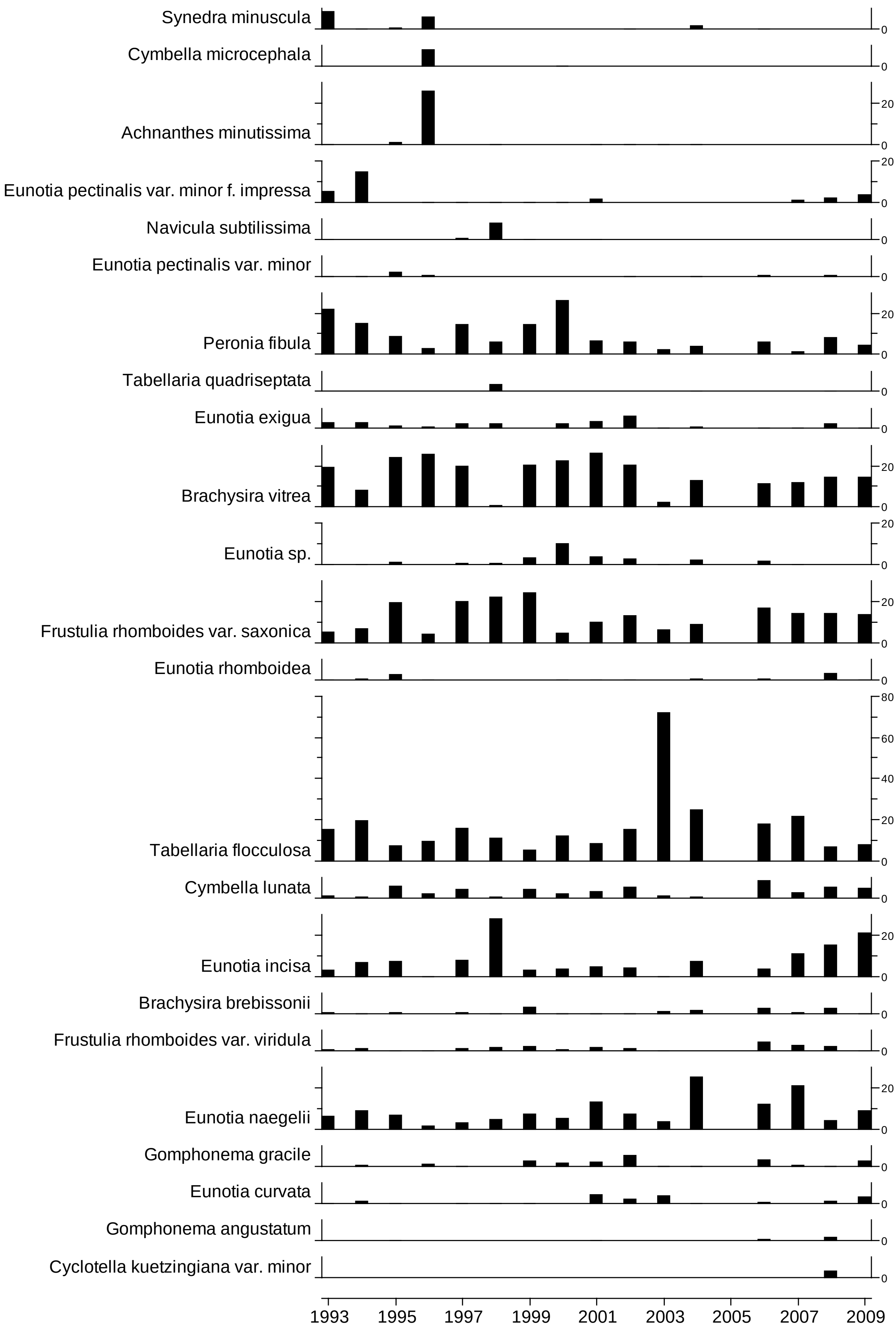


Figure 48 Allt Riabhach na Bioraich diatom percentage abundances

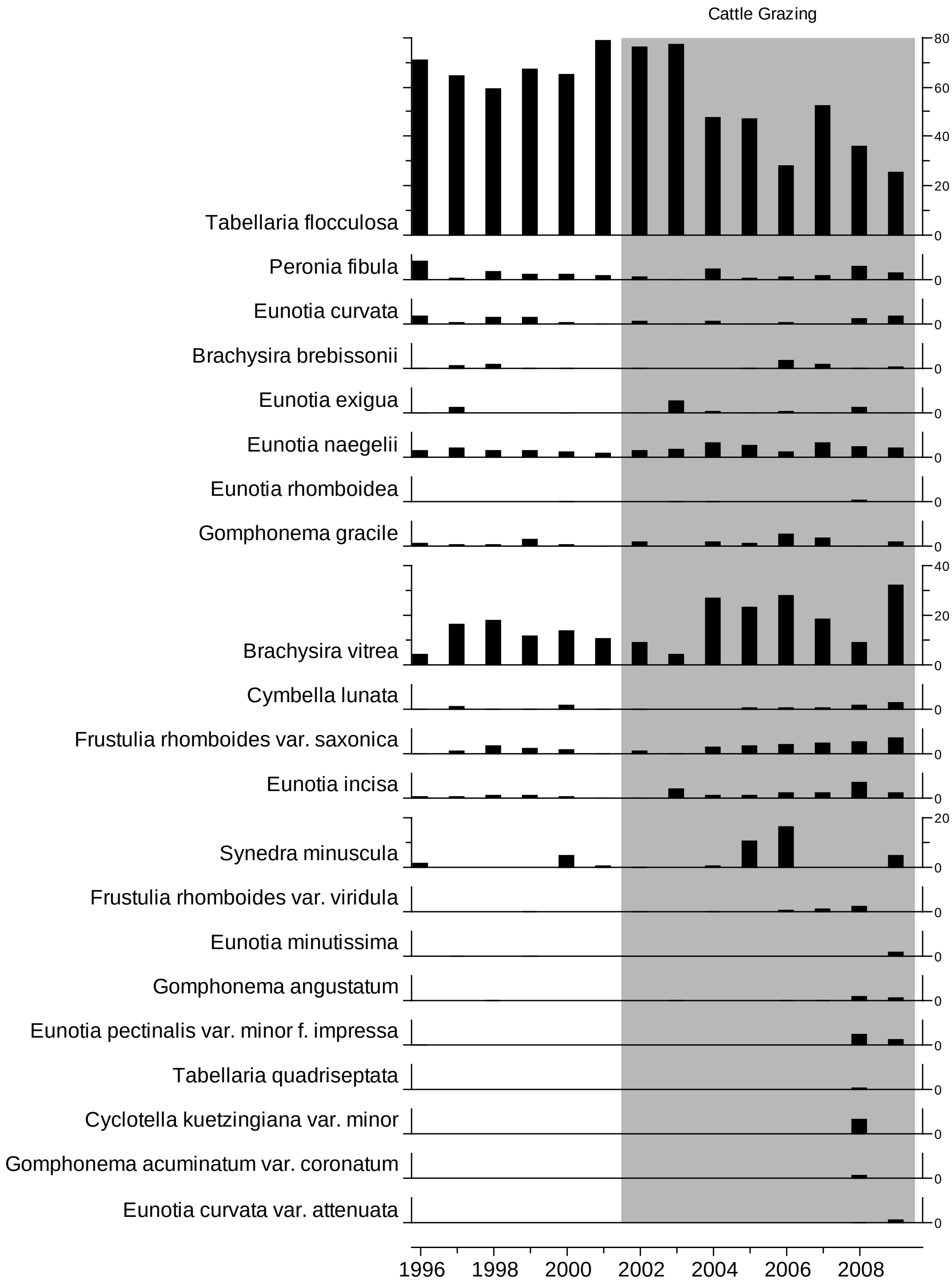


Figure 49 Control Burn macroinvertebrate percentage abundances

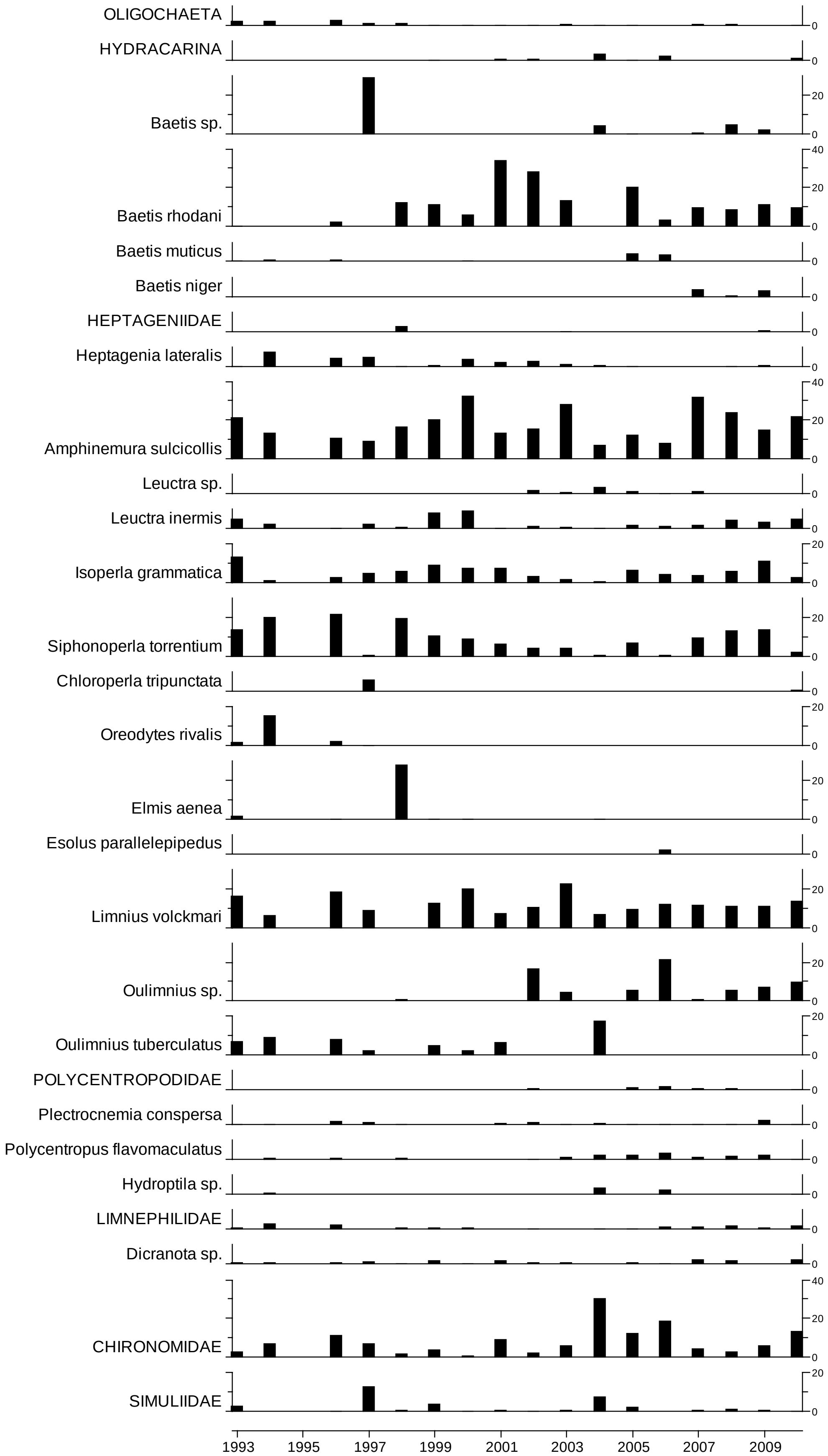


Figure 50 Experimental Burn macroinvertebrate percentage abundances

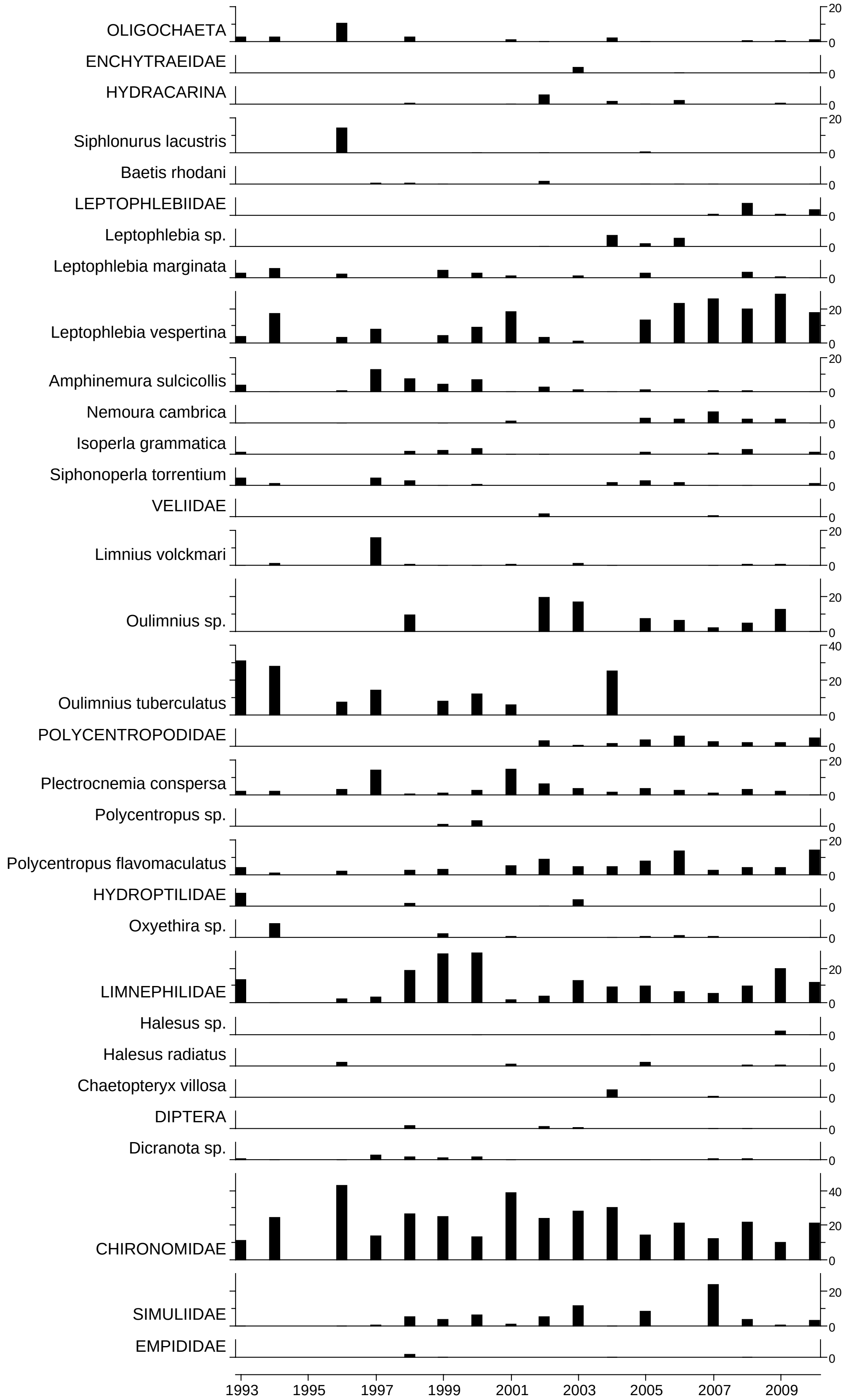


Figure 51 Allt Riabhach na Bioraich Burn macroinvertebrate percentage abundances

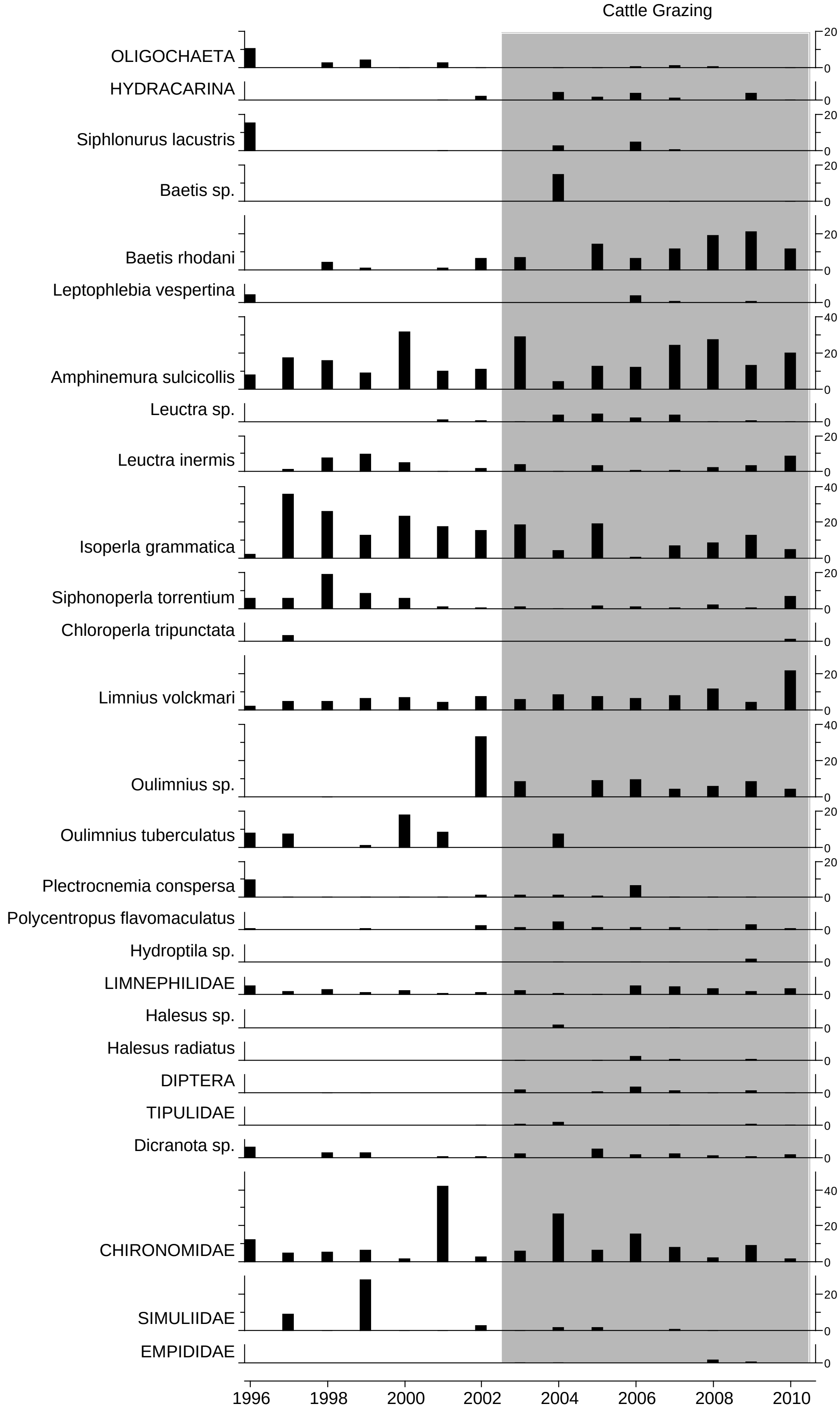


Figure 52 Selected Control Burn macroinvertebrate summary statistics

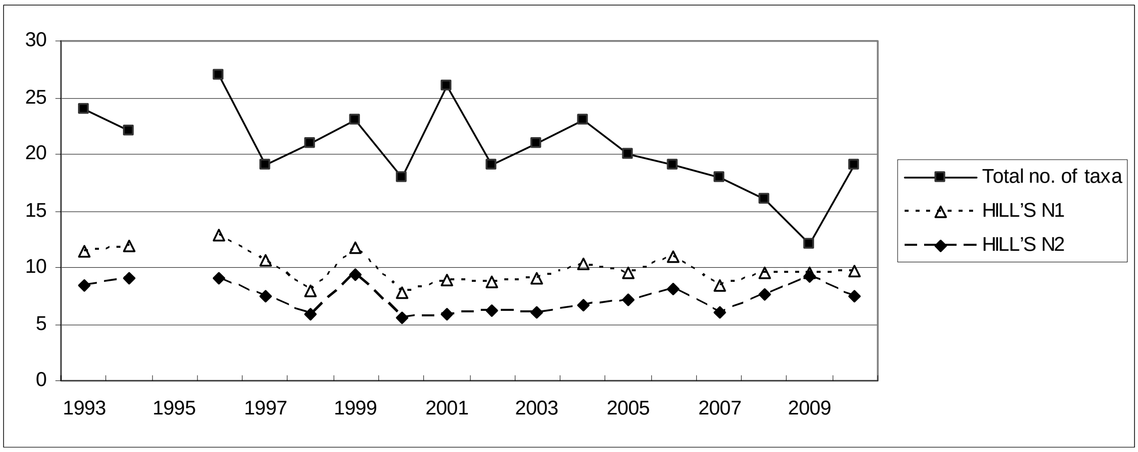


Figure 53 Selected Experimental Burn macroinvertebrate summary statistics

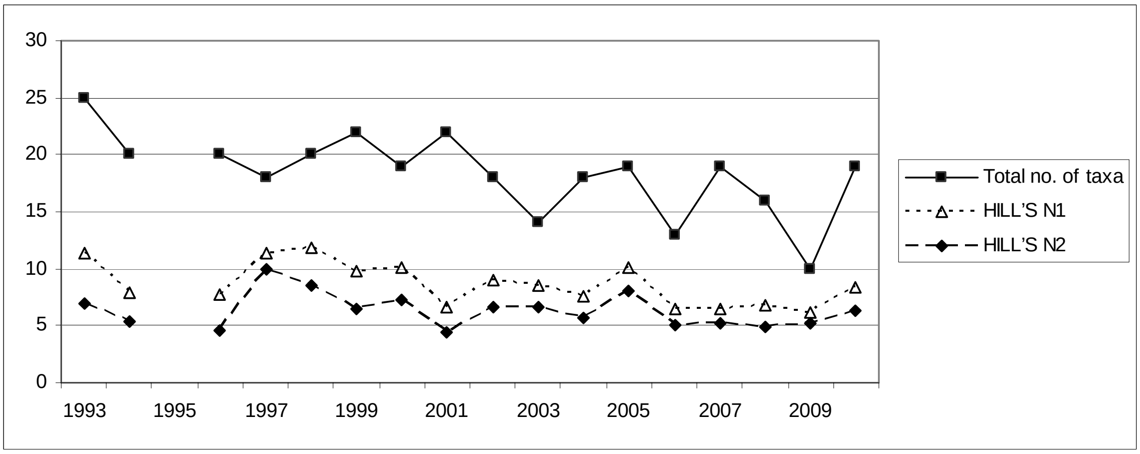


Figure 54 Selected Allt Riabhach na Bioraich macroinvertebrate summary statistics

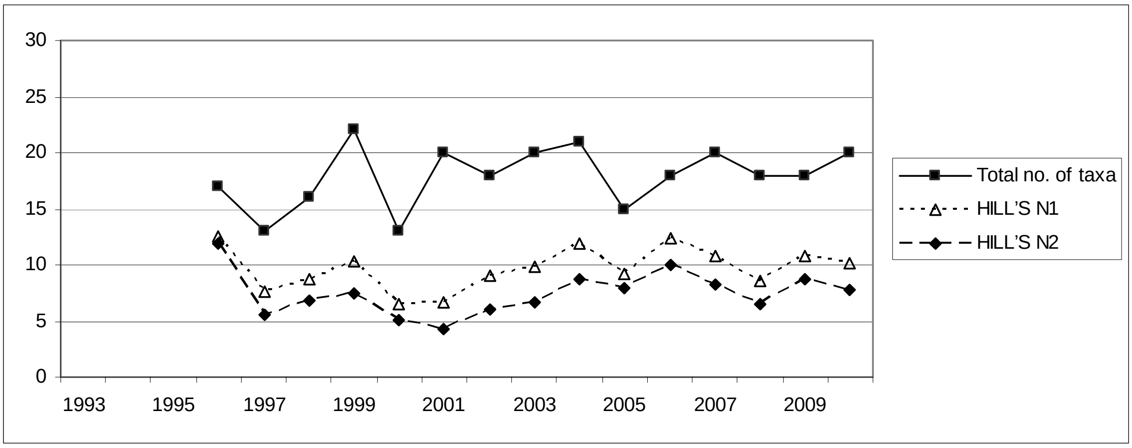


Figure 55 The ratio of macroinvertebrate Total Number of Taxa and its temporal variability between the Control and Experimental Burn 1993 – 2010.

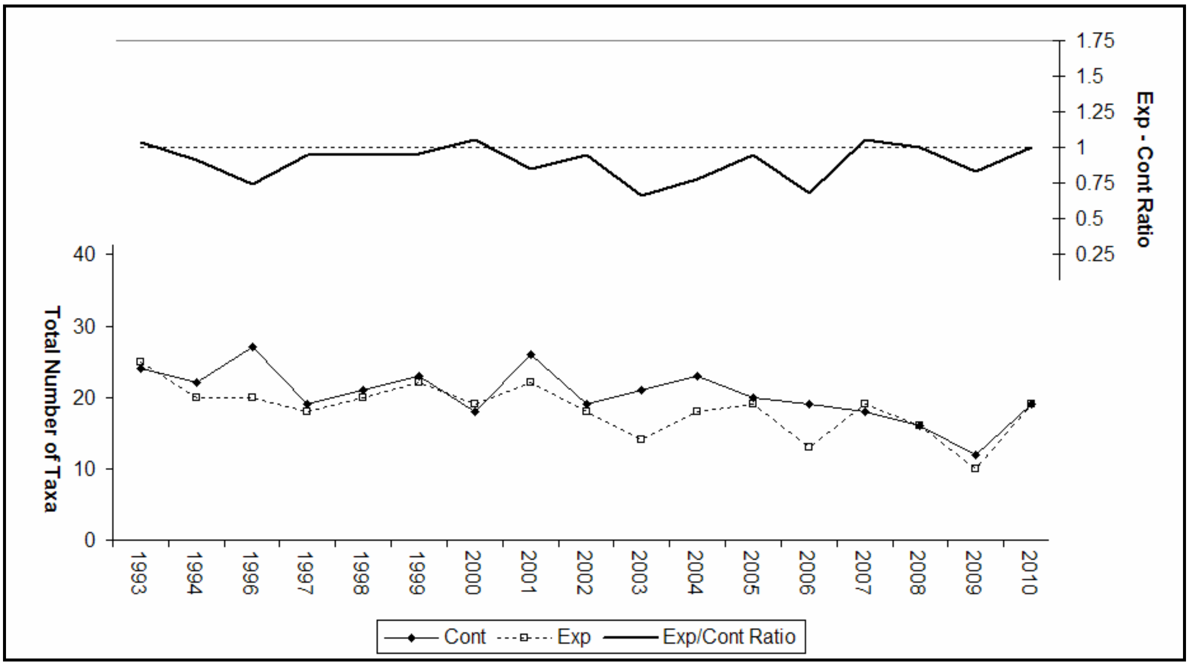


Figure 56 The ratio of macroinvertebrate Total Number of Taxa and its temporal variability between the Control and Allt Riabhach na Bioraich Burn 1996 – 2010.

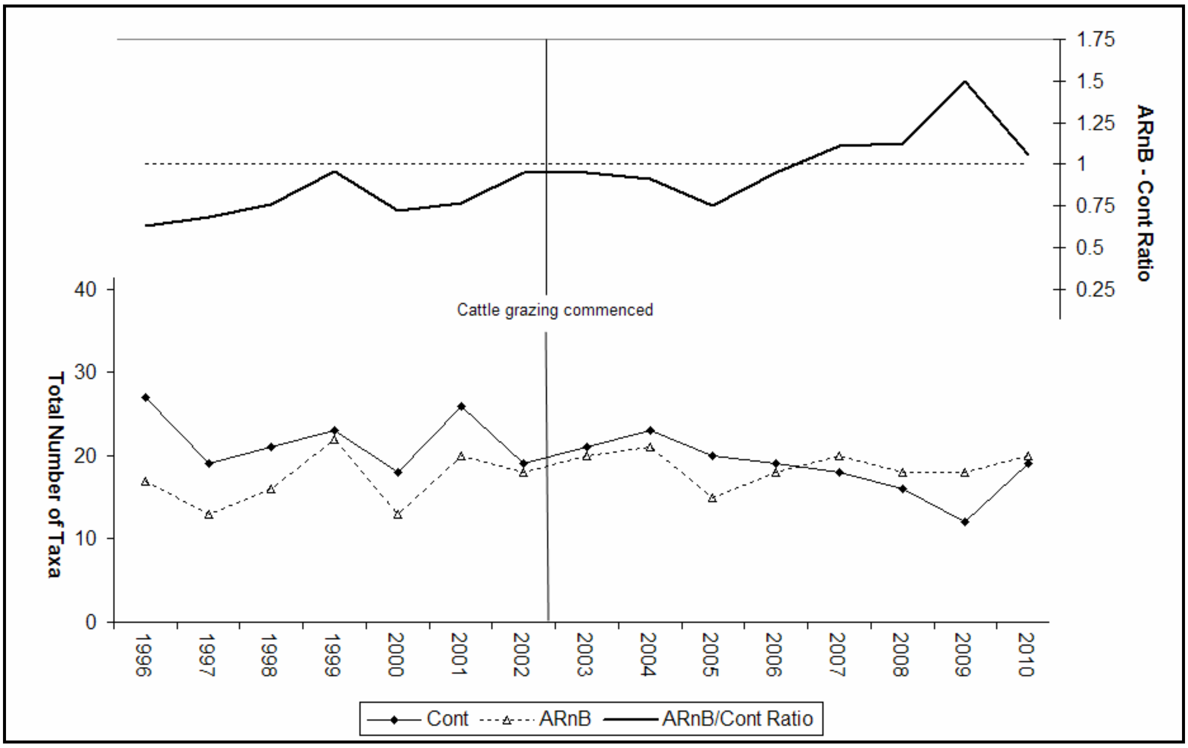


Figure 57 The ratio of macroinvertebrate BMWP and its temporal variability between the Control and Experimental Burn 1993 – 2010.

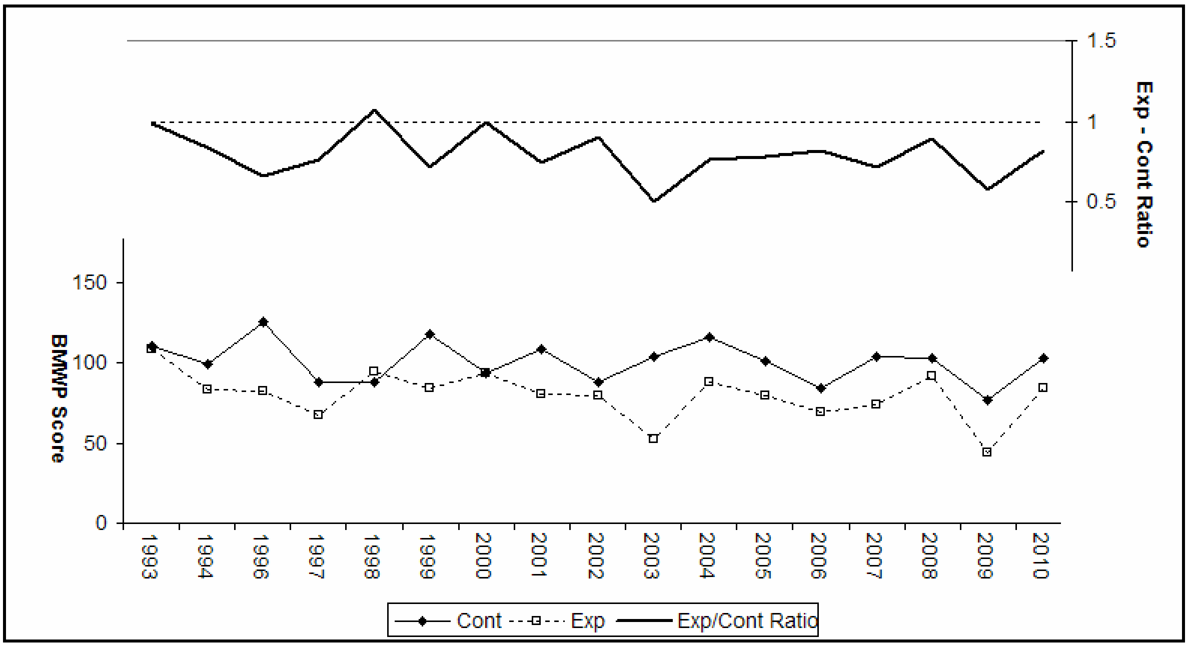


Figure 58 The ratio of macroinvertebrate BMWP and its temporal variability between the Control and Allt Riabhach na Bioraich Burn 1996 – 2010.

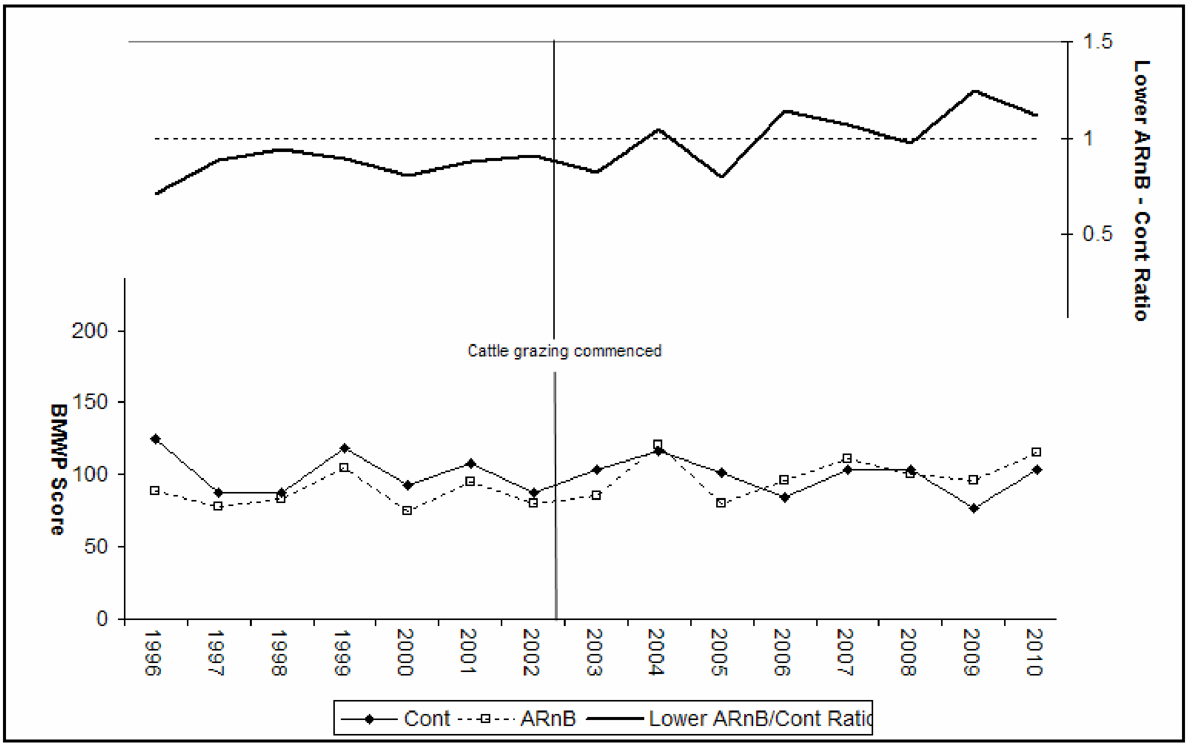


Figure 59 The ratio of macroinvertebrate Average Score Per Taxon and its temporal variability between the Control and Experimental Burn 1993 – 2010.

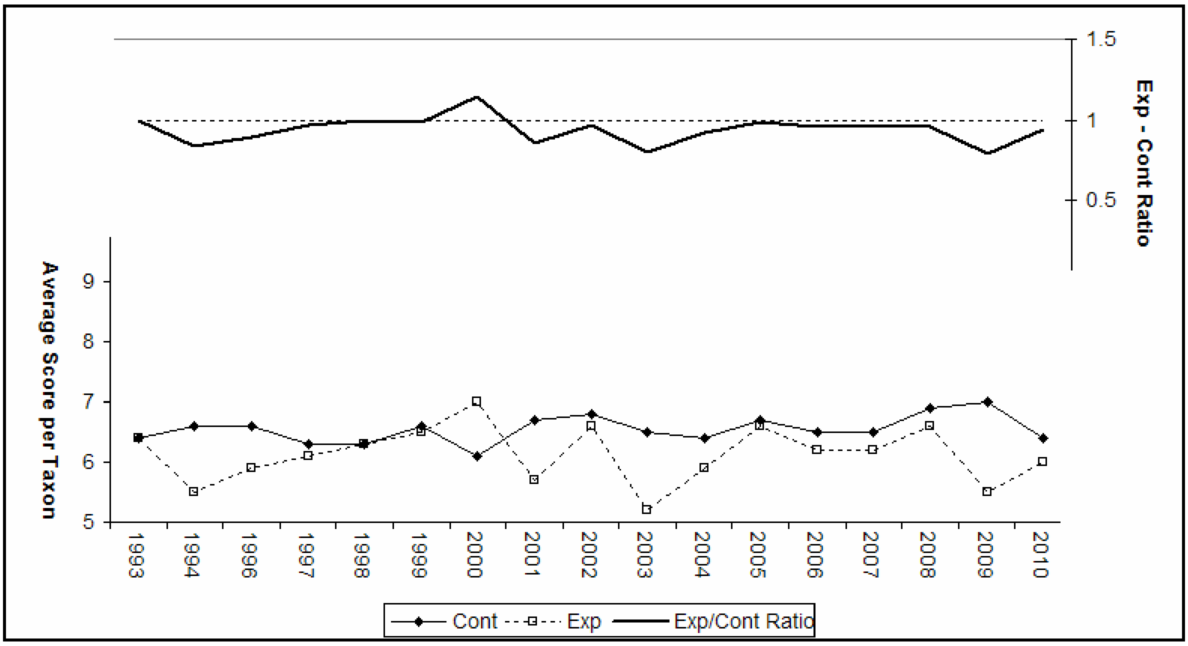


Figure 60 The ratio of macroinvertebrate Average Score Per Taxon and its temporal variability between the Control and Allt Riabhach na Bioraich Burn 1996 – 2010.

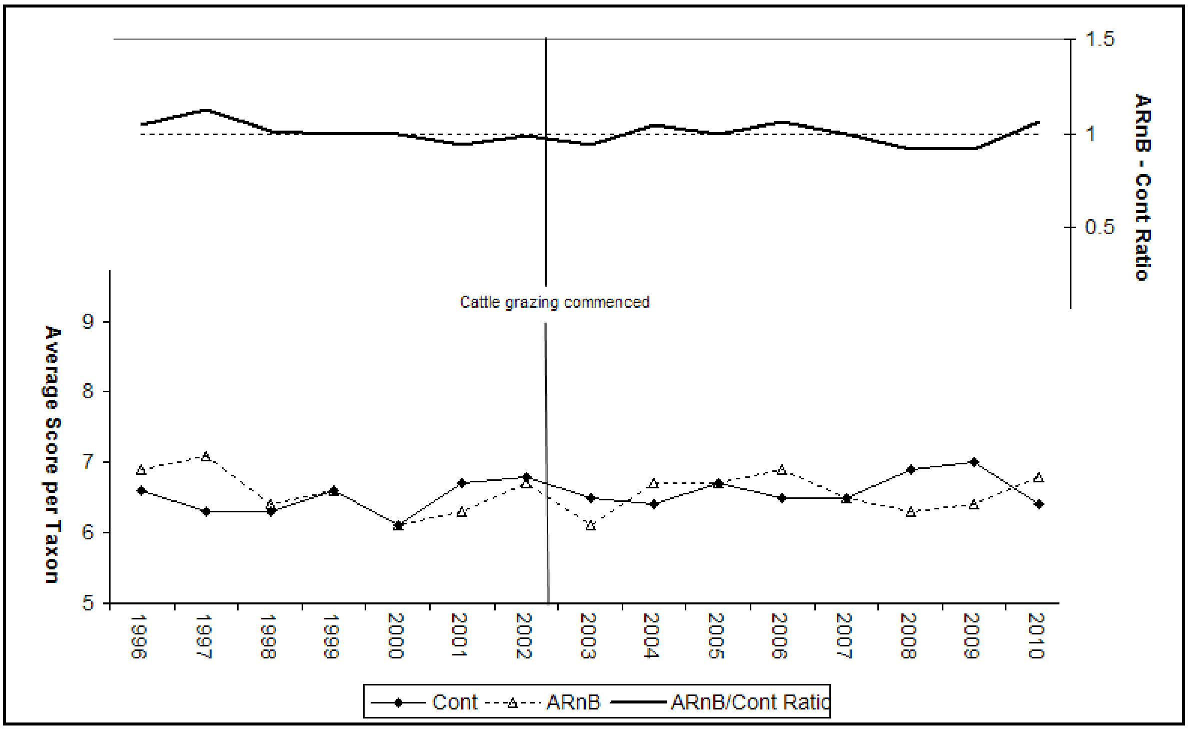


Figure 61 The ratio of macroinvertebrate Richness (rareftn 100) and its temporal variability between the Control and Experimental Burn 1993 – 2010.

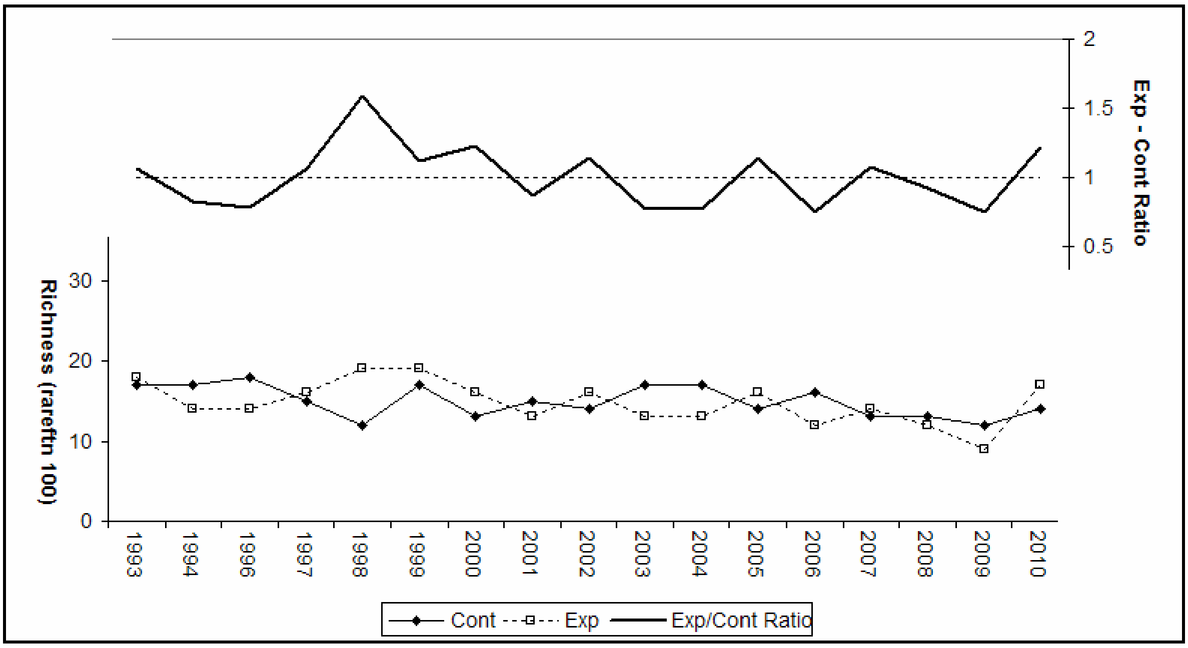


Figure 62 The ratio of macroinvertebrate Richness (rareftn 100) and its temporal variability between the Control and Allt Riabhach na Bioraich Burn 1996 – 2010.

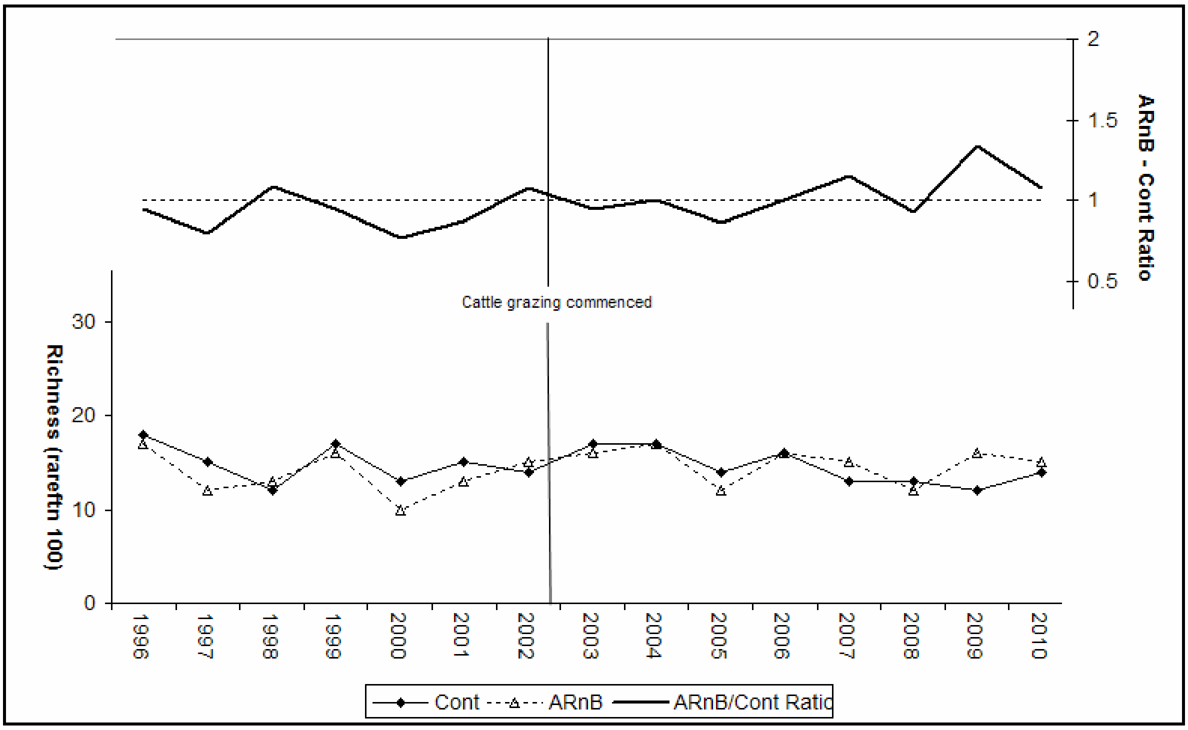


Figure 63 The ratio of macroinvertebrate Hill's N1 and its temporal variability between the Control and Experimental Burn 1993 – 2010.

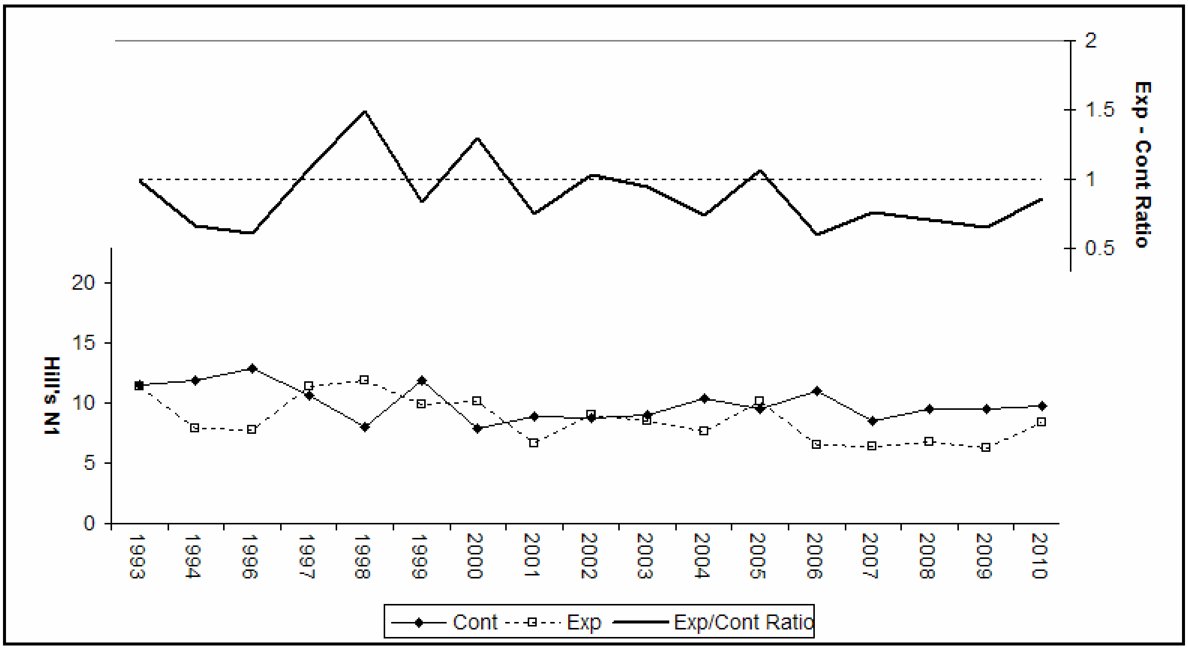


Figure 64 The ratio of macroinvertebrate Hill's N1 and its temporal variability between the Control and Allt Riabhach na Bioraich Burn 1996 – 2010.

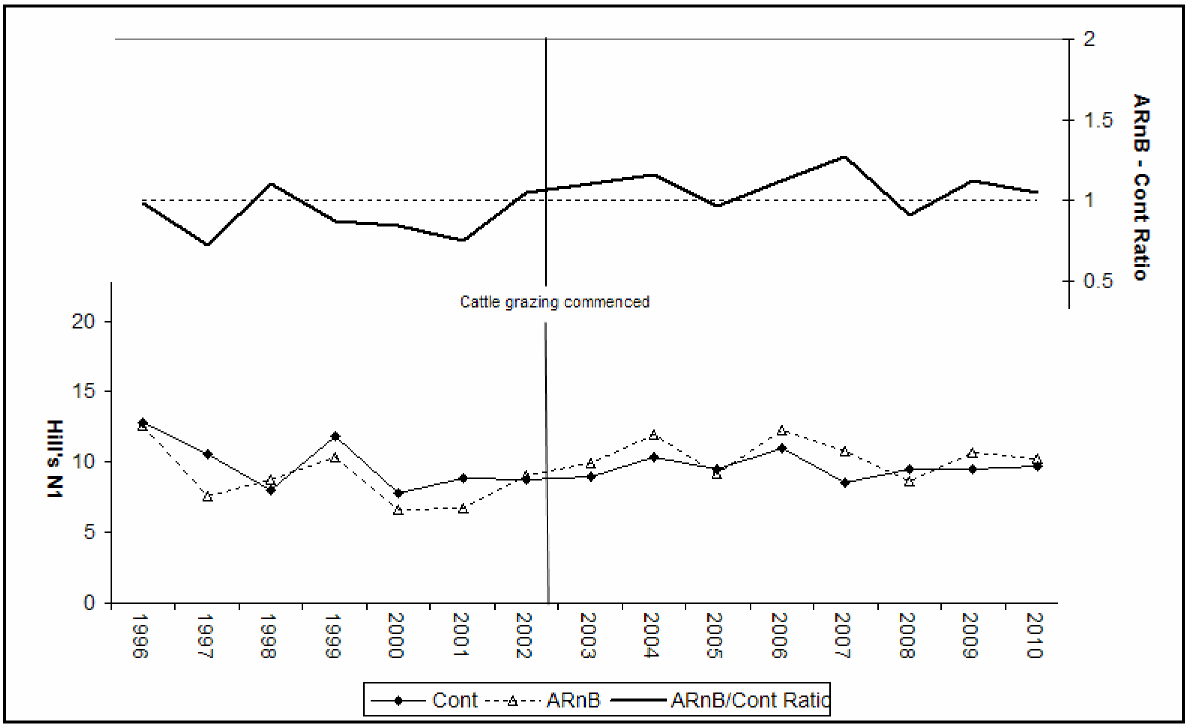
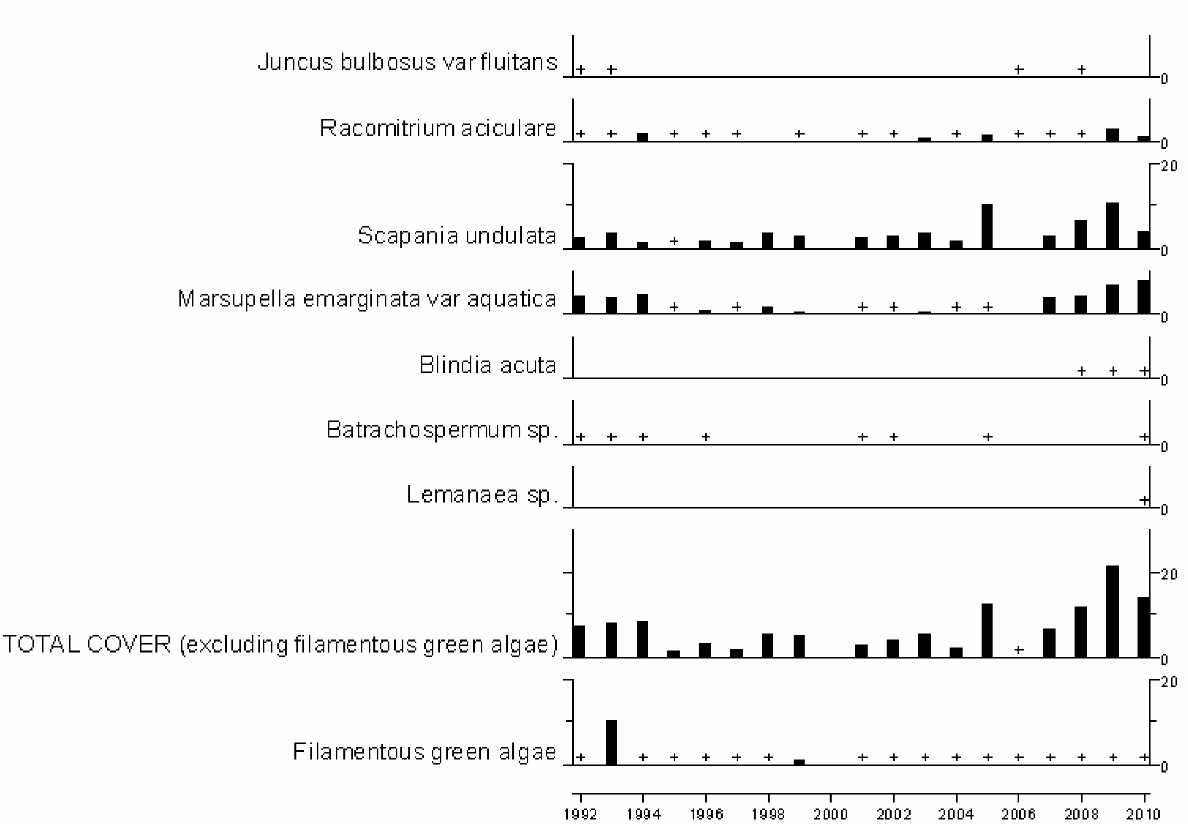


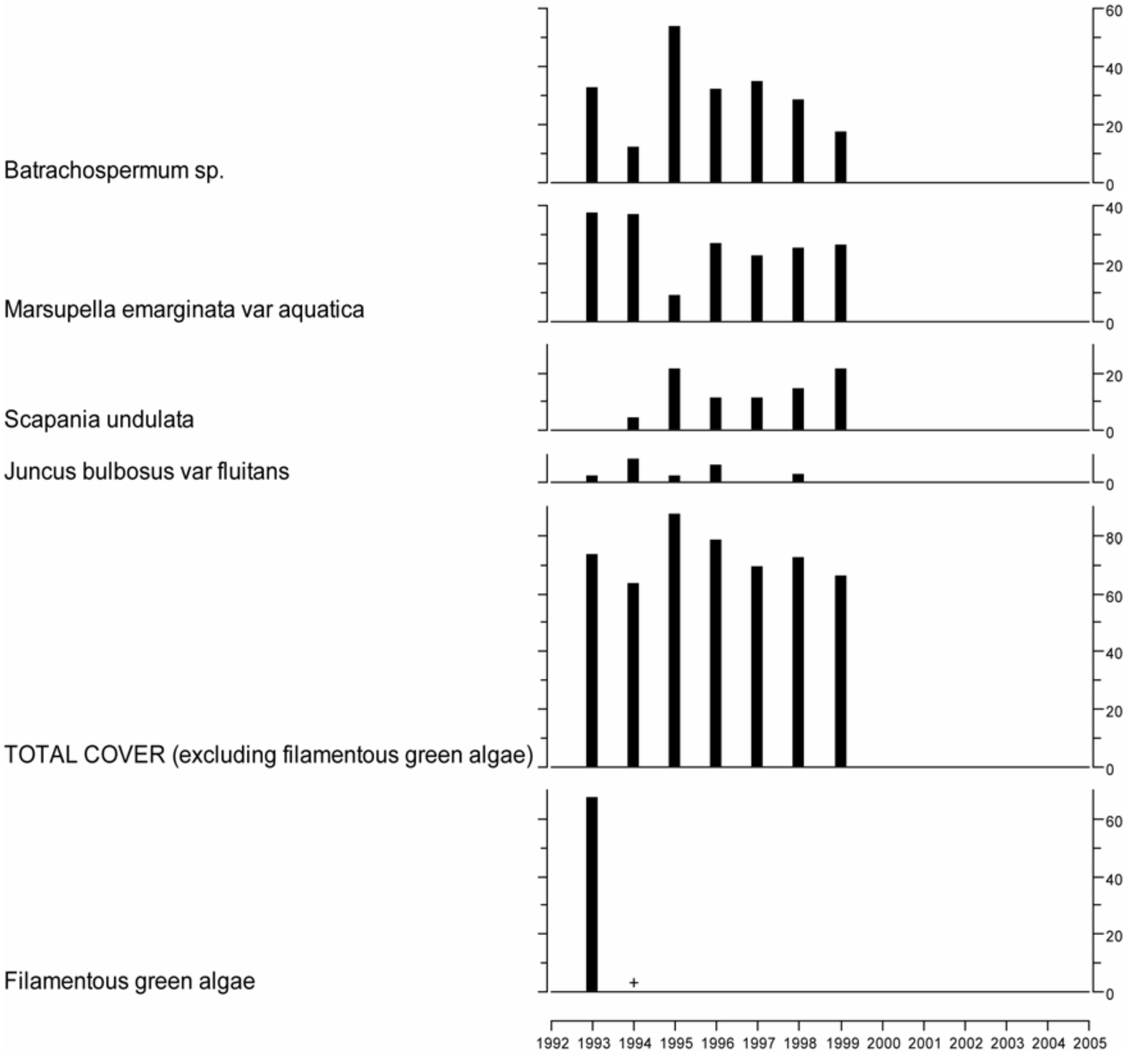
Figure 65 Control Burn Macrophyte percentage Abundances



Sampling stretch 50m long.

+ represents <1% abundance

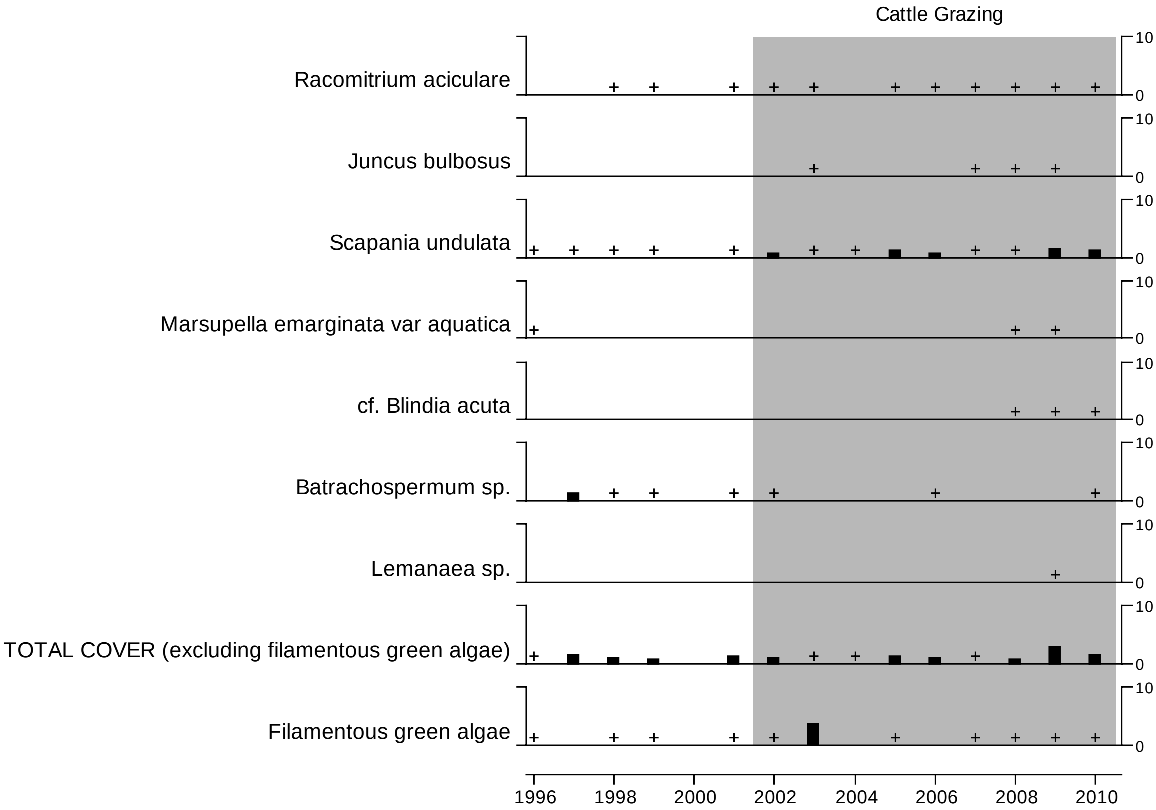
Figure 66 Experimental Burn Macrophyte percentage Abundances



Sampling stretch 20m long. Sampling ceased in 1999.

+ represents <1% abundance

Figure 67 Allt Riabhach na Bioraich Burn Macrophyte percentage Abundances



Sampling stretch 50m long.

+ represents <1% abundance

Figure 68 Control Burn fish densities

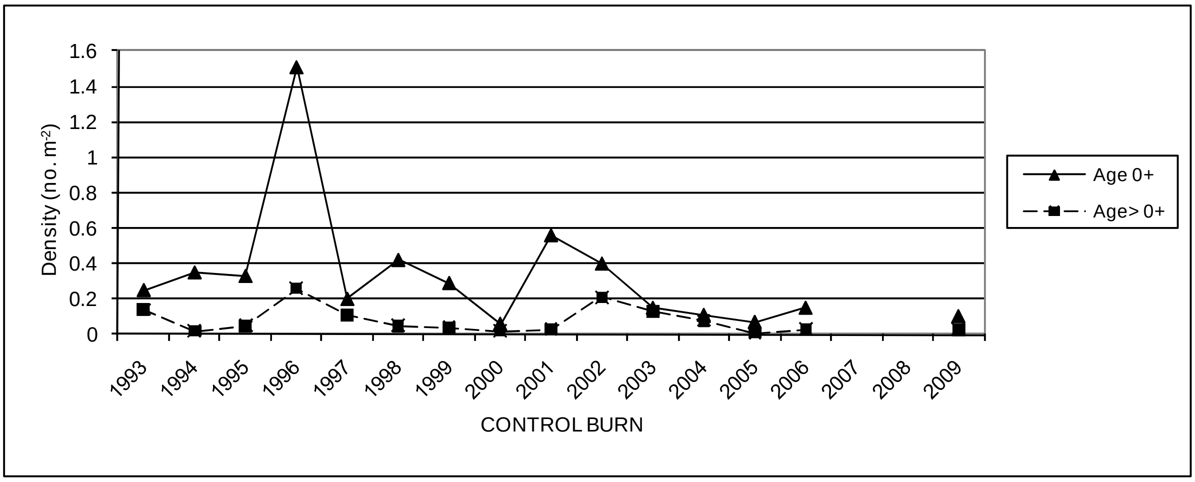


Figure 69 Experimental Burn fish densities

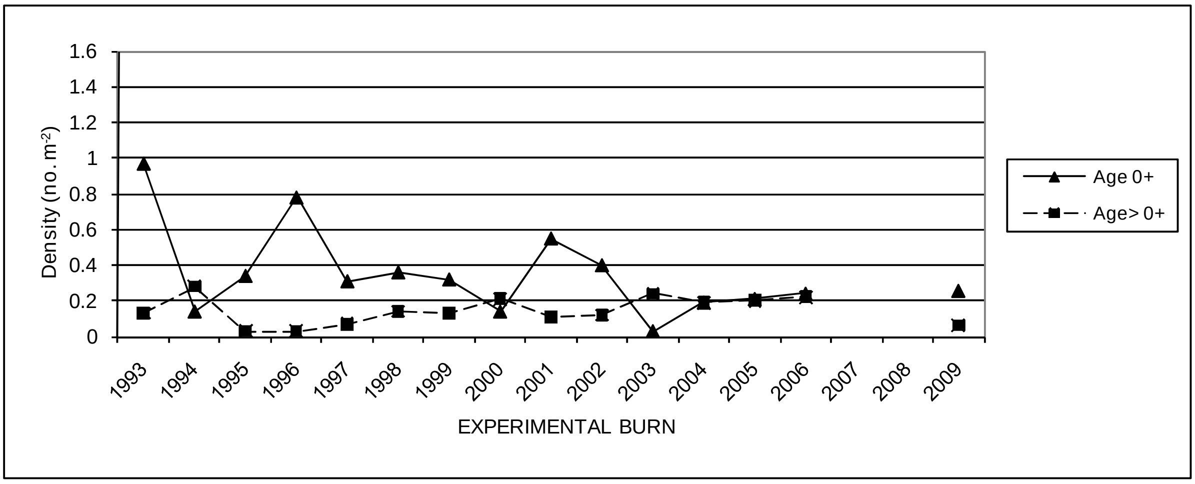


Figure 70 Allt Riabhach na Bioraich Burn fish densities

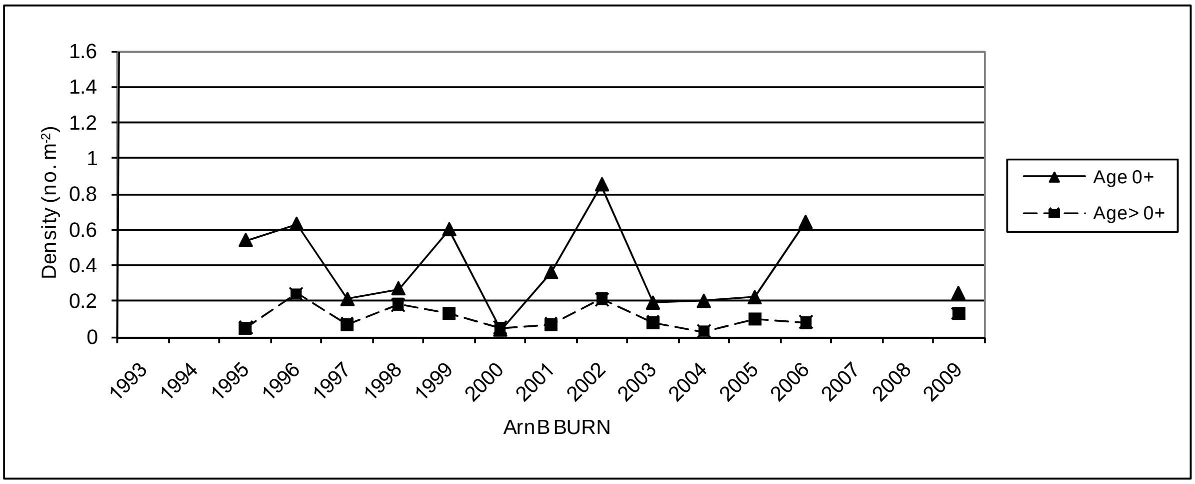


Figure 71 Fry Densities at All Experimental Burns

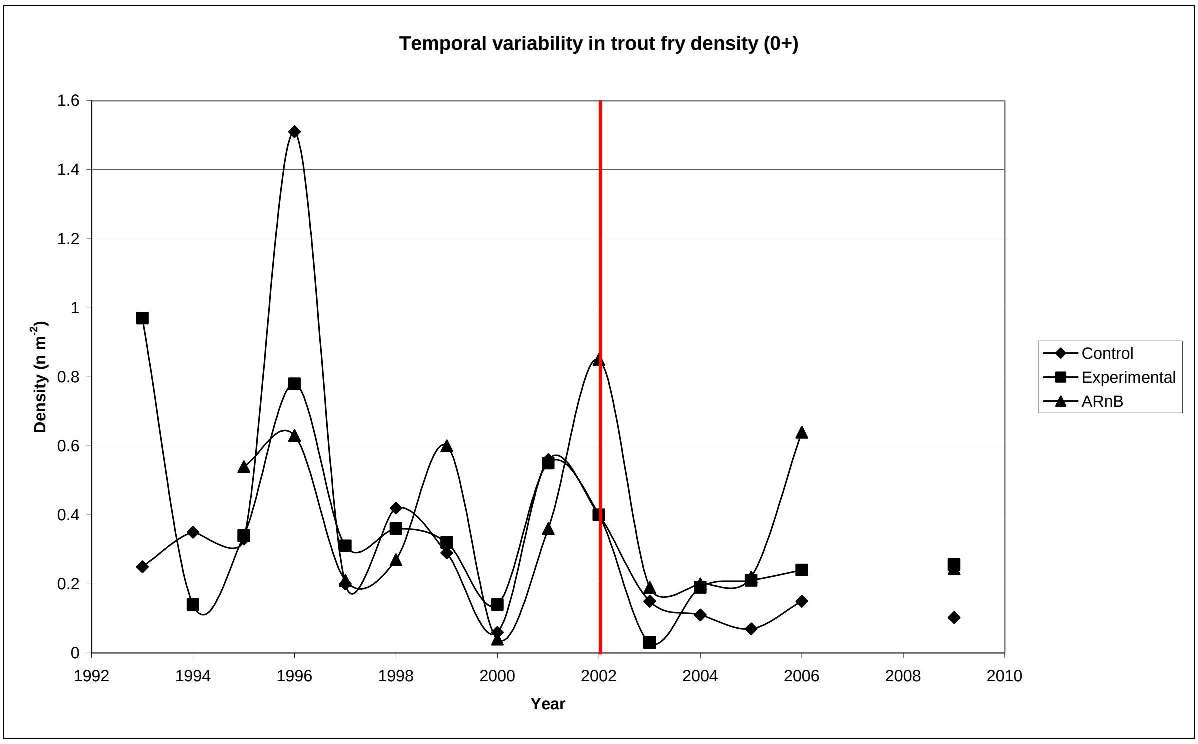


Figure 72 Parr Densities at All Experimental Burns

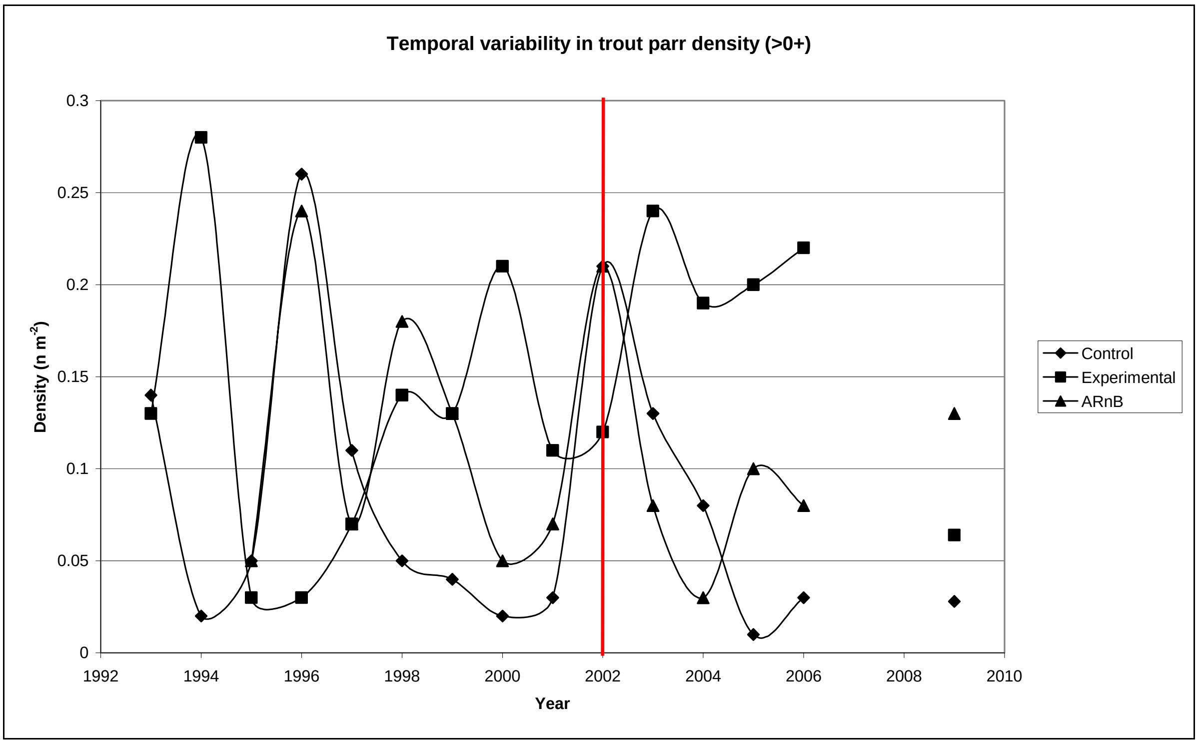


Figure 73 Temporal variability of fish log abundance ratios between the Control and Allt Riabhach na Bioraich burns

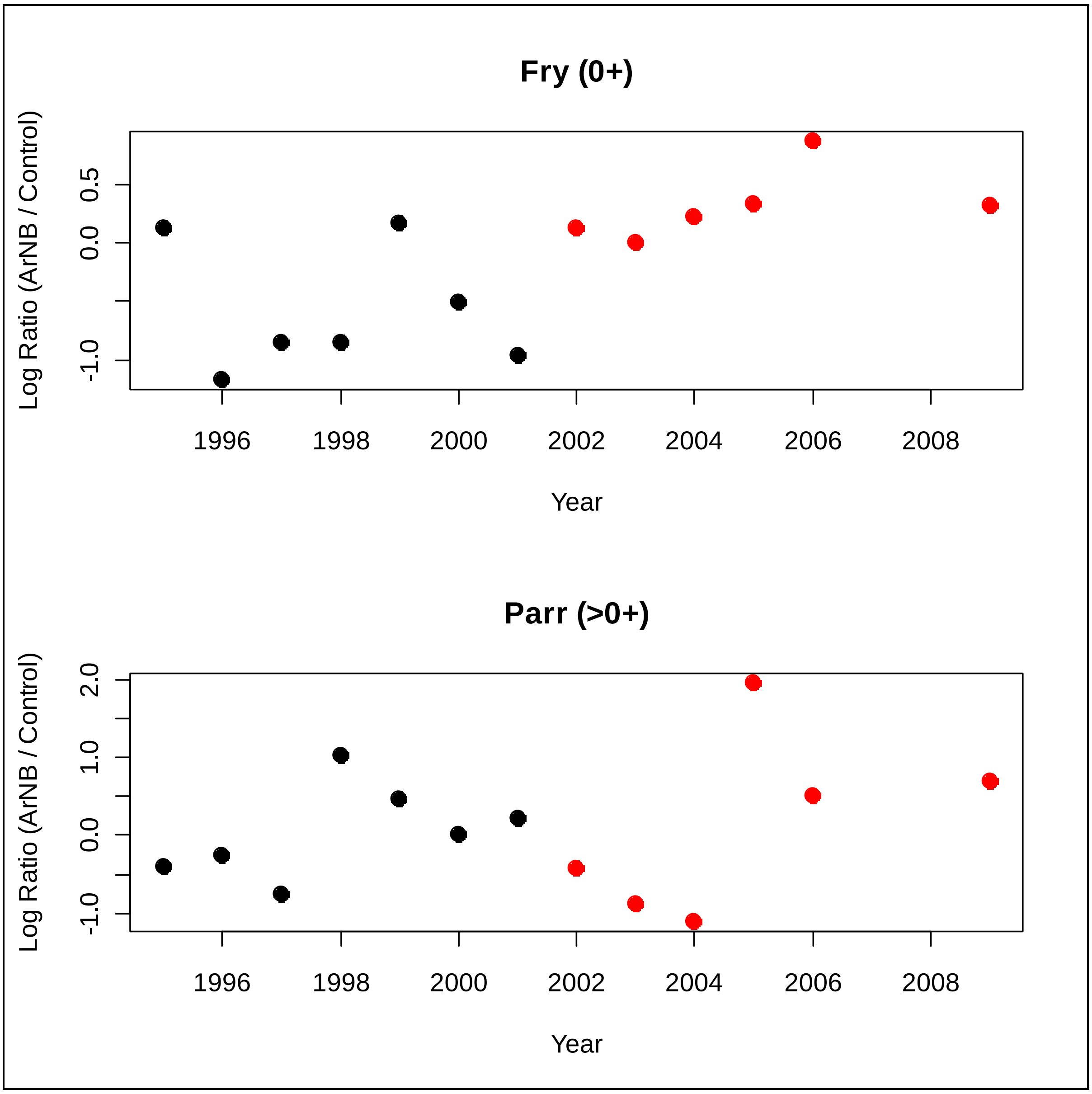


Figure 74 Loch Laidon 2009 Core LAI6 Percentage Dry Weight

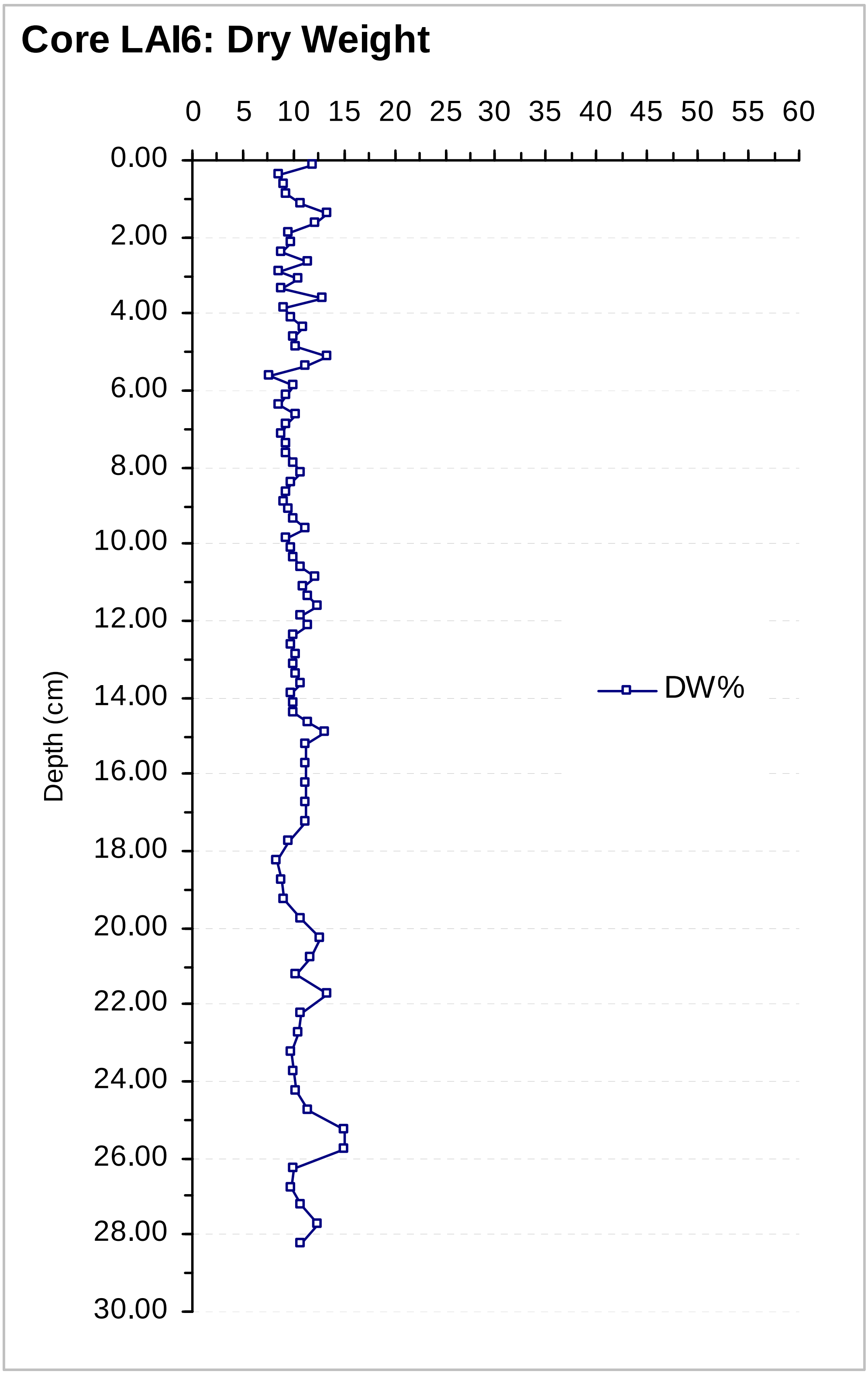


Figure 75 Loch Laidon 2009 Core LAI6 Percentage Loss On Ignition 550

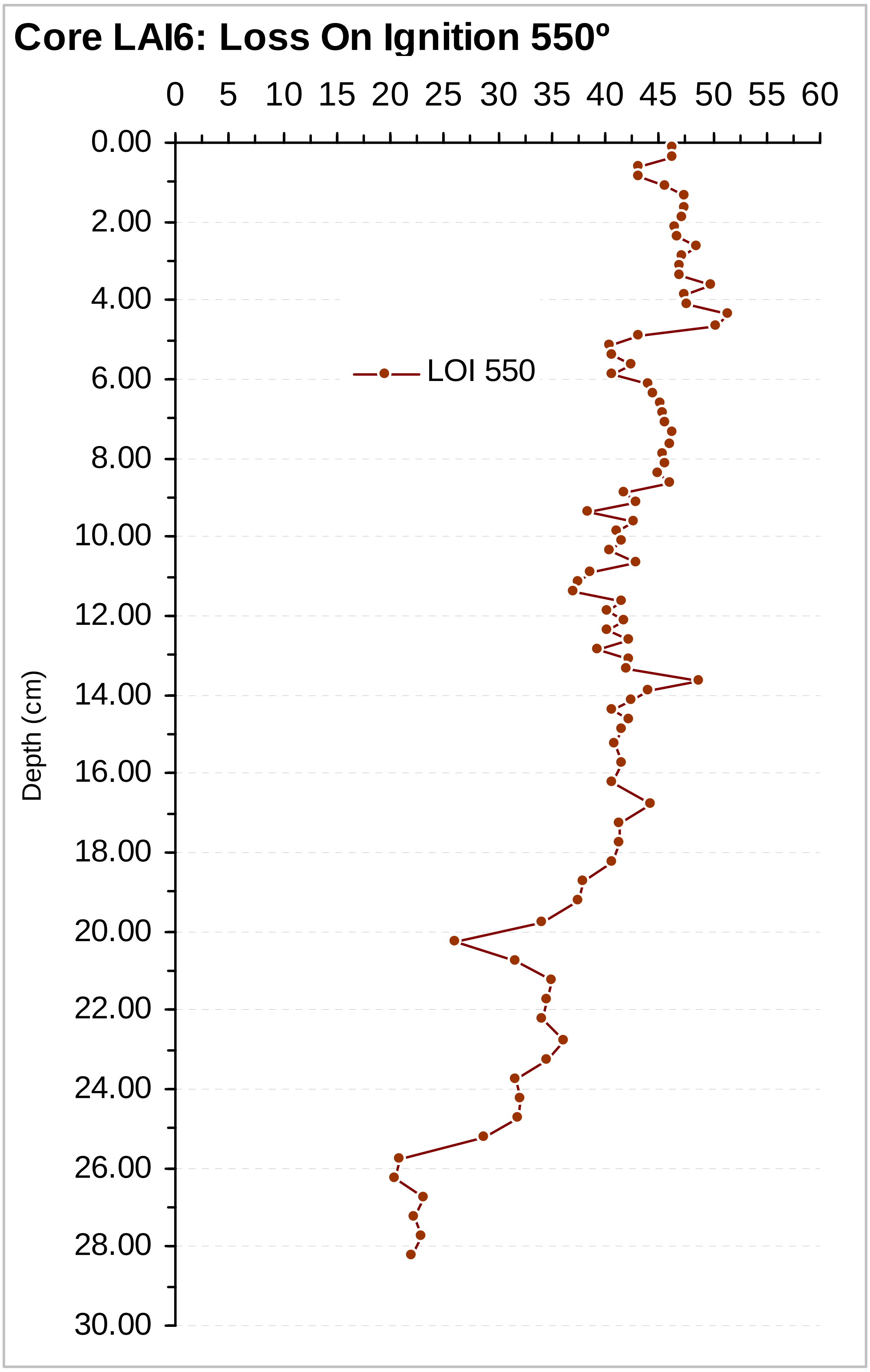


Figure 76 Loch Laidon 2009 Core LAI6 Percentage Loss On Ignition 950

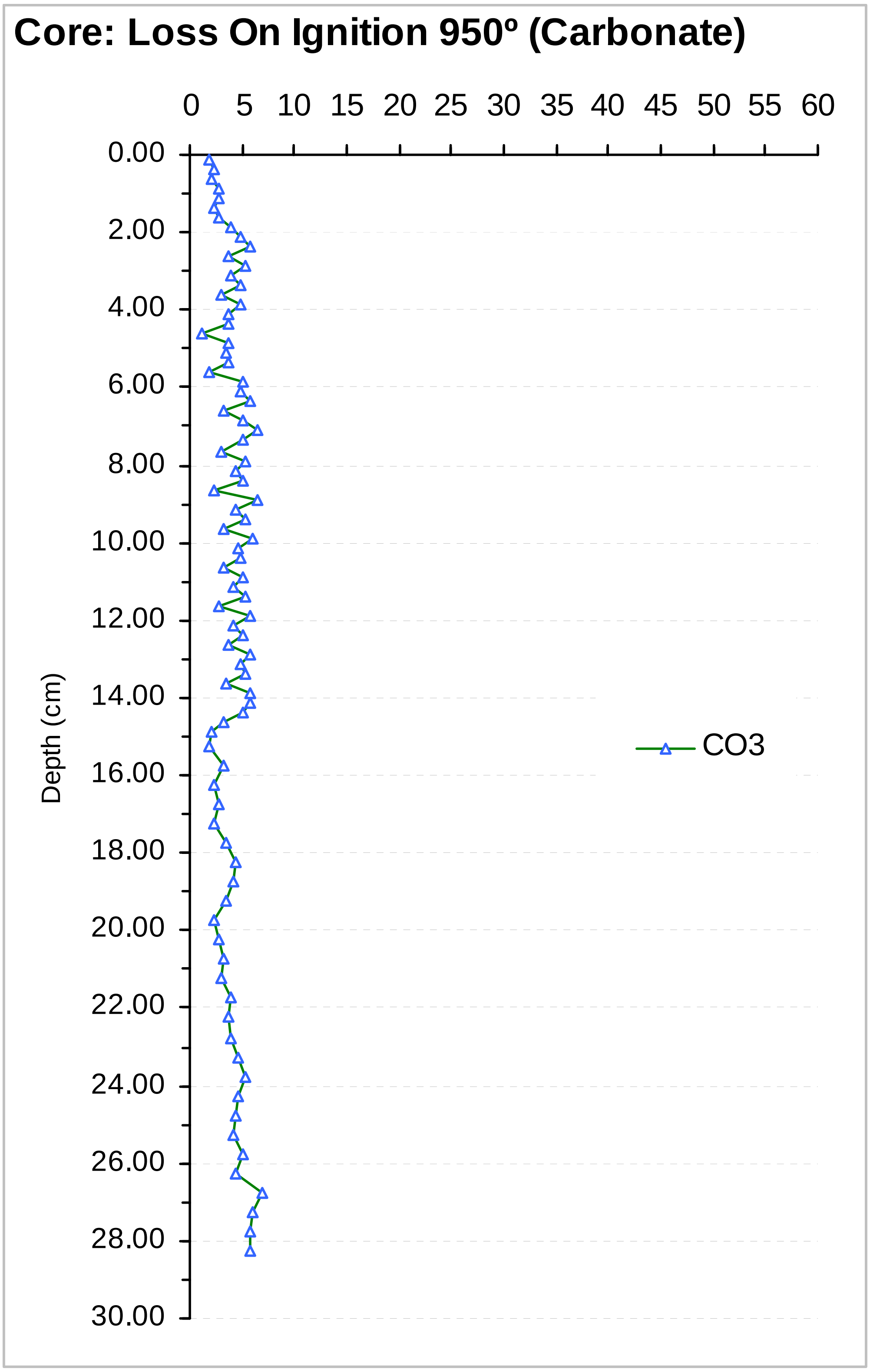


Figure 77 Loch Laidon 2009 Core LAI6 Spheroidal Carbonaceous Particle Profile

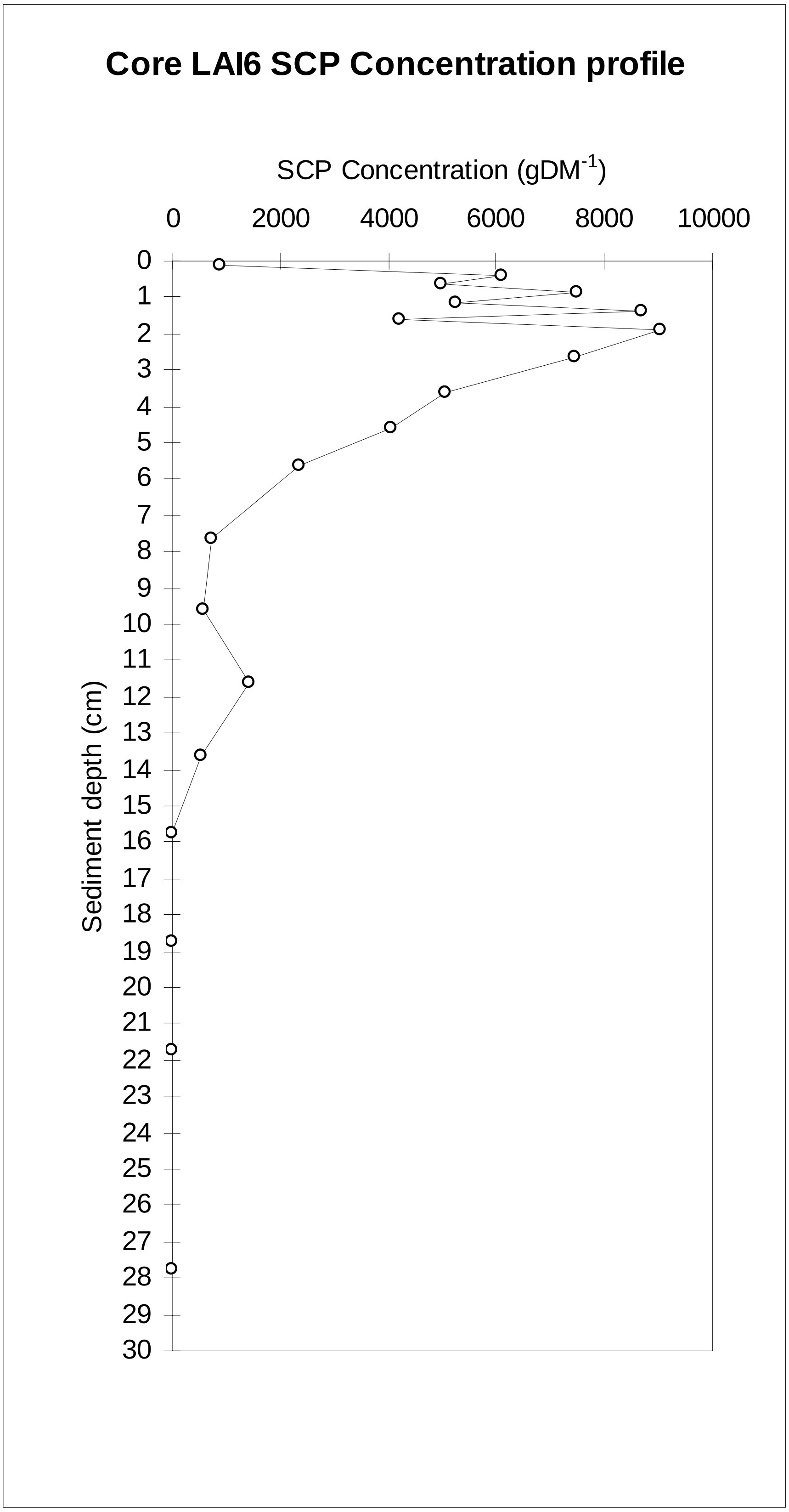


Figure 78 Loch Laidon 2009 Core LAI6 Full Diatom Stratigraphy

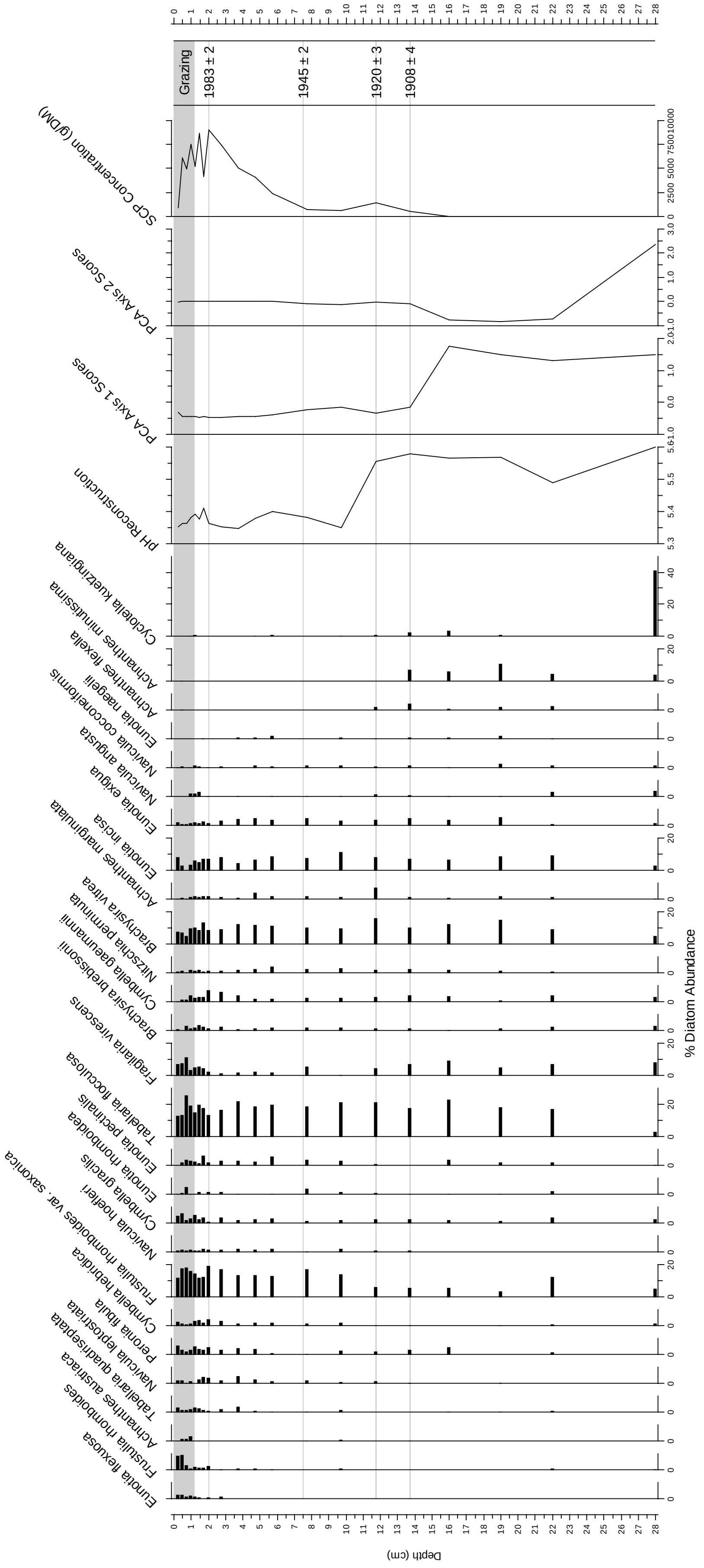
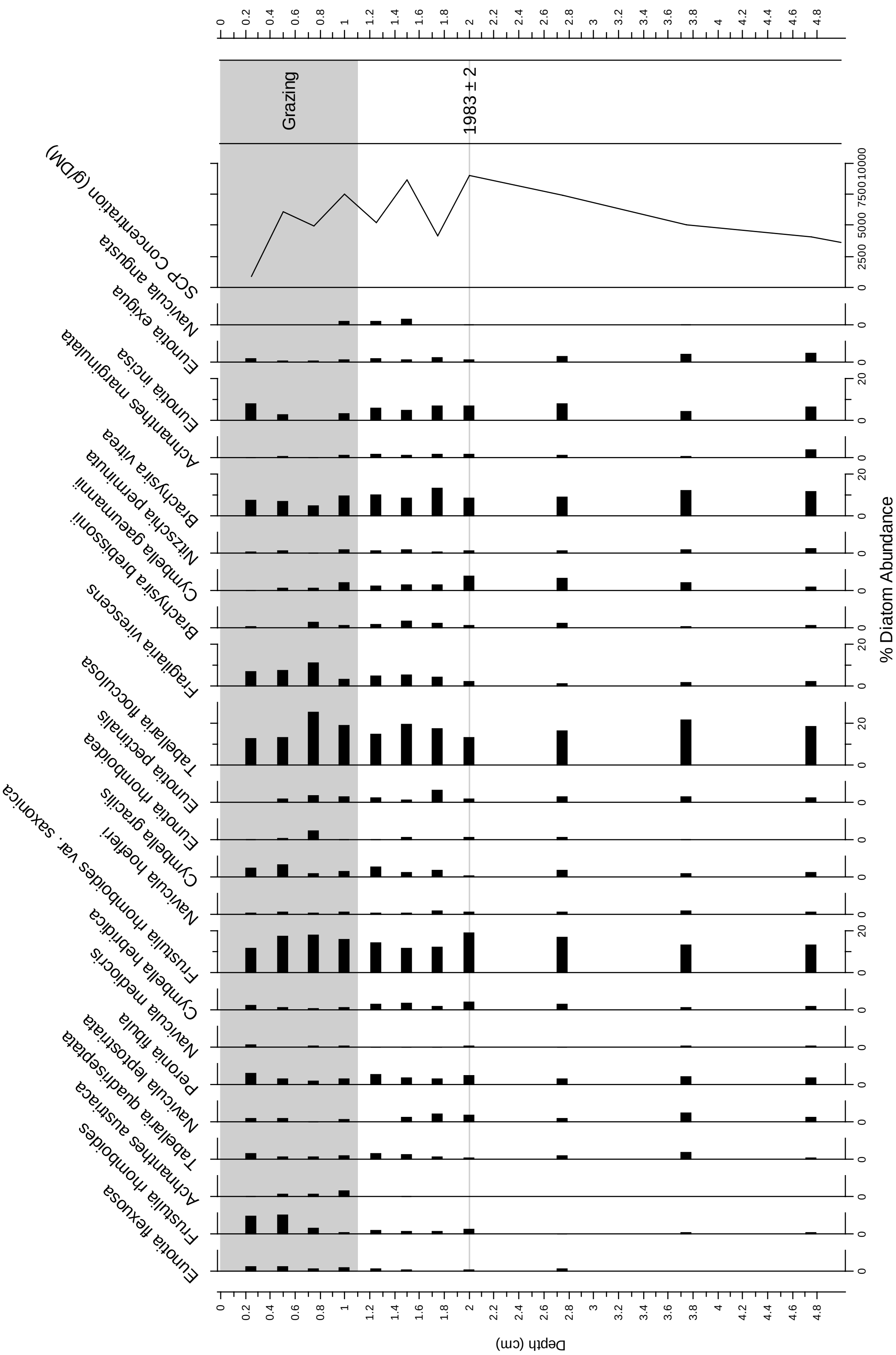


Figure 79 Loch Laidon 2009 Core LAI6 Top 5cm Diatom Stratigraphy



9 TABLES

Table 5 Summary statistics of selected chemical determinands for individual years at all sampling stations

Site Name	Year	pH			Alkalinity (µeq l-1)			Conductivity (µS cm-1)			Nitrate (µeq l-1)			Sulphate (µeq l-1)			Total Phosphorus (µg l-1)			Labile Aluminium (µeq l-1)		
		Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Control	1992	5.87	5.44	6.46	27.0	8	63	22.3	20	24	0.0	0	0	26.3	25	28				8.0	2	18
Control	1993	6.23	5.59	6.91	63.8	8	147	29.2	20	39	0.3	0	2	28.1	11	44	22.5	19.0	26.0	6.3	0	29
Control	1994	6.22	5.18	6.68	53.2	-3	105	29.3	23	39	0.5	0	2	33.9	23	85	18.9	2.5	58.0	4.4	0	17
Control	1995	6.42	5.72	7.02	73.3	16	161	32.2	21	46	0.6	0	2	62.0	18	175	3.1	2.5	6.0	4.6	0	28
Control	1996	6.03	5.39	6.9	50.0	2	173	28.8	20	44	1.1	0	5	40.5	18	62	3.3	2.5	10.0	3.8	0	10
Control	1997	6.32	5.65	6.94	53.3	18	146	28.9	23	37	0.8	0	2	25.9	13	43	2.9	2.5	6.0	5.3	0	10
Control	1998	6.19	5.61	6.82	62.9	9	169	26.8	21	36	0.2	0	1	22.3	13	35	3.3	2.5	11.0	4.9	0	16
Control	1999	5.86	5.29	6.53	30.9	2	103	28.4	19	48	0.3	0	1	25.4	10	54	5.0	2.5	6.0	4.0	2	7
Control	2000	6.33	5.46	6.75	54.5	-7	127	30.7	24	36	0.6	0	2	28.1	16	59	2.9	2.5	6.0	5.0	0	13
Control	2001	6.18	5.56	6.63	50.1	6	97	23.2	18	31	1.2	0	6	22.1	13	34	6.9	2.5	21.0	9.2	1	24
Control	2002	6.22	5.32	6.84	69.6	0	199	28.0	18	41	0.2	0	1	20.7	9	33	10.5	2.5	27.0	3.4	0	21
Control	2003	6.24	5.34	6.93	74.3	1	184	31.3	22	42	0.1	0	1	30.8	11	63	11.6	6.0	19.0	2.9	0	10
Control	2004	5.83	5.22	6.89	35.0	-4	131	22.2	12	34	0.0	0	0	14.6	9	26	8.8	4.0	12.0	8.0	0	16
Control	2005	6.27	5.48	6.81	69.4	2	178	35.7	19	68	0.2	0	2	22.8	7	47	6.6	2.0	10.0	3.9	0	8
Control	2006	6.34	5.39	6.93	94.4	8	225	29.4	17	43	0.1	0	1	22.5	11	29	5.4	0	12	3.7	1	10
Upper Experiment	1992	5.71	5.23	6.19	23.7	-1	52	26.0	19	33	0.0	0	0	43.7	23	82				0.3	0	1
Upper Experiment	1993	6.04	5.29	6.6	85.2	1	213	33.2	19	45	0.6	0	2	24.2	8	45	20.5	19.0	22.0	2.7	0	9
Upper Experiment	1994	6.19	5.47	6.78	72.5	5	136	33.5	24	44	0.5	0	1	26.8	13	51	18.9	0.0	60.0	2.9	0	7
Upper Experiment	1995	6.14	5.21	6.81	88.8	0	221	37.7	22	63	0.3	0	1	74.2	13	302	3.0	2.5	6.0	2.6	0	7
Upper Experiment	1996	5.86	5.16	6.75	61.5	-4	208	32.7	23	46	0.7	0	2	37.4	16	75	2.6	2.5	3.0	4.0	0	13
Upper Experiment	1997	5.90	5.46	6.5	53.4	13	216	34.0	26	74	0.5	0	1	42.0	9	233	2.5	2.5	2.5	2.3	0	10
Upper Experiment	1998	5.92	5.44	6.46	68.8	3	212	30.0	21	42	0.6	0	4	18.6	9	29	2.8	2.5	6.0	1.9	0	5
Upper Experiment	1999	5.79	5.29	6.49	54.0	1	215	32.4	18	50	0.7	0	4	21.1	7	46	4.7	2.5	6.0	3.1	0	10
Upper Experiment	2000	6.09	5.33	6.43	63.7	2	128	32.3	25	41	1.0	0	2	21.0	10	32	4.3	2.5	6.0	5.0	0	9
Upper Experiment	2001	6.03	5.58	6.31	53.4	11	97	24.5	17	31	0.9	0	2	18.7	10	39	6.4	2.5	11.0	4.0	0	12
Upper Experiment	2002	6.08	5.5	6.51	85.2	6	266	30.9	17	45	0.7	0	2	16.5	6	26	12.2	2.5	21.0	3.7	0	10
Upper Experiment	2003	6.06	5.36	6.6	82.4	2	221	33.2	21	43	0.7	0	2	25.1	10	48	14.5	6.0	35.0	1.8	0	5
Upper Experiment	2004	5.89	5.33	6.66	48.8	0	180	24.0	10	36	0.0	0	0	12.7	8	24	10.4	6.0	18.0	4.0	0	14
Upper Experiment	2005	6.13	5.42	6.64	80.9	1	213	40.2	21	80	0.4	0	3	20.6	6	49	8.6	3.0	15.0	1.8	0	3
Upper Experiment	2006	6.14	5.39	6.64	97.8	8	256	31.3	21	47	0.3	0	1	19	11	30	5.8	1	11	3.1	1	6
Lower Experiment	1995	6.13	5.13	6.77	97.4	-3	220	61.2	29	115	0.0	0	0	291.2	55	749	5.3	2.5	11.0	1.8	0	4
Lower Experiment	1996	5.82	4.98	6.67	62.3	-11	231	42.2	22	75	0.4	0	2	105.1	21	278	3.1	2.5	6.0	4.6	0	12
Lower Experiment	1997	5.91	5.54	6.67	46.2	9	140	34.7	28	44	0.4	0	1	51.8	28	80	5.6	2.5	17.0	2.4	0	7
Lower Experiment	1998	5.85	5.44	6.34	67.4	3	203	38.1	20	65	0.4	0	2	88.4	20	232	3.2	2.5	6.0	7.5	0	42
Lower Experiment	1999	5.70	4.97	6.29	49.9	-6	208	38.3	20	81	0.4	0	1	67.0	10	312	5.4	2.5	8.0	4.2	0	9
Lower Experiment	2000	6.15	5.63	6.39	64.9	3	132	39.9	27	54	0.9	0	2	77.8	18	128	4.3	2.5	6.0	3.9	0	13
Lower Experiment	2001	6.03	5.6	6.37	55.2	10	117	28.1	21	47	1.2	1	2	52.4	19	133	5.3	2.5	6.0	5.4	0	16
Lower Experiment	2002	6.02	5.65	6.37	68.4	11	179	36.5	19	61	0.5	0	2	72.5	13	199	12.4	2.5	24.0	3.2	0	11
Lower Experiment	2003	5.92	5.4	6.21	66.2	3	156	38.4	23	57	0.4	0	2	78.2	20	178	11.9	6.0	18.0	6.4	0	16
Lower Experiment	2004	5.80	5.2	6.76	47.1	-2	190	29.1	12	63	0.0	0	0	50.1	9	210	10.8	7.0	18.0	5.7	2	11
Lower Experiment	2005	6.05	5.38	6.57	77.7	0	222	49.3	21	83	0.6	0	3	102.9	10	351	7.8	3.0	10.0	2.6	0	6
Lower Experiment	2006	6.18	5.47	6.87	104.1	10	304	48.8	21	112	0.1	0	1	155.1	13	546	5.8	0	11	3.4	0	12
Lower ARnB	1995	6.16	5.41	6.8	54.5	7	122	33.5	25	43	2.3	0	9	84.2	26	156	3.4	2.5	6.0	3.2	0	8
Lower ARnB	1996	5.97	5.26	6.69	51.7	0	141	31.3	21	44	1.8	0	8	46.8	22	88	2.7	2.5	4.0	7.4	1	29
Lower ARnB	1997	6.02	5.64	6.63	44.1	18	104	29.0	25	38	1.1	0	4	30.5	20	49	2.9	2.5	6.0	4.0	0	10
Lower ARnB	1998	5.95	5.46	6.52	60.0	6	163	28.4	21	39	0.8	0	3	33.2	18	62	2.5	2.5	2.5	3.2	0	12
Lower ARnB	1999	5.79	5.02	6.56	34.3	-6	110	28.7	21	43	0.6	0	2	29.3	14	51	3.8	2.5	6.0	4.3	0	20
Lower ARnB	2000	6.02	5.47	6.59	43.8	2	97	30.2	24	35	0.7	0	2	32.4	20	47	4.3	2.5	6.0	5.8	2	15
Lower ARnB	2001	5.97	5.3	6.45	37.3	5	91	23.2	18	30	2.0	0	7	27.1	18	37	5.2	2.5	6.0	7.3	0	15
Lower ARnB	2002	5.97	4.59	6.6	58.4	-24	198	29.5	19	44	0.9	0	4	27.6	10	45	12.8	2.5	25.0	6.2	0	22
Lower ARnB	2003	5.99	5.25	6.62	62.1	-1	149	31.6	21	42	0.4	0	2	39.3	14	59	11.3	5.0	19.0	14.6	2	76
Lower ARnB	2004	5.71	5.17	6.66	29.6	-3	119	22.4	13	33	0.0	0	0	17.4	10	27	13.6	8.0	35.0	6.9	1	23
Lower ARnB	2005	6.06	5.36	6.63	60.9	0	156	36.0	18	66	0.8	0	3	30.9	9	48	7.7	3.0	10.0	4.8	0	14
Lower ARnB	2006	6.16	5.37	6.94	65.7	7	163	29.6	15	42	0.5	0	2	31.9	12	52	5.8	0	13	2.6	0	6
Upper ARnB	1995	6.19	5.56	6.59	44.3	9	84	30.8	23	41	2.8	0	8	76.8	20	158	3.4	2.5	6.0	2.3	0	8
Upper ARnB	1996	5.94	5.28	6.67	37.8	-1	114	28.4	20	43	1.7	0	7	42.6	21	82	2.8	2.5	4.0	5.0	1	11
Upper ARnB	1997	6.05	5.63	6.51	48.6	7	202	29.4	24	46	1.1	0	4	25.6	17	44	2.9	2.5	6.0	7.3	0	28
Upper ARnB	1998	6.02	5.54	6.68	44.5	6	130	25.3	20	32	0.6	0	2	23.0	14	33	3.1	2.5	6.0	6.8	0	27
Upper ARnB	1999	5.82	5.22	6.46	27.1	-2	85	27.9	19	45	0.4	0	2	24.8	15	39	4.1	1.0	10.0	3.7	0	13
Upper ARnB	2000	6.14	5.54	6.51	40.0	5	79	28.4	23	32	0.7	0	2	26.7	17	46	4.3	2.5	6.0	2.2	0	6
Upper ARnB	2001	6.02	5.44	6.38	36.9	4	71	21.9	18	27	1.7	0	7	23.3	14	36	9.7	2.5	35.0	8.5	0	22
Upper ARnB	2002	6.13	5.32	6.91	52.8	0	152	25.9	17	36	0.6	0	3	19.7	10	33	12.9	2.5	28.0	6.2	0	14
Upper ARnB	2003	6.03	5.23	6.57	49.0	-2	119	28.8	20	41	0.4	0	2	29.1	14	55	13.8	6.0	25.0	6.0	1	18
Upper ARnB	2004	5.75	5.17	6.67	26.4	-5	94	21.7	13	32	0.0	0	0	14.9	9	24	11.0	7.0	19.0	7.4	1	20
Upper ARnB	2005	6.07	5.24	6.6	45.0	-3	106	33.3	18	67	0.8	0	3	28.1	8	79	7.3	3.0	11.0	3.9	1	7
Upper ARnB	2006	6.16	5.38	6.58	62.1	8	143	27.4	17	36	0.7	0	3	22.1	13	33	5.9	1	16	4.6	0	12
Laidon Outflow	1995	5.93	5.71	6.15	19.0	14	24	23.5	23	24	2.0	2	2	39.0	35	43	2.5	2.5	2.5	1.0	0	2
Laidon Outflow	1996	5.92	5.52	6.27	19.4	6	35	25.8	18	32	3.7	2	6	49.5	34	91	3.1	2.5	6.0	2.1	0	7
Laidon Outflow	1997	5.91	5.51	6.31	14.7	2	26	29.0	25	33	2.3	1	5	30.9	27	34	3.4	2.5	10.0	2.4	0	8
Laidon Outflow	1998	5.93	5.63	6.15	19.0	10	28	24.8	22	28	1.9	1	3	28.5	24	34	4.3	2.5	17.0	2.6	1	6
Laidon Outflow	1999	5.87	5.48	6.09	17.2	2	23	27.6	24	36	1.3	0	3	25.3	12	31	4.3	2.5	6.0	1.9	0	12
Laidon Outflow	2000	5.86	5.3	6.11	13.8	-1	23	30.5	25	39	1.3	1	2	28.6	22	34	5.0	2.5	17.0	2.0	0	5
Laidon Outflow	2001	6.02	5.67	6.31	25.1	10	34	22.2	20	24	3.7	2	8	27.6	22	32	6.7	2.5	14.0	1.5	0	3
Laidon Outflow	2002	5.96	5.64	6.27	20.0	10	33	29.6	21	41	1.4	0	3	28.9	25	37	9.6	2.5	25.0	4.4	0	9
Laidon Outflow	2003	5.99	5.83	6.28	21.2	12	36	27.1	24	30	2.0	1	3	30.9	29	34	10.8	6.0	20.0	2.0	0	6
Laidon Outflow	2004	5.93	5.5	6.26	20.6	9	33	24.1	22	27	0.9	0	4	22.9	19	29	16.6	10.0	27.0	5.0	0	15
Laidon Outflow	2005	5.92	5.59	6.15	18.8	4	34	36.1	26	52	1.3	0	3	28.9	23	39	6.3	3.0	11.0	1.2	0	4
Laidon Outflow	2006	6.02	5.69	6.28	20.6	11	25	23.9	21	26	1.5	1	2	27.5	20	63	6.3	2	15	1.8	0	4
Forest	2000	6.29	5.72	7.27	123.7	19	330	36.0	22	58	0.7	0	2	25.7	14	45	5.7	2.5	12.0	13.7	0	33
Forest	2001	5.78	5.4	6	28.1	9	47	20.8	16	25	0.7	0	2	18.9	10	36	7.1	2.5	17.0	7.6	0	34
Forest	2002	5.82	5.48	6.1	43.3	5	111	26.5	17	36	0.2	0	1	16.8	8	31	11.0	2.5	26.0	15.1	1	51
Forest	2003	5.70	5.42	6	45.4	4	126	28.4	18	41	0.2	0	2	23.8	7	45	12.4	7.0	17.0	6.7	1	16
Forest	2004	5.69	5.39	6.03	22.0	0	65	21.1	13	32	0.0	0	0	13.7	9	24	12.1	8.0	24.0	12.8	3	24
Forest	2005	5.63	5.09	6.14	27.0	-7	100	33.6	20	74	0.0	0	0	19.6	6	49	7.6	2.0	12.0	4.9	1	13
Forest	2006	5.66	5.32	5.91	40.9	3	150	25.3	19	33	0.2	0	1	16.5	7	30	6.6	3	13	7.3	3	15

Table 6 Water chemistry for the Control Burn August 1992 – April 2010

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
12/08/1992	5.44	8	24	106		3	34	68	94	0	26	1		70	18	0.74	
30/10/1992	6.46	63	23	112		4	32	68	99	0	28	0		29	4	0.32	5
30/10/1992	6.46	63	23	112		4	32	68	99	0	28	0		29	4	0.323	5
06/12/1992	5.7	10	20	104		3	17	43	103	0	25	1		33	2	0.246	3.5
04/01/1993	5.63	8	20	105		4	25	41	101	0	44	0		21	3	0.269	3.8
30/03/1993	5.91	17	39	203		5	44	67	278	0	41	1		20	3	0.174	3.1
03/05/1993	6.57	91	35	177		6	42	97	186	0	35	0		9	5	0.167	3.3
18/06/1993	6.38	64	31	145		4	39	88	130	0	30	1	19	15	29	0.549	9.4
10/07/1993	6.31	57	27	141		4	33	77	129	0	19	2	26	71	1	0.61	9.1
25/07/1993	6.06	45	27	134		3	38	92	117	0	16	2		72	0	0.782	11
09/08/1993	5.91	32	23	114		3	33	72	98	2	11	4		92	13	0.884	12
22/08/1993	6.54	92	27	148		4	42	91	141	0	18	2		39	4	0.479	6.2
04/09/1993	6.76	147	36	168		7	46	111	151	0	26	0		17	1	0.288	4.3
29/09/1993	6.91	141	36	161		6	47	114	155	0	31	0		26	5	0.289	4.4
06/12/1993	5.59	8	20	99		4	25	32	86	1	38	1		37	5	0.459	6.7
18/02/1994	6.34	57	39	210	0	6	66	101	211	2	41	0	5	14	0	0.132	
01/05/1994	6.03	29	24	141	0	9	34	56	123	0	25	0	10	36	8	0.309	4.4
12/05/1994	6.48	62	29	161	0	6	48	82	143	0	30	0		22	5	0.213	3.2
10/06/1994	6.39	54	39	201	0	9	68	110	174	0	85	1		30	4	0.283	5.2
08/07/1994	5.98	39	27	151	0	6	52	83	111	0	35	1		80	0	0.632	11
07/08/1994	6.12	35	23	140	0	5	46	71	109	0	26	4	58	60	2	0.555	8.4
25/08/1994	6.47	68	29	152	0	5	61	113	118	0	27	1	2.5	41	1	0.564	9.1
03/09/1994	6.68	105	31	163	0	6	60	110	125	2	24	1	2.5	28	7	0.339	5.5
22/09/1994	6.5	86	29	152	0	6	56	119	123	0	23	1		26	17	0.385	7.5
29/12/1994	5.18	-3	23	108	0	4	30	31	126	1	23	1		24	0	0.198	4
27/03/1995	5.86	16	21	121	0	6	31	41	122	0	22	0	2.5	29	2	0.239	4.8
27/04/1995	6.61	85	24	133	0	8	43	81	107	0	20	0	2.5	16	0	0.204	4.8
02/06/1995	6.38	58	26	137	0	4	41	75	103	0	18	3	3	29	28	0.49	9.9
15/07/1995	6.65	87	40	178	0	9	75	128	127	2	96	0	2.5	29	1	0.34	8.9
06/08/1995	7.02	161	37	195	0	11	67	146	143	1	44	0		21	0	0.285	6
25/08/1995	6.77	116	37	186	0	10	62	115	144	2	37	1	2.5	20	1	0.262	5.6
04/09/1995	6.51	68	46	188	0	7	90	157	118	0	175	0	6	34	3	0.313	7.6
24/09/1995	5.72	18	34	156	0	5	66	99	108	0	107	0		62	4	0.469	11
11/11/1995	6.27	51	25	124	0	6	48	85	95	0	39	0	2.5	65	2	0.43	8.7
10/01/1996	5.39	2	20	100	3	6	37	50	78	2	59	0	2.5	44	5	0.297	6.6
27/02/1996	5.49	7	29	152	0	5	55	68	166	1	60	0	2.5	28	2	0.238	4.7
03/04/1996	5.72	13	24	124	3	6	39	61	112	5	49	1	2.5	28	0	0.243	5.3
02/05/1996	6.26	61	28	136	0	5	50	88	113	0	49	0	2.5	30	4	0.251	5.1
12/06/1996	5.68	18	22	109	0	2	38	62	88	0	21	3	10	70	2	0.586	11.3
04/07/1996	6.21	46	28	131	0	4	49	83	93	0	47	2	2.5	48	10	0.513	13.9
27/07/1996	6.54	83	29	143	0	5	61	112	102	0	31	1	2.5	48	2	0.551	11
18/08/1996	6.9	173	34	160	0	7	69	144	110	0	26	0	2.5	24	0	0.386	7.7
07/09/1996	6.61	124	30	159	0	7	71	131	114	1	24	1	2.5	31	5	0.496	10
28/09/1996	6.34	53	38	164	0	9	74	125	163	1	62	0	2.5	58	5	0.486	11.2
30/10/1996	5.69	16	20	94	0	7	37	57	79	0	18	4		69	10	0.564	11
03/12/1996	5.49	4	44	219	3	7	67	73	296	3	40	0	2.5	38	1	0.165	4
28/01/1997	6.25	41	26	128	2	5	42	72	102	2	43	0	2.5	40	0	0.301	6.2
10/03/1997	6.93	19	37	190	0	7	57	80	228	2	41	0	2.5	23	0	0.141	3.1
30/04/1997	6.2	43	29	170	0	5	52	89	162	2	25	1	2.5	46	0	0.384	7.7
21/05/1997	6.35	54	26	142	1	5	45	79	118	1	19	1	2.5	52	4	0.487	9.9
05/07/1997	6.55	92	31	160	4	7	54	100	121	0	29	0	2.5	29	10	0.41	8.8
30/07/1997	6.2	53	26	135	0	4	54	100	104	0	13	2	2.5	86	4	0.87	7.2

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
19/08/1997	6.94	146	36	169	0	8	67	135	122	0	24	0	2.5	32	9	0.447	9.5
07/09/1997	6.02	32	25	130	0	4	48	82	106	0	17	1	2.5	88	4	0.708	13.7
05/10/1997	6.06	35	30	143	0	8	55	96	145	0	20	0	2.5	58	10	0.607	13
14/11/1997	5.65	18	23	119	1	12	44	65	101	1	28	1	6	73	7	0.64	15
05/01/1998	5.91	15	25	139	0	6	46	60	159	1	29	0	2.5	34	2	0.213	4.3
05/02/1998	5.86	19	21	105	0	4	35	53	94	1	27	1	2.5	44	0	0.313	7.8
21/03/1998	6.31	45	33	174	0	7	52	74	192	0	29	0	2.5	20	5	0.161	3.5
07/05/1998	5.94	27	24	137	0	5	42	66	115	0	15	1	2.5	45	8	0.525	10.9
20/06/1998	6.75	147	36	177	0	7	60	114	120	0	35	2	2.5	1	13	0.204	5.1
20/07/1998	6.24	59	24	125	0	2	51	87	82	0	13	1	2.5	66	1	0.716	14.7
09/08/1998	6.23	62	23	129	0	3	53	82	79	0	13	1	2.5	59	16	0.704	13.3
29/08/1998	6.63	119	29	143	0	5	54	102	92	0	19	9	11	29	2	0.365	6.9
27/09/1998	6.82	169	33	151	0	6	67	132	108	0	23	0	2.5	21	2		6.4
25/10/1998	5.82	21	21	101	0	6	37	61	89	0	18	2	2.5	51	3	0.49	9.3
25/11/1998	5.61	9	26	129	0	3	40	57	146	0	24	2	2.5	34	2	0.327	6.9
12/02/1999	5.76	9	48	258	0	9	73	92	337	1	37	1	6	15	2	0.112	3.1
25/03/1999	5.74	13	26	147	1	5	35	45	161	0	20	1	2.5	28	4	0.289	6.4
10/05/1999	5.81	23	26	149	0	6	43	64	133	0	27	3	6	53	4	0.58	12.9
17/06/1999	6.09	38	25	146	0	4	44	73	134	0	10	2	6	63	4	0.552	11.3
12/07/1999	6.53	103	30	168	0	8	62	118	127	0	18	0		57	2	0.617	13
01/09/1999	6.04	40	30	146	0	4	62	106	120	0	54	3	6	59	7	0.581	12
26/09/1999	5.62	19	19	104	0	5	37	54	81	0	16	4	6	50	3	0.612	12.7
06/11/1999	5.29	2	23	115	0	7	33	42	126	1	21	0	2.5	30	6	0.357	8.1
20/01/2000	6.11	29	26	141	0	3	41	63	145	0	26	2	2.5	33	0	0.197	4.4
05/03/2000	5.46	4	28	168	0	3	39	48	185	1	27	1	2.5	26	1	0.192	4.8
14/04/2000	6.59	81	31	166	0	6	52	106	158	0	21	0	2.5	16	7	0.209	4.7
31/05/2000	6.53	78	34	188	0	5	64	108	149	0	59	0	2.5	26	13	0.336	7.2
17/06/2000	6.56	-7	35	190	0	5	67	114	181	1	31	0	2.5	32	0	0.25	5.8
12/07/2000	6.7	75	31	169	0	4	62	110	147	1	26	0	2.5	25	11	0.354	8.2
05/08/2000	6.6	92	35	175	2	5	62	108	146	2	38	0	2.5	30	3	0.391	9.3
04/09/2000	6.75	127	36	170	0	5	67	128	154	0	18	0	6	20	6	0.425	9.3
08/10/2000	5.75	22	27	142	0	5	46	68	144	0	16	0	2.5	67	9	0.613	12.5
21/11/2000	6.24	44	24	132	0	3	43	71	116	1	19	0	2.5	44	0	0.407	8.2
09/01/2001	6.01	27	18	102	0	5	30	52	75	1	22	0	21	50	1	0.413	8.5
08/03/2001	5.56	6	20	95	1	8	31	40	92	6	32	0	10	41	1	0.227	
26/04/2001	6.23	41	26	130	1	5	43	77	115	0	32	0	6	26	24	0.416	8.9
06/06/2001	6.63	97	31	150	0	5	51	105	103	0	34	0	2.5	18	9	0.387	8.4
03/07/2001	6.3	60	23	125	0	3	45	96	75	0	17	0	6	86	4	0.769	14.1
23/07/2001	6.39	74	25	123	3	4	50	97	90	2	15	0	2.5	40	14	0.645	12.7
19/08/2001	6.31	62	22	108	0	3	45	110	70	0	13	3	6	37	23	0.725	14.1
07/10/2001	5.58	14	24	111	0	9	39	51	112	1	15	2	6	44	9	0.548	12
14/11/2001	6.32	56	22	107	0	6	41	75	88	1	19	2	2.5	32	3	0.379	8.7
10/12/2001	6.42	64	21	113	0	7	43	78	86	1	22	1	6	33	4	0.356	7.3
22/01/2002	5.32	0	18	94	0	5	22	24	99	0	15	0	2.5	25	0	0.237	5.4
04/04/2002	6.25	41	34	201	0	8	51	77	215	1	32	1	2.5	16	0	0.252	5.4
07/05/2002	6.65	103	35	194	0	8	54	99	164	0	26	1	6	11	0	0.204	4.8
12/06/2002	5.87	30	20	121	0	3	37	56	78	0	13	3	6	64	0	0.755	14.9
14/07/2002	6.56	102	26	144	0	5	53	101	100	0	13	2	11	22	8	0.541	11.5
31/07/2002	5.81	33	19	99	0	3	40	65	57	0	9	3	17	53	21	0.933	19
01/09/2002	6.49	87	28	148	0	7	63	114	116	0	17	0	27			0.635	14.8
29/09/2002	6.84	199	41	170	0	8	80	174	126	0	21	0	6	17	0	0.276	5.9
21/10/2002	5.94	28	33	141	0	17	65	87	182	0	33	3	6	25	1	0.42	10.9
08/12/2002	6.42	73	26	122	0	6	47	88	99	1	28	1	21	30	1	0.375	8.2
26/01/2003	5.34	1	42	203	0	8	68	78	272	0	36	0	17	28	0	0.184	3.4
03/03/2003	5.99	20	29	154	2	8	42	58	157	1	46	1	6	32	5	0.261	5.6
28/04/2003	6.31	46	37	191	4	8	62	103	183	0	63	0	10	30	2	0.368	

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
11/06/2003	5.95	38	22	118	0	2	41	69	85	1	11	12	19	47	10	0.792	15.1
24/07/2003	5.9	40	23	122	2	5	45	79	89	0	24	2	11	51	3	0.621	13.9
10/08/2003	6.69	128	31	161	0	6	66	132	116	0	21	1	9	27	1	0.472	14.8
08/09/2003	6.93	184	39	170	0	8	74	155	128	0	27	1	13	12	1	0.249	9.5
27/10/2003	6.74	155	37	174	0	9	94	202	159	0	24	1	8	7	2	0.191	15.9
16/12/2003	6.35	57	22	119	0	6	42	77	97	0	25	0	11	26	2	0.298	5.5
11/02/2004	5.22	-4	34	171	0	5	44	49	219	0	26	3	7	20	3	0.143	2.3
09/04/2004	6.42	52	24		0	0	58	105	124	0	21	11	8	34	10	0.314	5.4
20/05/2004	6.24	55	22	112	0	0	50	104	88	0	9	4	9	51	14	0.664	12
16/06/2004	6.16	50	19	103		2.6	32.5	68.8	62	0	11	4	10	61	12	0.762	13.5
14/07/2004	6.89	131	30	141.2		5.1	46.3	98.2	88	0	18	2	10	19	7	0.1	5.1
10/08/2004	5.29	9	19	80	0	6	35	52	58	0	12	5		41	16	0.836	13
13/09/2004	5.6	18	22	90.5	0	7	38	55	86	0	10	3	12	41	8	0.635	11
05/10/2004	5.26	0	18	67	0	8	20	27	86	0	10	2	4	18	2	0.285	0.5
14/12/2004	5.37	4	12	50	0	5	10	16	47	0	14	1	10	10	0	0.31	4.2
26/01/2005	5.48	2	68	349	0	9	91	88	489	2	47	1	8	7	6	0.077	1.6
02/03/2005	6.43	60	43	216	1	8	57	86	259	0	29	6	10	6	5	0.119	2
20/04/2005	6.47	61	32	173	0	8	44	63	164	0	21	2	4	24	6	0.301	5.6
06/06/2005	5.68	25	19	101	0	3	26	37	66	0	7	3	5	47	5	0.744	13.4
14/07/2005	6.81	178	37	181	0	9	66	139	136	0	22		6	16	2	0.353	7.3
15/08/2005	6.77	129	35	154	0	6	60	125	137	0	24	1	8	10	1	0.411	8.2
07/09/2005	6.73	121	32	147	0	6	55	96	126	0	18	0	9	5	2	0.377	6.8
04/10/2005	5.99	26	26	127	0	5	39	56	148	0	13	0	7	35	0	0.357	7.8
06/12/2005	6.03	23	29	142	0	4	34	49	167	0	24	0	2	23	8	0.212	5
08/02/2006	5.57	13	22	105	0	7	26	36	96	0	28	1	0	40	6	0.377	9.4
26/03/2006	6.45	65	22	110	0	6	32	63	90	0	29	12	4.13	21	2	0.262	5.1
11/05/2006	6.67	112	33	155	0	8	48	85	130	0	24	1	2.55	8	3	0.209	5.35
07/06/2006	6.81	167	38	167	0	8	58	120	128	0	24	4	3.23	9	1	0.244	9.15
29/06/2006	6.75	151	33	156	26	5	58	111	120	0	25	4	5.59	18	1	0.288	13.2
27/07/2006	6.93	225	43	189	0	10	73	153	129	0	26	7	10.09	13	3	0.306	8.68
21/08/2006	6.36	72	29	138	1	4	51	94	115	0	20	2	11.86	40	5	0.686	15.24
13/09/2006	6.72	121	30	144	0	6	53	101	113	0	15	1	5.65	21	4	0.46	10.89
26/10/2006	5.39	8	17	78	0	8	25	35	63	0	11	0		29	10	0.519	12.09
23/11/2006	5.73	10	27	136	0	6	37	50	166	1	23	0	5.4	18	2	0.204	4.26
10/01/2007	5.7	11	25	129	0	5	30	40	146	0	18	0	4.66	14	1	0.223	6.36
21/02/2007	6.23	36	34	185	3	7	45	66	206	1	28	0	6.41	20	0	0.252	6.69
05/04/2007	6.71	132	40	191	3	8	59	105	190	1	26	0	5.41	3	0	0.15	3.87
04/06/2007	5.9	30	24	134	0	2	30	49	110	0	7	2	10.1	42	1	0.672	12.43
03/07/2007	6.27	73	25	134	6	3	43	70	93	0	9	3	12.87	45	3	0.831	15.08
09/08/2007	6.45	88	23	132	0	3	46	78	97	1	12	2	8.21	29	3	0.538	9.89
30/08/2007	6.85	120	31	141	0	4	60	114	117	0	11	0	11.76	30	6	0.646	12.1
25/10/2007	6.76	163	35	152	0	8	64	124	132	0	16	0	7.38	12	2	0.36	6.55
05/12/2007	5.76	17	19	90	1	5	24	36	91	1	11	0	6.29	12	4	0.434	8.85
05/02/2008	5.65	9	24	119	0	5	27	33	143	0	19	2	5.82	17	6	0.167	5.82
02/04/2008	5.76	11	27	149	0	5	29	37	170	0	21	0	5.87	8	0	0.215	4.02
16/07/2008	6.53	103	31	146	0	4	54	106	110	0	19	4	10.25	33	0	0.643	11.66
01/09/2008	5.82	31	22	114	0	4	40	67	87	0	7	0	8.23	59	5	0.842	16.47
03/10/2008	5.37	8	24	104	0	6	35	45	108	0	10	0	5.76	22	9	0.611	11.99
09/12/2008	6.14	35	24	118	0	3	30	44	117	0	19	6	3.02	18	2	0.28	6.16
12/01/2009	5.38	3	26	131	1	5	28	31	153	0	20	9	6.54	16	3	0.216	7.93
18/03/2009	6.03	24	26	136	0	3	28	37	140	0	19	0	2.62	23	5	0.223	4.65
27/04/2009	5.72	20	27	143	1	3	31	43	121	0	13	0	4.81	18	16		12.09
12/05/2009	6.37	58	29	147	0	3	35	49	138	0	16	0	2.51	17	1		5.48
12/06/2009	6.84	173	40	176	2	7	57	101	141	0	24	0	7.33	9	1	0.049	4.16
15/07/2009	5.52	34	22	102	0	11	35	51	77	0	13	1	6.01	32	5	0.738	15.22
11/08/2009	6.36	71	28	129	2	3	50	87	107	2	7	0	6.98	50	2	0.793	22.82

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
28/09/2009	6	33	33	111	1	4	41	59	116	0	9	6	7.3	47	8	0.458	13.54
16/11/2009	5.73	16	15	72	0	4	20	29	56	0	10	0	9.04	29	4	0.493	7.86
30/04/2010	5.98	29	21	104	0	3	29	48	85	0	11	2	3.7	36	0	0.544	10.49

Table 7 Water chemistry for the Experimental Burn (Upper site) September 1992 - October 2008

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
18/09/1992	5.71	20	33	136		3	36	113	152	0	82	0		21	1	0.412	
30/10/1992	6.19	52	26	130		3	32	61	128	0	26	0		15	0	0.271	4.4
06/12/1992	5.23	-1	19	93		2	14	27	88	0	23	0		27	0	0.261	3.4
04/01/1993	5.43	4	19	98		2	21	31	86	0	35	0		12	0	0.273	3.8
30/03/1993	5.86	20	41	230		5	44	64	296	1	45	2		9	3	0.165	2.9
03/05/1993	6.42	115	37	204		7	44	95	192	1	29	0		5	2	0.262	4.2
18/06/1993	6.33	122	37	202		4	44	100	156	0	16	0	19	19	9	0.509	8.2
10/07/1993	6.05	62	29	164		4	35	76	139	0	18	3	22	46	1	0.701	9.5
25/07/1993	5.71	36	29	156		2	42	73	130	0	12	3		48	9	0.858	13
09/08/1993	5.93	51	29	151		4	42	76	131	0	8	5		54	0	0.878	13
22/08/1993	6.36	142	33	186		6	60	108	159	1	14	3		28	2	0.654	8.7
04/09/1993	6.47	213	45	210		7	68	159	171	2	22	1		10	2	0.409	6.4
29/09/1993	6.6	171	45	209		15	64	135	207	2	28	0		20	0	0.35	5.6
06/12/1993	5.29	1	21	105		3	24	26	87	0	39	6		24	2	0.492	6.8
18/02/1994	6.3	66	44	243	0	6	75	109	246	1	49	1	0	5	0	0.096	
01/05/1994	5.88	27	29	183	0	4	44	58	159	0	28	1	13	26	7	0.414	5.4
12/05/1994	6.36	85	36	202	7	7	58	90	176	0	26	0		19	4	0.279	5
10/06/1994	6.25	67	40	224	0	5	62	100	200	0	51	0		22	2	0.292	5.2
08/07/1994	5.75	38	29	178	0	3	53	75	122	1	24	2		45	1	0.836	14
07/08/1994	6.78	130	31	181	0	13	78	137	141	1	19	4	60	17	6	0.454	7.6
25/08/1994	6.29	76	32	177	0	7	71	111	141	1	18	2	2.5	28	3	0.629	9.9
03/09/1994	6.51	136	37	200	0	12	81	136	153	1	16	5	2.5	18	3	0.488	7.6
22/09/1994	6.27	95	33	186	0	7	66	123	160	0	13	2		21	0		7.3
29/12/1994	5.47	5	24	125	0	6	39	36	139	0	24	1		35	3	0.238	4.6
27/03/1995	5.74	15	22	129	0	5	32	40	121	0	21	2	2.5	18	1	0.26	5.3
27/04/1995	6.1	61	29	168	0	15	48	80	158	0	24	1	2.5	30	1	0.284	6.6
02/06/1995	6.26	60	29	169	0	5	47	68	129	0	13	1	2.5	35	7	0.548	11
15/07/1995	6.46	140	46	202	0	6	86	154	138	0	94	1	2.5	12	2	0.343	8.5
06/08/1995	6.51	195	40	219	0	8	86	164	155	1	30	1		15	1	0.417	8.6
25/08/1995	6.81	221	49	225	0	7	99	176	171	0	35	1	2.5	9	0	0.266	6.1
04/09/1995	6.22	70	63	239	0	8	134	208	125	1	302	0	6	14	0	0.239	6.8
24/09/1995	5.21	0	35	167	0	5	66	84	115	0	112	0		37	5	0.494	12
11/11/1995	5.91	37	26	139	0	4	47	72	98	1	37	0	2.5	32	6	0.473	8.7
10/01/1996	5.31	0	23	126	2	6	42	47	96	1	68	0	2.5	35	5	0.305	6.6
27/02/1996	5.28	0	28	152	0	4	51	55	166	1	56	0	2.5	19	8	0.237	4.8
03/04/1996	6.29	67	36	189	4	12	62	105	172	1	75	1	2.5	15	0	0.17	4.7
02/05/1996	6.06	62	31	159	2	6	51	83	132	0	44	0	2.5	21	3	0.311	6.5
12/06/1996	5.41	13	24	127	0	2	36	47	103	0	17	3	3	41	2	0.627	12.6
04/07/1996	5.83	39	27	144	0	3	51	77	104	0	32	1	2.5	23	13	0.586	19.8
27/07/1996	6.24	124	34	168	0	4	71	128	122	0	19	2	2.5	20	2	0.52	12.7
18/08/1996	6.75	208	41	198	0	7	89	169	140	1	20	1	2.5	14	1	0.464	9.7
07/09/1996	6.13	117	35	174	0	9	78	130	136	1	16	2	2.5	27	4	0.677	14
28/09/1996	6.31	102	42	194	0	9	78	128	183	1	42	1	2.5	18	1	0.372	9.3
30/10/1996	5.53	10	25	118	0	10	41	53	112	0	20	2		46	8	0.505	10
03/12/1996	5.16	-4	46	227	0	7	72	73	305	2	40	0	2.5	25	1	0.166	3.9

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
28/01/1997	5.95	28	26	142	2	4	39	58	106	1	43	0	2.5	26	1	0.371	7.4
10/03/1997	5.68	14	39	204	0	6	57	70	241	1	38	0	2.5	15	0	0.154	3.3
30/04/1997	5.88	31	30	178	0	5	49	72	168	1	17	0	2.5	27	0	0.37	7.5
21/05/1997	5.98	41	27	152	0	3	43	67	125	0	13	2	2.5	33	0	0.55	11.2
05/07/1997	6.12	79	29	166	6	8	50	87	114	1	14	1	2.5	30	10	0.59	12
30/07/1997	6.02	63	28	155	0	4	58	93	112	0	9	2	2.5	39	0	0.841	17.7
19/08/1997	6.5	216	74	229	0	10	95	380	148	1	233	1	2.5	25	0	0.638	14
07/09/1997	5.69	23	26	140	0	4	52	73	116	0	12	2	2.5	59	6	0.766	15
05/10/1997	5.76	26	33	158	0	9	64	86	183	0	14	1	2.5	46	1	0.541	12
14/11/1997	5.46	13	28	143	0	16	51	59	127	0	27	1	2.5	50	3	0.697	16
05/01/1998	5.44	3	32	167	0	5	61	62	214	0	29	0	2.5	25	0	0.195	4
05/02/1998	5.64	15	21	110	0	3	35	45	93	1	27	1	2.5	26	0	0.361	8.2
21/03/1998	6.19	54	38	185	0	6	58	80	208	1	26	0	2.5	9	5	0.135	3.4
07/05/1998	5.63	17	27	146	0	4	43	53	129	0	13	1	2.5	30	5	0.507	10.9
20/06/1998	6.46	161	36	194	0	6	65	119	129	0	20	2	2.5	16	0	0.271	6.9
20/07/1998	5.89	45	23	130	0	1	52	74	77	0	9	2	2.5	46	1	0.773	16.3
09/08/1998	6.05	70	26	140	0	4	62	86	86	0	10	2	2.5	43	3	0.751	16.5
29/08/1998	6.33	159	36	172	0	7	76	129	117	1	15	3	6	24	0	0.437	9
27/09/1998	6.43	212	42	189	2	8	96	169	145	4	17	2	2.5	35	3	0.529	11
25/10/1998	5.56	15	23	109	0	9	43	55	103	0	17	2	2.5	38	0	0.522	9.8
25/11/1998	5.46	6	26	136	0	4	42	52	144	0	22	1	2.5	39	4	0.371	7.9
12/02/1999	5.7	8	50	278	0	7	83	93	363	1	36	0	6	13	2	0.119	3.7
25/03/1999	5.56	8	28	167	2	5	37	42	177	0	20	1	2.5	29	0	0.358	7.9
10/05/1999	5.67	20	28	168	0	6	44	55	153	0	18	3	6	49	1	0.608	14.3
17/06/1999	5.84	32	27	164	0	2	46	60	143	0	7	3	6	47	1	0.613	12.3
12/07/1999	6.21	133	36	196	0	6	87	129	138	1	11	31		50	5	0.93	19.3
03/08/1999	6.49	215	46	222	0	10	100	167	158	4	20	1	6	34	10	0.639	13.3
01/09/1999	6.07	61	35	173	0	5	70	109	157	0	46	0	2.5	18	2	0.431	9.7
26/09/1999	5.32	8	18	92	0	9	33	41	75	0	10	4	6	30	6	0.624	13.7
06/11/1999	5.29	1	24	129	0	10	36	45	134	0	22	0	2.5	22	1	0.354	5.9
20/01/2000	6.01	37	28	167	0	3	47	70	167	0	32	6	6	13	0	0.171	3.9
05/03/2000	5.33	2	27	161	0	5	35	40	171	1	25	1	2.5	19	0	0.19	4.5
14/04/2000	6.31	84	34	191	0	6	54	104	182	1	19	0	2.5	7	3	0.186	4.7
31/05/2000	6.16	56	32	193	0	3	56	84	155	1	30	0	2.5	24	9	0.444	9.6
17/06/2000	6.43	90	35	207	0	5	68	100	177	2	18	0	2.5	15	9	0.347	8.1
12/07/2000	6.36	76	33	189	0	4	67	104	158	1	19	2	6	23	6	0.503	12
05/08/2000	6.3	105	38	194	2	5	73	110	154	2	26	4	6	23	1	0.546	13.6
04/09/2000	6.34	128	41	200	0	7	83	129	182	1	10	0	6	22	9	0.624	13
08/10/2000	5.62	20	30	160	0	13	54	64	171	0	13	1	2.5	37	7	0.628	11.9
21/11/2000	6.01	39	25	139	0	5	42	56	125	1	18	0	6	21	6	0.406	8.3
09/01/2001	5.98	32	17	100	0	4	31	49	69	1	18	0	6	22	2	0.383	7.9
08/03/2001	5.58	11	21	109	1	5	31	40	100	1	39	0	2.5	29	0	0.327	
26/04/2001	5.96	28	27	147	2	5	45	65	135	0	28	0	6	21	10	0.414	9.7
06/06/2001	6.3	97	31	164	1	4	53	95	119	0	16	0	6	12	4	0.388	9.2
03/07/2001	5.98	62	24	137	0	3	48	78	84	0	12	0	11	54	0	0.792	15.1
23/07/2001	6.22	73	24	135	2	4	54	78	90	2	11	0	6	35	3	0.69	14.3
19/08/2001	6.12	91	27	127	1	5	64	93	90	1	10	5	6	13	12	0.693	15.5
07/10/2001	5.6	16	28	112	0	15	48	51	137	1	15	2	6	30	0	0.488	11.5
14/11/2001	6.31	61	24	119	0	11	48	76	107	2	17	3	6	16	4	0.361	10
10/12/2001	6.28	63	22	114	0	8	46	72	94	1	21	7	8	12	5	0.338	7.6
22/01/2002	5.5	6	17	106	0	6	28	32	111	0	16	0	6	21	2	0.246	5.9
04/04/2002	6	36	40	252	0	9	58	76	288	1	26	1	2.5	13	0	0.215	4.9
07/05/2002	6.38	119	38	227	0	9	61	104	190	1	20	1	6	10	0	0.24	4.8
12/06/2002	5.99	49	23	148	0	4	46	61	86	0	8	5	11	28	0	0.752	15.9
14/07/2002	6.36	137	35	168	0	5	75	115	115	0	12	10	13	7	10	0.625	14
31/07/2002	5.9	56	22	116	0	4	62	78	67	0	6	6	21	29	8	0.94	20

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
01/09/2002	6.34	110	32	159	0	6	83	122	138	1	11	1	2.5	23	0	0.669	16.6
29/09/2002	6.51	266	45	200	0	9	96	173	163	2	16	0	19	4	6	0.289	8.5
21/10/2002	5.55	12	33	148	0	23	68	73	199	0	26	3	21	11	8	0.448	12
08/12/2002	6.22	61	24	132	0	6	45	73	102	2	24	1	20	22	3	0.362	8.4
26/01/2003	5.36	2	41	198	0	5	61	61	259	0	35	1	18	17	5	0.176	4.5
03/03/2003	5.95	16	35	184	2	7	47	55	192	1	48	0	6	31	3	0.239	5.3
28/04/2003	6.05	44	35	202	3	6	54	77	193	1	37	0	13	16	4	0.357	8.3
11/06/2003	5.8	38	22	135	0	1	40	55	81	0	10	3	35	23	1	0.8	14.5
21/07/2003	5.86	50	24	132	2	4	51	77	87	0	18	3	12	20	0	0.674	14.4
10/08/2003	6.45	197	39	189	0	7	102	174	127	1	14	3	11	18	1	0.645	15.7
08/09/2003	6.6	221	43	197	0	7	89	171	156	2	18	2	13	6	0	0.278	8.9
27/10/2003	6.32	124	39	196	5	9	93	181	209	1	22	0	8	2	1	0.117	14.6
16/12/2003	6.15	50	21	118	0	4	39	67	89	0	24	0	10	15	1	0.33	6
12/02/2004	5.33	0	34	178	0	6	54	53	227	0	24	0	6	13	4	0.138	2.2
09/04/2004	6.19	44	26	151	0	1	58	85	138	0	18	1	8	14	1	0.296	5.3
20/05/2004	6.44	100	28	159	9	1	75	144	117	1	11	4	10	15	0	0.423	9.4
16/06/2004	6.21	63	19	113		2	30	51	64	0	8	5	11	26	2	0.644	12.5
14/07/2004	6.66	180	36	165.9		4.3	64.5	120.5	102	0	13	4	11	10	5	0.208	5.9
10/08/2004	5.41	15	20	93	0	7	41	60	66	0	11	5		23	14	0.795	12.7
13/09/2004	5.68	23	24	98.9	0	7	38	53	101	0	8	7	18	14	5	0.556	9.9
05/10/2004	5.44	4	19	75	0	11	23	31	95	0	10	1	7	10	3	0.26	4
14/12/2004	5.65	10	10	48	0	4	9	15	43	0	11	2	12	5	2	0.284	3.8
26/01/2005	5.42	1	80	404	0	8	107	105	527	3	49	2	8	0	1	0.041	1.2
02/03/2005	6.2	38	46	249	0	7	57	72	294	0	31	0	15	3	2	0.11	1.9
20/04/2005	6.32	61	34	195	1	9	44	52	186	0	13	1	5	16	3	0.298	5.7
06/06/2005	5.67	29	21	123	1	3	27	31	80	0	6	3	6	23	3	0.742	13.6
14/07/2005	6.49	213	42	195	0	6	82	144	130	0	14	5	10	16	0	0.53	9.9
15/08/2005	6.64	200	41	181	0	5	80	147	148	0	19	2	9	3	2	0.332	7.8
07/09/2005	6.52	132	35	161	0	6	63	104	139	1	14	1	12	7	3	0.45	8.3
04/10/2005	5.92	28	31	138	0	4	44	53	170	0	11	1	9	10	2	0.259	6.3
06/12/2005	6	26	32	160	0	4	37	50	181	0	28	18	3	10	0	0.189	4.7
08/02/2006	5.71	19	26	126	0	7	28	41	128	0	30	5	1	21	5	0.261	6.6
26/03/2006	6.14	40	21	111	0	6	26	42	93	1	30	8	4	15	1	0.24	4.7
11/05/2006	6.35	117	36	173	0	8	54	85	153	0	16	5	4.47	7	6	0.257	5.5
07/06/2006	6.57	165	39	182	0	6	61	110	142	0	16	3	6.95	12	2	0.294	8.23
29/06/2006	6.37	152	34	156	115	3	58	101	115	0	14	5	7.06	18	3	0.387	22.11
27/07/2006	6.64	256	47	211	0	5	90	165	146	0	17	4	10.7	7	3	0.424	10.34
21/08/2006	6.19	90	29	144	0	3	51	76	108	0	19	7	8.59	10	1	0.448	12.33
13/09/2006	6.4	122	32	157	0	4	58	91	121	1	11	2	3.68	10	5	0.434	11.18
26/10/2006	5.39	8	21	101	0	10	33	37	101	0	13	0		14	3	0.509	9.61
23/11/2006	5.61	9	28	146	0	7	42	46	188	1	24	0	4.79	11	2	0.183	3.88
10/01/2007	5.6	8	25	129	0	4	30	34	145	0	18	0	4.71	4	3	0.225	5.64
21/02/2007	5.89	23	37	224	6	6	46	56	232	1	29	2	6.01	6	2	0.239	6.59
05/04/2007	6.4	110	42	216	4	7	58	92	222	2	22	5	5.48	2	0	0.153	4.94
04/06/2007	5.83	32	24	147	0	2	31	40	113	0	6	3	10.14	23	0	0.705	14.07
03/07/2007	6.03	77	26	142	4	4	48	66	87	0	7	3	8.55	29	0	0.943	16.35
09/08/2007	6.24	130	31	140	0	4	70	101	103	1	9	3	7.62	50	7	0.581	11.8
30/08/2007	7.09	182	41	175	1	5	104	157	142	1	12	2	12.62	59	9	0.923	18.48
25/10/2007	6.32	140	39	172	0	9	70	112	174	3	11	0	5.9	7	2	0.308	6.14
07/12/2007	5.67	16	20	106	0	4	27	31	103	0	10	0	5.54	4	4	0.452	8.21
05/02/2008	5.66	30	23	116	0	3	27	31	139	0	18	0	5.75	8	4	0.145	5.64
02/04/2008	5.68	14	33	186	0	5	39	42	215	0	22	0	5.9	3	0	0.213	3.86
16/07/2008	6.28	134	35	176	0	4	60	97	120	0	19	0	6.38	9	11	0.439	9.74
01/09/2008	5.64	27	23	135	0	3	42	57	112	0	8	0	6.9	33	6	0.775	14.82
04/10/2008	5.31	5	26	114	0	7	36	39	133	0	8	0	4.83	8	7	0.46	9.79

Table 8 Water chemistry for the Experimental Burn (Lower site) July 1995 - April 2010

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
15/07/1995	6.63	155	62	210	0	6	73	276	148	0	206	1	2.5	12	0	0.348	7.7
06/08/1995	6.77	220	115	287	0	11	99	868	154	0	749	2		18	2	0.524	11
04/09/1995	6.36	85	67	245	0	8	110	275	144	0	337	0	11	16	0	0.28	7.6
24/09/1995	5.13	-3	33	165	0	7	64	86	120	0	109	0		33	4	0.514	13
11/11/1995	5.76	30	29	139	0	9	44	82	113	0	55	0	2.5	51	3	0.384	7.4
10/01/1996	5.26	-1	22	119	2	3	39	43	82	1	69	0	2.5	40	2	0.369	8
27/02/1996	5.28	-1	28	148	0	7	48	46	165	0	51	0	2.5	19	12	0.167	3.5
03/04/1996	6.31	70	50	185	0	8	59	211	168	1	188	1	2.5	11	0	0.149	4
02/05/1996	6.03	63	48	167	0	6	50	195	134	0	175	0	2.5	18	3	0.299	6.1
12/06/1996	4.98	-11	27	128	0	3	34	41	109	0	21	3	4	36	2	0.7	14.3
04/07/1996	5.89	38	34	151	0	3	50	113	111	0	79	0	2.5	26	6	0.538	15.8
27/07/1996	6.15	125	48	184	3	7	67	209	140	0	111	2	6	18	6	0.488	10.9
18/08/1996	6.67	231	75	227	0	9	90	430	148	0	278	1	2.5	14	1	0.477	10
07/09/1996	6.02	125	51	193	0	12	81	228	147	0	118	3	3.5	41	2	0.75	15.7
28/09/1996	6.3	97	49	206	0	13	75	172	199	2	94	1	2.5	12	1	0.35	9
30/10/1996	5.49	13	26	122	0	15	42	57	113	0	27	0		49	10	0.479	10
03/12/1996	5.41	-2	48	230	3	10	73	77	309	1	50	1	2.5	22	10	0.155	3.6
28/01/1997	5.87	24	30	145	2	5	40	83	114	1	75	0	2.5	24	1	0.328	6.7
10/03/1997	5.54	9	44	207	0	8	59	101	243	1	77	0	2.5	13	0	0.133	3
30/04/1997	5.77	28	35	179	2	6	48	96	174	1	48	0	2.5	25	1	0.344	7.3
21/05/1997	6.11	40	33	154	0	3	40	107	128	0	65	1	2.5	31	0	0.474	10.2
05/07/1997	6.08	75	39	176	3	8	49	143	127	0	80	1	2.5	21	7	0.502	11
30/07/1997	6.02	75	34	169	3	7	57	124	135	0	38	2	16	29	3	0.731	15.3
19/08/1997	6.67	140	38	173	3	9	67	142	124	1	39	1	2.5	29	0	0.445	9.4
07/09/1997	5.72	22	29	149	3	6	52	81	125	0	28	1	2.5	64	4	0.766	16.4
05/10/1997	5.74	31	37	171	0	12	65	115	194	0	39	0	2.5	36	2	0.519	12
14/11/1997	5.55	18	28	144	0	17	49	63	134	0	29	1	17	43	4	0.613	14
05/01/1998	5.44	3	33	170	0	7	59	67	215	0	36	0	2.5	20	0	0.176	3.7
05/02/1998	5.64	14	22	115	0	5	35	48	100	1	32	1	2.5	28	2	0.323	7.7
21/03/1998	6	47	45	210	2	9	64	142	241	1	95	0	2.5	13	4	0.131	3.3
20/06/1998	6.26	144	61	209	0	6	70	291	132	0	232	1	2.5	4	13	0.27	6.8
20/07/1998	5.75	39	26	137	0	3	50	91	86	0	29	5	6	42	42	0.759	16
09/08/1998	5.85	62	31	143	0	5	63	124	85	0	51	2	2.5	50	2	0.808	17.4
29/08/1998	6.21	142	51	178	0	5	75	235	118	0	145	3	6	31	0	0.47	9.8
27/09/1998	6.34	203	65	207	3	10	99	351	149	2	218	1	2.5	32	2	0.482	10
25/10/1998	5.58	14	20	100	0	5	35	51	89	0	20	2	2.5	57	6	0.496	10.8
25/11/1998	5.44	6	27	143	0	6	42	54	151	0	26	1	2.5	31	4	0.351	7.5
12/02/1999	5.47	3	50	255	0	12	77	84	336	1	36	0	6	15	1	0.082	2.8
25/03/1999	5.51	7	28	163	1	7	36	44	174	0	24	1	2.5	28	4	0.32	7.2
10/05/1999	5.75	26	29	168	0	7	43	63	161	0	30	2	6	40	1	0.474	11.3
17/06/1999	5.71	25	29	169	0	3	46	72	155	0	26	4	6	31	9	0.607	12.9
12/07/1999	5.87	111	45	207	0	9	92	195	150	0	75	3		109	7	1.195	23
03/08/1999	6.25	208	81	246	0	12	111	432	156	1	312	0	2.5	31	3	0.684	14.1
01/09/1999	6.29	68	39	175	0	7	65	133	164	1	67	3	6	19	0	0.38	8.8
26/09/1999	4.97	-6	20	88	0	11	29	32	74	0	10	6	8	30	8	0.691	14.7
06/11/1999	5.46	7	24	131	0	12	38	47	137	1	23	0	6	34	5	0.352	7
20/01/2000	5.99	36	35	168	0	4	48	110	171	2	71	1	6	11	2	0.149	3.6
05/03/2000	6.39	3	27	158	0	6	34	40	171	0	27	0	2.5	22	0	0.161	4.2
14/04/2000	6.38	90	48	200	0	6	55	205	184	1	128	0	2.5	7	3	0.191	4.6
31/05/2000	6.11	57	37	200	0	4	58	127	165	1	78	0	2.5	22	13	0.31	6.9
17/06/2000	6.2	80	46	217	0	6	70	185	186	1	105	1	2.5	31	1	0.356	8.6

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
12/07/2000	6.37	76	41	200	0	6	69	170	169	1	86	0	6	15	9	0.468	10.3
05/08/2000	6.23	117	52	215	2	8	75	201	178	1	114	1	6	24	6	0.535	13.4
04/09/2000	6.27	132	54	217	2	9	83	228	189	1	114	0	6	31	2	0.64	14
08/10/2000	5.63	20	31	161	0	17	52	63	170	0	18	1	2.5	52	1	0.58	9.2
21/11/2000	5.93	38	28	142	0	7	43	77	130	1	37	0	6	24	2	0.374	8
09/01/2001	5.95	31	21	103	0	6	34	71	76	1	41	0	6	37	2	0.347	7.8
08/03/2001	5.61	10	22	107	1	6	30	42	100	1	39	0	6	21	2	0.235	5
26/04/2001	5.95	30	31	149	0	6	45	88	137	1	51	0	2.5	21	8	0.421	9.6
06/06/2001	6.31	117	47	199	5	9	62	218	140	1	133	0	6	22	0	0.4	10.4
03/07/2001	5.95	62	27	137	0	4	47	101	83	1	41	4	6	42	16	0.791	15
23/07/2001	6.26	84	22	144	3	5	54	112	96	2	41	0	6	16	7	0.632	14.1
19/08/2001	6.04	88	33	126	1	6	65	137	90	1	52	5	6	15	12	0.73	17.9
07/10/2001	5.6	19	26	117	2	15	48	58	130	1	19	3	6	31	6	0.49	10.5
14/11/2001	6.37	51	26	114	0	11	44	95	103	2	46	2	2.5	19	1	0.334	8.6
10/12/2001	6.21	60	26	119	0	8	43	106	97	1	61	3	6	13	0	0.338	7.3
22/01/2002	5.71	11	19	112	0	7	29	37	117	0	18	0	2.5	21	0	0.227	5.4
04/04/2002	5.96	34	46	249	0	10	60	115	282	1	73	1	2.5	14	0	0.185	4.4
07/05/2002	6.37	113	60	239	0	10	65	263	193	2	199	1	6	10	0	0.234	5.6
12/06/2002	5.89	42	24	145	0	4	43	71	93	0	23	4	6	30	0	0.712	15.2
14/07/2002	6.23	108	40	168	0	5	67	169	120	0	81	3	12	11	11	0.598	12.7
31/07/2002	5.65	40	22	117	0	5	57	72	69	0	13	6	22	50	6	0.949	
01/09/2002	6.19	90	34	160	0	7	77	144	143	0	50	5	6	28	5	0.663	15.8
29/09/2002	6.31	179	61	201	0	11	90	367	153	1	181	2	22	16	8	0.362	9.1
21/10/2002	5.78	13	30	141	0	21	59	69	181	0	30	2	21	20	1	0.329	8.8
08/12/2002	6.09	54	29	137	0	8	42	102	112	1	57	1	24	22	1	0.326	7.6
26/01/2003	5.4	3	41	202	0	8	61	70	254	0	39	0	18	24	4	0.165	4.2
03/03/2003	5.7	15	37	187	2	9	48	65	200	0	63	1	6	20	3	0.2	5.2
28/04/2003	6.16	57	40	201	0	7	56	120	195	1	67	0	13	14	0	0.324	7.5
11/06/2003	5.68	33	23	126	0	2	38	60	88	1	20	7	16	26	9	0.733	13.5
21/07/2003	5.81	47	26	131	2	4	51	94	94	0	36	2	9	26	9	0.643	14.4
10/08/2003	5.99	156	49	198	2	8	98	259	135	2	117	4	12	101	16	1.215	22.2
08/09/2003	6.21	146	57	196	0	8	80	268	157	0	178	1	13	19	7	0.373	9.8
27/10/2003	6.08	95	48	195	0	9	78	269	204	1	126	0	8	3	10	0.115	22.5
16/12/2003	6.21	44	25	121	0	6	37	99	95	0	58	0	11	19	0	0.305	5.5
11/02/2004	5.36	0	34	177	0	7	53	50	225	0	28	0	7	12	6	0.139	2.3
09/04/2004	6.1	41	30	152	0	3	51	138	139	0	59	1	8	15	2	0.287	5.1
20/05/2004	6.41	95	35	154	0	0	55	192	119	1	67	4	11	24	6	0.423	8
16/06/2004	6.12	63	24	125		2.3	35.3	90	69	0	43	4	12	34	2	0.619	11.8
14/07/2004	6.76	190	63	185.7		5.6	70.1	311.9	110	0	210	4	10	6	6	0.204	6
10/08/2004	5.45	17	21	89	0	11	41	52	68	0	12	5		28	11	0.778	12.7
13/09/2004	5.57	19	24	100.7	0	11	42	51	100	0	11	4	18	26	10	0.53	10.3
05/10/2004	5.2	-2	19	76	0	12	21	26	91	0	9	0	9	14	5	0.302	3.6
14/12/2004	5.25	1	12	55	0	6	10	12	50	0	12	2	11	9	3	0.347	4.8
26/01/2005	5.38	0	79	406	29	11	106	109	513	3	61	0	8	1	3	0.038	1
02/03/2005	6.26	46	52	248	0	10	59	120	292	1	82		10	3	0	0.103	1.9
20/04/2005	6.18	53	42	203	1	11	49	100	195	0	86	2	5	17	4	0.34	6.3
06/06/2005	5.51	22	21	118	2	3	27	33	78	0	10	3	7	38	6	0.747	13.8
14/07/2005	6.53	222	83	230	0	8	91	449	138	0	351	6	7	12	1	0.504	9.2
15/08/2005	6.57	187	58	189	0	7	77	270	155	0	158	1	10	3	4	0.315	6.8
07/09/2005	6.34	118	45	163	0	7	62	176	138	0	100	0	10	15	1	0.458	9.2
04/10/2005	5.78	26	29	140	0	6	44	69	169	0	28	1	10	16	3	0.28	6.5
06/12/2005	5.92	25	35	163	0	5	39	70	181	1	50	0	3	11	1	0.184	4.8
08/02/2006	5.78	20	23	120	0	5	26	36	113	0	24	7	0	13	1	0.316	7.7
26/03/2006	6.07	40	25	116	2	8	28	62	103	1	47		3.6	9	0	0.233	4.8
11/05/2006	6.44	124	61	183	0	9	60	249	155	0	202	4	7.15	7	3	0.278	6.29
07/06/2006	6.62	177	79	219	0	9	75	406	147	0	339	7	3.51	10	0	0.278	9.29

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
29/06/2006	6.46	168	60	174	48	5	63	283	121	0	210	4	6.6	16	3		15.78
27/07/2006	6.87	304	112	270	0	9	96	742	151	0	546	6	10.61	5	0	0.36	8.45
21/08/2006	6.05	68	34	154	2	4	49	98	132	0	45	2	9.88	20	6	0.462	12.31
13/09/2006	6.4	117	43	164	3	6	58	160	129	0	90	0	3.96	16	7	0.457	12.79
26/10/2006	5.47	13	21	98	0	11	33	37	90	0	13	0		27	12	0.546	10.88
23/11/2006	5.63	10	30	149	0	8	45	58	184	0	35	1	4.55	11	2	0.191	4.27
10/01/2007	5.59	10	26	132	0	5	32	39	149	0	24	0	4.93	9	1	0.221	5.8
21/02/2007	5.95	28	41	268	13	8	59	109	248	1	64	1	5.08	8	4	0.235	5.22
05/04/2007	6.56	137	78	243	4	9	69	340	225	2	283	0	5.48	2	0	0.164	5.42
04/06/2007	5.77	34	28	153	3	5	34	55	125	0	21	2	11.08	26	7	0.704	13.45
03/07/2007	5.87	65	28	136	5	4	49	87	91	0	29	2	12.39	34	7	0.986	17.31
09/08/2007	6.12	127	40	142	0	5	76	165	103	0	77	3	9.94	90	31	0.713	14.79
30/08/2007	7.08	169	53	170	0	7	101	239	138	0	109	1	10.92	99	6	1.06	16.87
25/10/2007	6.27	136	49	173	0	11	67	190	167	2	104	0	6.52	5	0	0.328	6.2
05/12/2007	5.62	14	21	109	0	5	26	31	110	0	13	2	6.26	8	1	0.408	8.03
05/02/2008	5.58	8	25	120	0	4	28	34	145	0	25	0	4.96	8	4	0.136	6.79
02/04/2008	5.55	12	35	186	0	6	40	54	216	0	40	0	6.01	4	0	0.215	4.05
16/07/2008	6.48	143	47	186	0	4	61	198	128	0	119	1	6.73	4	2	0.386	8.89
01/09/2008	5.54	25	25	134	0	4	41	58	113	0	12	0	7.54	35	8	0.776	15.34
04/10/2008	5.54	12	24	107	0	6	34	38	121	0	9	0	6.02	12	0	0.39	8.32
09/12/2008	5.79	22	26	128	1	2	30	50	125	0	40	0	2.43	8	0	0.274	6.42
12/01/2009	5.27	-1	28	143	2	3	28	29	166	0	23	6	3.15	11	1	0.157	6.01
18/03/2009	5.94	29	38	180	2	5	39	78	188	0	69	0	2.43	12	7	0.221	4.96
27/04/2009	5.56	16	30	161	1	5	32	40	147	0	16	0	4.78	12	8		11.69
12/05/2009	6.1	62	31	164	0	4	38	47	153	0	12	1	2.67	13	0		6.19
12/06/2009	6.75	212	88	234	2	8	78	414	158	0	354	1	8.4	11	0	0.33	5.72
15/07/2009	6.17	89	34	143	0	4	50	112	105	1	44	5	4.92	20	2	0.636	12.41
11/08/2009	6.1	60	27	126	2	4	47	77	105	2	11	0	6.17	41	3	0.725	20.5
28/09/2009	6.17	53	33	131	2	5	49	105	138	0	51	14	14.52	18	0	0.338	13.04
16/11/2009	5.58	13	16	75	1	4	20	25	58	0	12	0	7.59	19	6	0.506	8.07
30/04/2010	5.86	25	23	114	0	3	28	51	95	0	25	5	3.82	18	2	0.443	8.75

Table 9 Water chemistry for the Allt Riabhach na Bioraich (Lower site) June 1995 - April 2010

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
02/06/1995	6.15	42	25	137	0	5	41	68	109	1	26	0	2.5	53	0	0.431	8.8
15/07/1995	6.35	68	41	175	0	9	76	128	121	9	104	0	2.5	30	8	0.436	11
06/08/1995	6.8	122	38	207	0	13	65	142	148	2	80	1		15	3	0.287	6.6
04/09/1995	6.19	44	43	182	0	9	84	132	118	0	156	0	6	39	0	0.347	8.5
24/09/1995	5.41	7	28	150	0	6	63	85	107	1	96	0		66	8	0.517	13
11/11/1995	6.03	44	26	130	0	6	47	81	94	1	43	1	2.5	65	0	0.411	7.9
27/02/1996	5.68	17	30	155	1	5	55	74	166	2	64	0	2.5	29	1	0.213	4.1
03/04/1996	6.07	35	33	153	6	12	59	100	135	8	88	0	2.5	29	2	0.194	4.6
02/05/1996	5.98	67	31	139	0	6	48	98	115	0	60	0	2.5	32	2	0.241	4.8
12/06/1996	5.52	14	23	115	0	3	37	51	91	0	23	3	4	40	29	0.563	6.7
04/07/1996	5.92	35	27	130	0	4	49	85	96	0	46	0	2.5	47	14	0.553	23
27/07/1996	6.36	75	29	140	0	5	57	117	100	1	34	1	2.5	42	4	0.532	10.7
18/08/1996	6.69	141	35	158	0	7	62	144	108	2	39	2	2.5	24	2	0.398	8
07/09/1996	6.34	117	34	162	0	11	65	137	117	1	40	2	2.5	35	4	0.485	10.2
28/09/1996	6.21	53	37	169	0	10	74	120	174	3	57	1	2.5	46	9	0.484	10.9
30/10/1996	5.61	15	21	97	0	7	36	53	80	1	22	1		90	7	0.525	10
03/12/1996	5.26	0	44	218	0	8	71	75	293	2	42	0	2.5	35	7	0.16	3.7

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
28/01/1997	6.09	37	27	129	2	6	41	73	104	4	49	4	6	45	0	0.305	6
10/03/1997	5.64	18	38	184	0	9	56	77	218	3	46	1	2.5	26	0	0.142	3
30/04/1997	5.92	31	29	154	0	5	48	79	149	1	27	0	2.5	43	1	0.382	7.8
21/05/1997	6.09	41	26	144	4	5	45	76	120	0	25	1	2.5	52	7	0.501	10.4
05/07/1997	6.23	70	30	148	3	7	51	97	108	0	35	1	2.5	55	0	0.48	9.9
30/07/1997	6.18	57	27	136	0	5	54	97	104	0	27	1	2.5	70	8	0.769	15.7
19/08/1997	6.63	104	33	163	0	8	60	112	120	1	22	1	2.5	32	0	0.478	9.8
07/09/1997	5.68	20	25	125	0	4	47	71	103	0	20	2	2.5	89	10	0.74	14.5
05/10/1997	5.75	21	29	143	0	7	57	84	145	0	24	0	2.5	82	5	0.644	14
14/11/1997	6.02	42	26	139	0	8	50	76	114	2	30	1	2.5	57	5	0.561	12
05/01/1998	5.46	6	28	146	1	6	49	55	168	2	31	0	2.5	31	0	0.209	3.9
05/02/1998	5.72	15	21	115	3	7	36	53	102	3	30	1	2.5	47	1	0.346	8.2
21/03/1998	6.05	43	34	171	2	8	50	77	183	1	40	0	2.5	24	2	0.149	3.8
20/06/1998	6.48	148	39	180	0	9	60	138	120	0	62	1	2.5	23	0	0.228	5.7
20/07/1998	5.94	46	24	129	0	4	48	77	81	0	18	1	2.5	85	3	0.735	15.2
09/08/1998	5.89	37	22	123	0	4	44	71	82	0	20	1	2.5	55	9	0.634	12.5
29/08/1998	6.36	120	31	156	0	8	51	106	101	0	34	1	2.5	27	1	0.35	7.1
27/09/1998	6.52	163	35	159	0	8	66	159	109	1	51	1	2.5	21	0	0.312	6.8
25/10/1998	5.49	14	24	109	0	12	43	51	107	0	20	2	2.5	49	12	0.513	10.3
25/11/1998	5.56	8	26	134	0	5	40	55	145	1	26	1	2.5	45	4	0.318	6.7
12/02/1999	5.8	16	43	238	0	8	69	89	299	2	38	1	2.5	16	0	0.098	2.8
25/03/1999	5.56	7	26	142	0	6	35	42	158	1	23	1	2.5	39	0	0.274	6.2
10/05/1999	5.89	27	27	149	0	9	45	68	139	0	28	3	6	51	0	0.558	12
17/06/1999	5.74	23	25	142	0	2	42	61	129	0	14	2	2.5	52	20	0.617	12.9
12/07/1999	6.2	82	29	168	0	7	57	105	124	0	27	0		82	2	0.752	15.3
03/08/1999	6.56	110	36	179	0	9	59	138	145	2	51	0	6	24	0	0.372	7.7
01/09/1999	5.83	30	28	136	0	5	54	78	110	0	40	2	2.5	61	10	0.647	13
26/09/1999	5.5	20	21	108	0	5	36	52	88	0	21	3	6	68	5	0.563	10.6
06/11/1999	5.02	-6	23	110	0	6	35	31	119	0	22	1	2.5	18	2	0.303	7.9
20/01/2000	5.86	27	26	140	0	4	40	71	140	2	33	1	2.5	31	2	0.19	4.1
05/03/2000	5.47	6	28	163	0	4	39	52	182	1	29	0	2.5	24	2	0.188	4.4
14/04/2000	5.47	2	31	188	0	3	43	57	215	1	27	0	2.5	10	5	0.108	2.4
31/05/2000	6.31	55	31	174	0	5	57	95	145	0	47	0	2.5	34	15	0.364	8
17/06/2000	6.27	61	35	187	0	6	61	100	179	1	40	0	2.5	34	3	0.269	6.4
12/07/2000	6.33	62	30	163	0	5	59	109	139	0	31	0	6	29	12	0.397	8.5
05/08/2000	6.48	80	34	174	3	6	58	104	143	1	45	0	6	26	3	0.389	9.3
04/09/2000	6.59	97	35	169	0	6	62	118	152	0	27	0	6	24	4	0.439	9.8
08/10/2000	5.47	14	28	144	0	6	46	62	146	0	20	2	6	83	9	0.636	10.7
21/11/2000	5.92	34	24	127	0	4	40	66	117	1	25	0	6	40	3	0.414	8.3
09/01/2001	5.92	28	18	97	0	4	31	55	73	1	25	0	6	47	0	0.372	8.2
08/03/2001	5.51	6	22	98	2	8	32	41	97	7	36	0	6	21	8	0.222	5
26/04/2001	6.03	38	28	141	3	9	43	76	123	2	37	0	2.5	35	11	0.47	10
06/06/2001	6.45	91	30	151	2	6	53	98	108	0	36	4	6	23	4	0.371	8.3
03/07/2001	5.95	45	23	125	1	3	43	77	79	1	22	2	2.5	95	14	0.788	14.4
23/07/2001	6.32	66	24	126	2	4	47	80	86	1	20	0	5	46	2	0.563	11.6
19/08/2001	6.06	35	21	108	1	3	35	64	82	2	23	3	6	24	15	0.474	11.2
07/10/2001	5.3	5	24	99	0	10	40	46	107	2	18	3	6	51	6	0.541	11.5
14/11/2001	6.04	15	22	108	0	8	39	67	88	2	25	5	6	34	4	0.379	8.5
10/12/2001	6.07	44	20	109	0	8	39	68	86	2	29	3	6	22	9	0.371	8
22/01/2002	4.59	-24	25	101	0	5	22	15	112	0	17	2	6	15	0	0.314	7.2
04/04/2002	6.01	36	32	191	3	10	47	68	200	4	36	1	2.5	18	5	0.237	5.1
07/05/2002	6.27	50	38	215	0	8	54	91	217	0	42	0	6	9	0	0.176	4.3
12/06/2002	5.8	34	21	123	0	5	38	60	79	0	15	2	6	63	2	0.772	15.1
14/07/2002	6.31	88	29	142	0	6	54	104	98	0	22	3	19	32	9	0.61	12.7
31/07/2002	5.53	21	19	97	0	4	39	53	55	1	10	4	18	57	22	0.928	
01/09/2002	6.17	67	29	153	0	9	62	103	121	0	21	0	2.5	40	3	0.673	16.7

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
29/09/2002	6.6	198	44	180	4	13	80	184	133	1	45	0	20	8	3	0.275	7
21/10/2002	6.24	60	32	155	0	17	64	95	163	1	31	3	25	12	6	0.376	9.1
08/12/2002	6.19	54	26	133	0	8	44	83	110	2	37	1	23	16	12	0.365	8.3
26/01/2003	5.25	-1	42	197	0	9	66	64	273	0	36	0	19	28	4	0.189	4.6
03/03/2003	5.84	15	30	155	2	9	43	55	161	2	45	0	5	38	5	0.27	6
28/04/2003	6.2	48	36	189	3	9	63	98	183	0	57	0	12	31	6	0.375	8.3
11/06/2003	5.75	32	23	120	0	3	43	66	89	0	14	3	14	47	15	0.831	15.9
24/07/2003	5.56	24	22	108	0	5	37	57	79	0	25	2	12	52	19	0.6	12.9
10/08/2003	6.33	129	37	169	0	10	69	166	120	1	59	1	9	39	76	0.473	15
08/09/2003	6.62	149	38	174	0	11	70	159	137	0	51	4	11	11	2	0.276	14.4
27/10/2003	6.35	125	35	170	0	11	88	187	160	0	38	0	8	7	2	0.178	22
16/12/2003	6	38	21	112	0	8	38	64	95	1	29	0	10	34	2	0.326	5.85
12/02/2004	5.2	-3	33	162	0	6	46	46	206	0	24	4	8	20	2	0.138	2.1
09/04/2004	6.13	45	25	130	0	1	50	91	122	0	27	1	8	27	1	0.301	4.8
20/05/2004	6.06	46	22	112	0	0	51	93	87	0	13	3	9	59	9	0.665	12
16/06/2004	5.97	34	19	105		3.5	29.6	55.1	69	0	16	3	10	57	10	0.675	12.3
14/07/2004	6.66	119	31	143.6		6.8	46.3	94	92	0	25	4	35	25	3	0.226	6.2
10/08/2004	5.17	3	20	80	0	10	36	46	60	0	15	6		41	23	0.848	13.3
13/09/2004	5.51	16	22	89.6	0	12	39	51	85	0	11	4	20	46	5	0.671	11.7
05/10/2004	5.26	0	17	66	0	10	20	26	81	0	10	1	9	20	4	0.292	3.9
14/12/2004	5.45	6	13	54	0	7	13	20	52	0	16	2	10	16	5	0.333	4.5
26/01/2005	5.36	0	66	333	0	11	90	80	463	3	47	0	8	6	5	0.069	1.5
02/03/2005	6.2	52	41	204	0	10	55	82	244	2	39	1	10	10	2	0.132	2
20/04/2005	6.23	47	32	171	0	10	44	63	171	0	29	2	4	25	6	0.299	
06/06/2005	5.6	22	18	98	2	3	26	34	64	0	9	6	7	48	4	0.739	13.5
14/07/2005	6.63	156	41	179	0	11	62	144	131	0	48	7	10	23	1	0.442	7.4
15/08/2005	6.6	133	37	162	0	9	63	126	144	0	31	1	10	10	5	0.411	8
07/09/2005	6.36	98	33	155	0	8	51	95	135	0	33	2	10	24	0	0.388	9
04/10/2005	5.76	21	26	132	0	7	41	54	156	0	16	1	7	52	14	0.36	9.2
06/12/2005	5.79	19	30	142	0	6	35	47	169	2	26	0	3	22	6	0.206	5.3
08/02/2006	5.65	15	24	113	0	8	30	44	111	0	32	1	0	28	2	0.349	8.1
26/03/2006	6.24	53	23	110	0	8	30	56	98	2	30		3.8	22	0	0.23	4.5
11/05/2006	6.27	57	30	136	0	6	37	67	130	1	33	4	5.28	11	2	0.198	5.16
07/06/2006	6.67	149	41	169	0	10	53	133	132	0	52	3	3.48	11	0	0.239	8.39
29/06/2006	6.34	87	37	134	69	7	44	83	121	0	38	2	6.2	13	4	0.294	12.77
27/07/2006	6.94	163	42	192	0	12	60	134	140	0	52	1	10.79	20	1	0.408	9.82
21/08/2006	6.15	62	31	140	2	5	50	82	115	0	23	4	12.92	46	5	0.664	15.55
13/09/2006	6.39	56	27	133	2	6	39	67	117	1	26	0	5.34	18	3	0.397	10.7
26/10/2006	5.37	8	15	80	0	9	25	31	58	0	12	0		38	6	0.62	11.87
23/11/2006	5.55	7	26	137	0	9	38	41	167	1	21	0	4.96	15	3	0.207	4.49
10/01/2007	5.56	7	25	120	0	6	29	33	139	1	18	0	4.97	16	1	0.201	5.57
21/02/2007	5.96	28	34	179	5	9	44	61	195	3	31	0	6.3	24	2	0.259	7.26
05/04/2007	6.78	117	45	197	3	10	58	124	199	0	59	0	5.13	4	0	0.154	4.89
04/06/2007	5.71	25	24	131	0	3	31	43	109	0	9	3	10.22	29	18	0.705	13.63
03/07/2007	5.97	48	24	129	4	4	38	59	98	0	14	2	12.07	65	0	0.784	14.57
09/08/2007	6.03	39	27	136	0	5	37	58	129	0	19	1	8.52	88	3	0.408	8.09
30/08/2007	6.65	92	32	142	0	5	61	104	121	0	18	2	9.87	33	13	0.683	14.39
25/10/2007	6.38	146	38	155	0	11	62	125	135	3	32	0	9.1	6	1	0.311	6.81
05/12/2007	5.73	15	19									0					
05/02/2008	5.52	6	24	122	0	6	28	32	145	1	21	0	6.6	14	1	0.16	9.42
02/04/2008	5.54	8	28	196	4	8	41	46	202	0	24	0	6.66	10	1	0.219	6.17
16/07/2008	6.36	88	31	152	2	4	50	88	113	0	26	2	8.13	21	1	0.497	10.23
01/09/2008	5.7	28	21	111	0	4	38	56	84	0	9	0	6.98	52	10	0.835	16.34
04/10/2008	5.49	12	22	96	0	7	34	41	99	0	11	0	6.34	25	9	0.581	11.57
09/12/2008	5.84	25	23	116	0	4	30	39	118	1	19	11	2.67	16	3	0.28	6.19
12/01/2009	5.4	3	26	132	2	5	27	29	153	0	21	7	5.4	14	3	0.205	6.46

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
18/03/2009	5.9	21	26	137	2	5	29	37	143	0	22	0	2.54	15	11	0.218	5.44
27/04/2009	5.68	20	27	140	0	4	32	42	119	0	14	0	5.2	26	4		12.84
12/05/2009	6.13	56	30	145	0	4	34	50	139	0	20	0	1.69	12	5		5.48
12/06/2009	6.9	163	44	177	2	9	54	120	141	0	54	1	6.61	12	3	0.361	4.93
15/07/2009	6.28	83	30	136	0	4	50	90	105	3	18	2	4.41	26	6	0.675	12.59
11/08/2009	6.01	75	33	143	2	2	57	97	127	1	24	0	6.51	24	2	0.69	21.11
28/09/2009	6	34	25	114	1	5	41	58	118	0	12	0	7.48	44	1	0.506	12.59
16/11/2009	5.61	14	15	71	1	5	20	26	59	0	11	0	7.42	33	7	0.505	7.95
30/04/2010	5.9	26	21	104	0	4	30	43	85	0	12	4	3.44	36	0	0.531	9.88

Table 10 Water chemistry for the Allt Riabhach na Bioraich (Upper site) June 1995 - October 2008

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
02/06/1995	6.17	38	23	139	0	7	39	60	105	0	20	0	2.5	49	2	0.457	9.4
15/07/1995	6.56	63	40	174	0	9	77	125	119	8	107	1	2.5	33	1	0.446	11
06/08/1995	6.59	84	30	186	0	10	53	108	137	6	43	1		53	1	0.488	9
04/09/1995	6.22	35	41	177	0	6	82	127	112	1	158	0	6	40	2	0.348	8.4
24/09/1995	5.56	9	28	146	0	5	62	86	105	1	94	0		60	8	0.488	11
11/11/1995	6.06	37	23	124	0	5	45	71	92	1	39	0	2.5	59	0	0.392	7.9
10/01/1996	5.42	3	20	106	4	5	39	49	83	2	60	3	4	44	5	0.301	6.7
27/02/1996	5.71	13	29	152	0	5	53	68	159	2	58	0	2.5	30	2	0.196	3.8
03/04/1996	6.02	23	31	145	0	8	58	88	127	7	82	0	2.5	27	4	0.193	4.3
02/05/1996	6.04	40	27	134	0	6	44	72	111	0	48	0	2.5	33	11	0.236	4.8
12/06/1996	5.55	16	22	112	0	2	36	52	89	0	23	3	4	59	8	0.546	11.1
04/07/1996	5.99	32	26	130	0	4	50	79	94	0	42	0	2.5	54	4	0.533	17.5
27/07/1996	6.3	67	27	134	0	6	56	103	100	0	30	1	2.5	39	7	0.528	11
18/08/1996	6.67	114	30	154	0	6	63	117	108	2	26	2	2.5	27	1	0.412	8.1
07/09/1996	6.48	88	29	148	0	10	60	110	113	1	24	0	2.5	32	6	0.487	10.1
28/09/1996	6.2	45	37	167	0	10	73	116	165	3	57	1	2.5	43	2	0.504	11.2
30/10/1996	5.62	14	20	97	0	6	36	53	80	1	21	1		70	4	0.514	10
03/12/1996	5.28	-1	43	218	2	7	69	75	290	2	40	1	2.5	36	6	0.16	4
28/01/1997	6.06	28	25	125	2	5	41	64	101	4	44	6	6	41	0	0.293	5.9
10/03/1997	5.63	7	36	182	0	8	53	66	218	2	39	0	2.5	24	0	0.141	3
30/04/1997	5.99	27	28	153	0	5	47	71	145	0	23	0	2.5	44	2	0.39	7.8
21/05/1997	6.2	37	25	137	0	3	43	70	115	0	20	1	2.5	51	13	0.48	10.1
05/07/1997	6.28	58	27	141	0	4	49	82	105	0	27	1	2.5	50	1	0.46	9.6
30/07/1997	6.19	49	29	137	0	5	55	97	101	0	19	1	2.5	67	6	0.83	16.9
19/08/1997	6.51	202	46	199	0	8	98	175	138	2	17	1	2.5	27	5	0.688	15
07/09/1997	5.76	21	25	125	0	4	46	68	104	0	18	1	2.5	90	28	0.714	14.1
05/10/1997	5.81	21	29	140	0	7	56	81	144	1	22	0	2.5	85	4	0.64	13
14/11/1997	6.06	36	24	134	1	9	47	72	110	2	27	1	2.5	64	8	0.561	12
05/01/1998	5.67	8	26	145	0	6	47	55	164	2	31	1	2.5	34	1	0.209	3.8
05/02/1998	5.75	14	21	103	0	5	33	48	93	2	27	1	2.5	47	0	0.333	7.6
21/03/1998	6.02	31	32	164	0	7	46	60	176	1	30	1	2.5	23	1	0.144	3.4
07/05/1998	5.76	19	24	127	0	4	39	55	108	0	16	1	2.5	43	8	0.501	10.1
20/06/1998	6.52	101	32	166	0	8	53	86	115	1	33	1	2.5	13	6	0.238	5.8
20/07/1998	6.08	43	23	125	0	4	47	71	78	0	15	1	2.5	67	3	0.709	14.1
09/08/1998	6.01	39	20	118	0	3	42	64	72	0	14	1	2.5	58	17	0.648	12.6
29/08/1998	6.46	83	25	137	0	5	38	514	90	0	21	1	2.5	12	27	0.38	7.1
27/09/1998	6.68	130	29	150	0	8	60	110	104	0	21	5	6	24	3	0.326	6.8
25/10/1998	5.69	15	20	100	0	6	36	51	89	0	19	3	6	52	6	0.473	10.5
25/11/1998	5.54	6	26	138	0	5	42	54	153	1	26	0	2.5	51	3	0.31	6.7

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
12/02/1999	5.67	6	45	248	0	7	71	82	315	2	38	0	2.5	18	2	0.099	3.1
25/03/1999	5.62	8	25	144	0	7	35	40	160	0	22	1	2.5	37	1	0.263	6
10/05/1999	5.84	24	28	149	0	8	45	64	136	0	25	3	10	51	0	0.566	12.5
17/06/1999	5.95	17	29	178	0	6	39	55	191	1	25	1	2.5	19	3	0.242	5.3
12/07/1999	6.24	63	26	157	0	5	51	84	119	0	15	0		64	13	0.729	14.6
03/08/1999	6.46	85	30	167	0	8	54	98	137	0	23	0	2.5	32	6	0.438	8.5
01/09/1999	5.8	28	27	135	0	4	55	85	108	0	39	4	6	75	2	0.665	14
26/09/1999	5.59	15	19	100	0	5	34	47	82	0	15	8	1	50	6	0.577	11.1
06/11/1999	5.22	-2	22	112	0	6	31	35	117	1	21	0	6	44	0	0.328	7.3
20/01/2000	5.93	19	25	138	0	4	38	53	145	2	27	1	2.5	28	1	0.19	4.3
05/03/2000	5.54	5	28	165	0	4	40	50	185	1	27	0	2.5	27	2	0.173	4
14/04/2000	6.34	54	29	159	0	6	49	87	158	0	23	0	6	21	3	0.207	4.7
31/05/2000	6.28	48	30	168	0	5	58	88	142	0	46	0	2.5	47	2	0.389	8.5
17/06/2000	6.45	44	31	179	0	4	54	82	171	1	28	0	2.5	36	0	0.276	6.1
12/07/2000	6.33	46	28	158	0	4	55	96	139	1	24	0	6	37	0	0.402	8.4
05/08/2000	6.38	60	31	173	2	6	55	89	145	1	37	1	6	33	6	0.44	11.9
04/09/2000	6.51	79	32	162	0	5	58	99	149	0	17	0	6	28	6	0.466	11
08/10/2000	5.57	15	27	139	0	6	46	62	144	0	18	1	2.5	67	2	0.626	10.4
21/11/2000	6.05	30	23	128	0	4	39	62	117	1	20	0	6	36	0	0.399	8.1
09/01/2001	5.97	23	18	100	0	4	30	51	75	1	22	0	6	49	2	0.371	8.6
08/03/2001	5.47	4	22	98	2	8	32	40	100	7	36	0	10	20	8	0.2	4.5
26/04/2001	5.99	30	25	133	0	6	43	98	116	2	33	0	2.5	25	20	0.447	9.5
06/06/2001	6.38	71	27	144	1	5	48	83	103	0	30	2	2.5	19	14	0.416	8.8
03/07/2001	6.07	45	22	121	0	3	42	73	76	0	19	32	35	96	5	0.852	14.8
23/07/2001	6.29	58	22	119	1	4	47	75	77	2	17	0	2.5	43	0	0.641	12.4
19/08/2001	6.1	44	20	102	0	3	40	66	63	1	14	2	6	40	22	0.686	13.6
07/10/2001	5.44	9	23	99	0	9	39	46	106	1	18	2	6	37	14	0.539	11
14/11/2001	6.31	39	20	106	0	7	36	63	86	2	20	5	6	38	0	0.374	8.7
10/12/2001	6.22	46	20	110	0	7	38	63	85	1	24	15	20	28	0	0.343	6.9
22/01/2002	5.32	0	17	98	0	7	24	31	103	0	16	0	6	26	4	0.259	5.9
04/04/2002	6.02	27	30	190	4	10	46	60	199	3	33	0	2.5	21	14	0.265	5.6
07/05/2002	6.36	59	30	179	0	8	44	71	155	0	23	0	6	11	3	0.233	5
12/06/2002	5.85	32	21	124	0	4	38	56	78	0	12	3	12	52	11	0.741	14.7
14/07/2002	6.33	70	26	141	0	5	49	82	100	0	13	3	14	26	13	0.618	13.7
31/07/2002	5.63	23	18	99	0	4	39	55	55	0	10	5	18	70	12	0.893	
01/09/2002	6.23	59	25	142	0	6	59	94	115	0	15	0	6	43	2	0.664	15.7
29/09/2002	6.91	152	36	165	0	9	73	131	130	0	18	0	16	19	0	0.313	7.4
21/10/2002	6.35	54	32	154	0	20	63	91	169	0	27	2	28	16	2	0.316	
08/12/2002	6.27	52	24	130	0	8	46	75	103	3	30	2	20	27	1	0.382	8.3
28/01/2003	5.23	-2	41	202	0	9	64	64	274	1	36	0	18	30	11	0.183	2.7
03/03/2003	5.82	13	29	153	2	9	42	51	158	2	43	0	6	17	18	0.265	6.6
28/04/2003	6.26	41	35	187	3	8	61	91	181	0	55	0	14	33	2	0.379	8.8
11/06/2003	5.81	31	22	119	0	2	43	64	89	0	14	2	25	57	5	0.813	15.6
21/07/2003	5.61	21	21	114	0	6	38	67	83	0	27	0	14	58	12	0.6	13.3
10/08/2003	6.3	83	28	156	0	8	58	96	114	0	19	1	12	50	1	0.582	14.3
08/09/2003	6.57	119	32	158	0	8	64	109	127	0	21	1	13	15	2	0.288	9.6
27/10/2003	6.45	99	31	164	0	11	85	146	156	1	22	0	8	8	2	0.187	24.4
16/12/2003	6.22	36	20	113	0	7	36	59	95	0	25	0	10	31	1	0.288	5.2
11/02/2004	5.17	-5	32	161	0	5	46	45	206	0	24	0	7	13	1	0.138	2.1
09/04/2004	6.18	33	23	128	0	2	47	73	121	0	21	2	8	26	7	0.309	5.2
20/05/2004	6.11	43	22	113	0	0	52	90	89	0	9	3	9	56	8	0.657	12.4
16/06/2004	6.05	41	19	101		3.1	31	66	59	0	12	3	11	59	16	0.757	13.1
14/07/2004	6.67	94	27	140.5		6.7	41.3	72.3	90	0	17	4	10	25	5	0.271	6.6
10/08/2004	5.26	8	20	80	0	10	36	49	59	0	15	5		44	20	0.824	12.7
13/09/2004	5.57	17	22	89.2	0	11	40	52	85	0	10	4	19	53	3	0.651	11.6
06/10/2004	5.26	0	17	64	0	9	20	25	80	0	10	1	10	18	4	0.29	3.8

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
14/12/2004	5.49	7	13	55	0	7	14	20	52	0	16	5	14	16	3	0.33	4.4
26/01/2005	5.24	-3	67	335	0	11	90	76	464	3	45	0	9	8	7	0.071	1.4
02/03/2005	6.25	36	38	200	0	10	51	65	239	2	26	1	11	8	3	0.13	2
20/04/2005	6.23	41	29	165	0	9	39	49	159	0	19	1	4	30	3	0.298	5.7
06/06/2005	5.64	21	18	92	1	3	24	32	60	0	8	3	8	44	4	0.675	12.3
14/07/2005	6.49	106	33	166	0	9	53	88	129	0	19	5	7	24	2	0.436	8.1
15/08/2005	6.6	96	32	149	0	7	56	98	137	0	20	0	8	18	1	0.446	8.7
07/09/2005	6.51	77	29	139	0	6	46	70	125	0	79	2	9	23	7	0.399	7.3
04/10/2005	5.8	17	25	129	0	7	38	48	153	0	14	0	7	36	4	0.353	7.3
06/12/2005	5.85	14	29	141	0	5	33	42	169	2	23	0	3	20	4	0.206	5
08/02/2006	5.62	12	23	111	0	8	29	40	108	1	30	4	1	23	7	0.351	8.4
26/03/2006	6.24	47	23	109	0	8	31	51	96	2	33		4.3	24	1	0.249	5.4
11/05/2006	6.37	69	30	146	0	9	39	60	136	0	23	4	5.37	18	1	0.248	5.13
07/06/2006	6.52	101	32	161	0	10	47	76	130	0	23	0	2.27	18	3	0.261	9.51
29/06/2006	6.52	98	30	137	30	7	47	70	112	0	21	2	6.42	21	0	0.334	13.51
27/07/2006	6.58	143	36	183	0	12	59	102	130	3	24	2	9.71	20	11	0.392	8.74
21/08/2006	6.11	52	30	138	0	4	49	77	115	1	20	4	15.95	48	4	0.719	17.26
13/09/2006	6.55	81	28	141	2	7	48	72	116	0	13	0	4.2	21	5	0.46	12.17
26/10/2006	5.38	8	17	80	0	9	25	31	58	0	13	0		30	12	0.626	12.42
23/11/2006	5.73	10	25	135	0	8	37	43	161	0	21	0	5.28	20	2	0.203	3.92
10/01/2007	5.63	8	24	124	0	6	30	33	143	1	18	0	4.84	17	0	0.207	5.75
21/02/2007	6.03	24	32	182	3	9	43	55	195	2	26	1	5.04	17	3	0.253	5.25
05/04/2007	6.38	77	37	189	5	9	49	73	204	1	24	0	4.71	4	0	0.143	5.08
04/06/2007	5.82	25	23	131	3	3	31	43	110	0	8	2	10.24	41	4	0.669	13.33
03/07/2007	6.13	55	24	131	5	5	40	61	95	0	9	1	12.26	53	2	0.818	14.5
09/08/2007	6.24	59	25	125	0	4	42	61	98	0	10	1	8.3	7	7	0.531	9.19
30/08/2007	6.69	80	29	138	0	4	55	85	118	0	10	2	10.84	32	11	0.674	13.3
25/10/2007	6.58	114	32	145	0	9	56	91	131	2	15	0	8.21	5	2	0.331	6.77
05/12/2007	5.72	14	18									0					
05/02/2008	5.42	3	23	117	0	5	26	26	139	1	19	0	5.27	12	2	0.153	6.3
02/04/2008	5.67	9	27	345	18	15	74	84	221	0	26	0	10.07	11	0	0.227	6.9
16/07/2008	6.35	78	30	147	0	4	51	80	113	1	21	0	9.16	28	2	0.596	11.11
01/09/2008	5.74	26	20	110	0	4	39	57	82	0	8	0	6.91	56	4	0.837	15.98
04/10/2008	5.55	14	22	96	0	7	33	42	98	0	12	0	6.69	22	75	0.572	10.93

Table 11 Water chemistry for the Loch Laidon outflow September 1995 - April 2010

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
24/09/1995	6.15	24	24	150	0	4	39	69	136	2	43	1		20	0	0.225	7.1
11/11/1995	5.71	14	23	118	0	6	37	60	101	2	35	2	2.5	38	2	0.331	6.2
10/01/1996	5.57	7	18	102	2	5	32	49	86	3	38	0	2.5	35	0	0.303	6.4
27/02/1996	5.66	14	22	120	3	5	38	62	105	4	47	1	2.5	29	1	0.271	5.2
03/04/1996	6.08	35	32	148	1	8	61	99	129	6	91	0	2.5	31	3	0.209	4.7
02/05/1996	5.83	16	26	129	1	5	41	68	117	5	52	0	2.5	19	2		4.5
12/06/1996	5.75	16	27	132	2	5	41	68	117	3	47	3	4	32	3	0.271	6.1
27/07/1996	6.19	21	26	130	0	4	44	83	116	4	48	0	2.5	33	1	0.218	5
18/08/1996	6.27	27	25	130	3	5	44	87	115	4	47	0	2.5	14	0	0.214	5.2
07/09/1996	6.2	28	26	134	2	6	46	93	116	4	48	0	2.5	13	3	0.21	4.7
28/09/1996	6.25	26	27	137	0	5	44	76	121	4	50	0	2.5	20	1	0.231	5.2
30/10/1996	5.81	17	27	133	0	5	44	67	120	2	42	1		52	4	0.382	7.8
03/12/1996	5.52	6	28	145	0	7	44	53	160	2	34	1	6	30	7	0.269	5.9
28/01/1997	5.78	15	26	125	2	5	40	58	135	5	31	0	2.5	15	1	0.173	3.8

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
10/03/1997	5.51	2	32	171	0	5	45	55	196	2	34	0	2.5	20	2	0.141	3.1
30/04/1997	5.79	8	33	177	0	6	45	55	199	1	33	0	2.5	15	8	0.152	3.3
21/05/1997	5.54	3	30	167	5	6	42	51	188	2	31	1	2.5	22	0	0.174	4.2
05/07/1997	5.84	16	30	159	7	6	41	58	170	2	31	0		21	1	0.202	4.3
30/07/1997	6	15	29	159	0	6	41	61	162	2	32	9	10	16	5	0.197	4.8
19/08/1997	6.22	24	29	155	2	5	42	72	154	2	31	0	2.5	14	1	0.209	4.9
07/09/1997	6.08	20	29	155	0	5	42	69	153	2	31	1	2.5	27	1	0.263	5.9
05/10/1997	5.99	18	27	141	0	5	44	73	134	2	27	1	2.5	35	2	0.362	8.1
14/11/1997	6.31	26	25	137	2	7	39	63	128	3	28	1	2.5	22	3	0.323	7.2
05/01/1998	5.83	17	23	126	0	6	38	57	116	3	34	1	17	39	1	0.325	6
05/02/1998	5.75	13	23	119	0	5	34	50	116	2	28	1	2.5	43	1	0.249	5.7
21/03/1998	5.85	15	23	131	0	5	34	49	128	2	31	1	2.5	27	2	0.197	4.7
20/06/1998	5.9	15	27	156	0	9	41	56	161	2	29	1	2.5	18	3	0.168	4.1
20/07/1998	6.15	23	28	153	0	5	43	63	148	1	29	1	2.5	19	6	0.243	5.4
09/08/1998	6.06	26	26	142	0	4	41	62	126	3	28	0	2.5	29	2	0.293	7
29/08/1998	6.07	22	24	125	0	3	36	57	115	1	25	1	2.5	20	3	0.344	7
27/09/1998	6.08	28	22	122	0	4	38	69	105	2	24	1	2.5	26	1	0.373	7.7
25/10/1998	5.94	21	24	126	0	4	39	63	116	2	28	3	6	30	2	0.377	9.7
25/11/1998	5.63	10	28	147	0	5	43	60	165	1	29	1	2.5	34	5	0.285	6.6
12/02/1999	5.89	20	32	176	0	5	47	68	200	2	31	0	6	13	2	0.098	2.8
25/03/1999	5.48	2	36	203	0	5	45	47	243	1	31	1	6	28	1	0.149	3.9
10/05/1999	5.88	14	26	168	0	5	37	50	188	1	27	1	2.5	20	1	0.169	3.8
17/06/1999	5.81	23	24	142	0	3	42	58	130	0	12	2	6	49	12	0.579	11.7
12/07/1999	5.95	16	27	166	0	5	38	54	171	1	25	0		15	0	0.257	6.6
03/08/1999	6.09	19	26	153	0	4	38	59	156	1	24	0	2.5	18	0	0.255	5.8
01/09/1999	5.84	20	27	150	0	4	37	57	144	1	24	2	6	25	1	0.267	5.2
26/09/1999	5.99	23	25	133	0	4	37	64	132	3	27	2	2.5	23	0	0.34	7.2
06/11/1999	5.93	18	25	139	0	5	41	66	143	2	27	1	2.5	27	0	0.317	7
20/01/2000	5.65	8	27	155	0	3	40	56	174	2	30	2	6	17	2	0.127	3.3
05/03/2000	5.3	-1	39	225	0	5	55	55	272	1	34	1	2.5	23	5	0.102	2.9
14/04/2000	5.65	6	32	194	0	6	43	58	220	1	28	0	6	9	0	0.1	2.5
31/05/2000	5.88	10	30	179	0	5	48	66	206	1	28	0	2.5	22	4	0.114	2.6
17/06/2000	5.97	16	31	191	0	6	45	65	199	1	29	0	2.5	18	4	0.137	3.6
12/07/2000	5.97	15	30	178	0	4	43	57	186	1	29	0	6	9	5	0.357	4.2
05/08/2000	6.07	17	30	174	2	5	38	52	186	2	29	0	2.5	14	0	0.16	4.4
04/09/2000	6.11	22	31	168	0	4	38	60	186	1	30	0	2.5	7	0	0.17	4.4
08/10/2000	6.04	23	30	171	0	5	43	67	175	1	27	1	2.5	31	0	0.332	6.1
21/11/2000	5.93	22	25	135	0	5	36	61	134	2	22	0	17	27	0	0.312	6.3
09/01/2001	5.87	23	22	118	0	5	33	59	110	3	27	0	6	28	2	0.221	5.5
08/03/2001	5.67	10	20	100	3	5	26	41	99	8	26	0	11	13	2	0.23	4.6
26/04/2001	5.96	18	22	116	2	4	28	53	114	3	29	0	2.5	15	0	0.206	5
06/06/2001	5.97	19	23	126	4	5	29	51	115	3	31	2	6	15	2	0.207	5.2
03/07/2001	6.31	34	24	131	4	7	31	66	119	3	32	2	14	18	1	0.273	5.4
23/07/2001	6.27	32	24	143	7	15	32	60	129	5	31	0	2.5	12	0	0.277	7.1
19/08/2001	6	27	22	112	1	3	31	58	95	3	27	1	6	24	0	0.349	7.8
07/10/2001	6.05	27	24	115	0	5	34	57	107	4	28	3	10	26	3	0.379	8.7
14/11/2001	6.15	33	21	104	1	6	31	70	97	3	22	1	2.5	17	3	0.325	7.3
10/12/2001	5.96	28	20	107	0	8	32	59	101	2	23	3	6	22	2	0.3	6.5
22/01/2002	5.64	10	21	129	0	8	32	46	130	2	28	5	6	27	1	0.287	6.4
04/04/2002	5.78	11	39	233	0	7	55	64	284	1	37	0	2.5	5	6	0.095	2.8
07/05/2002	5.97	15	41	247	0	8	55	69	280	1	36	0	6	8	0	0.101	2.9
12/06/2002	5.87	15	34	202	0	6	48	60	209	0	29	1	11	17	4	0.251	6.7
14/07/2002	6.04	20	31	179	0	6	45	79	180	1	27	2	6	11	6	0.299	6.9
31/07/2002	5.92	20	28	172	0	5	40	56	164	1	25	1	11	15	9	0.318	
01/09/2002	6.05	24	25	161	0	5	42	64	146	1	25	0	2.5	17	0	0.352	8.4
29/09/2002	6.03	29	26	157	0	6	43	74	145	2	25	0	6	9	9	0.365	8.3

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
21/10/2002	6.27	33	26	147	1	5	43	74	139	2	27	3	25	19	3	0.362	7.7
08/12/2002	5.98	23	25	138	4	6	39	62	132	3	30	1	20	21	6	0.356	8.7
26/01/2003	5.83	15	30	157	0	7	48	66	171	3	33	1	20	24	2	0.184	6.2
03/03/2003	5.83	12	30	154	3	6	42	51	177	3	31	1	8	17	1	0.217	5.4
28/04/2003	5.92	13	29	160	4	6	42	52	182	2	32	1	12	11	2	0.171	4
11/06/2003	5.96	19	27	151	3	7	38	53	153	1	30	1	12	16	0	0.288	6.2
21/07/2003	5.94	25	26	144	3	7	37	62	141	1	30	1	7	10	4	0.276	7.5
10/08/2003	6.15	21	24	139	1	5	38	60	135	2	29	0	6	24	6	0.27	10.8
08/09/2003	6.28	30	26	138	2	7	39	69	134	2	30	0	12	12	0	0.272	13.1
27/10/2003	6.13	36	25	137	0	7	52	101	135	2	29	0	9	12	1	0.279	24.5
16/12/2003	5.91	20	27	150	0	6	43	68	151	2	34	0	12	29	2	0.3	6.51
12/02/2004	5.72	9	27	143	0	4	36	47	159	1	26	0	11	31	2	0.201	3.2
09/04/2004	6.04	23	27	151	0	0	41	67	169	0	29	1	11	20	2	0.169	3.1
20/05/2004	5.97	20	24	136	0	2	37	53	141	1	22	3	10	17	5	0.225	4.6
16/06/2004	6.17	27	25	134		5.8	26.5	59.7	125	0	22	4	11	19	3	0.263	5.7
14/07/2004	6.11	25	24	124.8		4.6	26.6	46.3	113	0	23	3	27	15	2	0.199	4.6
10/08/2004	6.26	33	23	119	0	5	28	54	101	4	23	3		14	2	0.29	4.7
13/09/2004	6.03	26	23	111.5	0	5	31	52	91	2	20	3	17	33	0	0.439	7.8
06/10/2004	5.5	10	22	100	0	6	27	43	102	0	19	2	26	39	15	0.456	5.4
14/12/2004	5.59	12	22	109	0	6	26	37	100	0	22	2	20	36	14	0.441	5.7
26/01/2005	6.15	34	47	229	0	7	57	84	284	3	35	1	10	8	0	0.093	1.5
02/03/2005	5.59	4	52	281	1	8	74	64	365	0	39	1	11	5	4	0.086	1.4
20/04/2005	5.65	4	40	228	0	7	55	43	276	2	30	1	4	12	0	0.116	3
06/06/2005	5.87	18	38	197	0	7	45	49	239	1	29	1	3	14	2	0.167	4.2
14/07/2005	6	19	32	180	0	6	39	47	200	1	26	2	9	23	0	0.245	5.2
15/08/2005	6.03	23	31	169	0	6	36	55	192	1	27	2	6	9	1	0.228	4.9
07/09/2005	6.07	23	30	157	0	6	37	51	177	1	27	0	6	12	2	0.269	5.6
04/10/2005	5.97	21	26	143	0	5	36	49	151	1	23	0	5	17	1	0.329	6.9
06/12/2005	5.96	23	29	139	0	8	34	54	169	2	24	0	3	17	1	0.215	5.9
08/02/2006	5.69	11	25	125	0	6	27	37	142	2	23	2	4	21	4	0.219	5.4
26/03/2006	5.93	23	23	117	0	5	27	43	129	2	24	14	15	13	0	0.181	3.9
11/05/2006	6.18	24	24	116	0	5	26	43	125	1	23	1	2.43	11	0	0.172	4.31
07/06/2006	6.06	20	25	130	0	5	28	41	136	2	24	0	2.24	14	1	0.196	8.38
29/06/2006	6.18	19	24	121	23	6	28	37	132	1	22	1	5.31	7	2	0.199	10.75
27/07/2006	6.17	22	24	141	0	6	30	43	131	1	24	4	8.69	9	1	0.201	5.54
21/08/2006	6.04	25	26	124	0	5	26	41	128	1	26	2	8.31	8	1	0.226	7.73
13/09/2006	6.28	24	25	128	2	5	28	44	127	2	26	1	4.7	9	4	0.25	7.44
26/10/2006	5.82	20	22	121	0	4	30	44	101	1	20	0		30	4	0.491	10.23
23/11/2006	5.88	18	21	113	7	6	30	45	113	2	63	1	7.34	18	1	0.351	6.79
21/02/2007	5.49	2	44	243	5	6	59	51	298	2	33	0	5.67	11	2	0.108	4.37
05/04/2007	5.7	8	34	186	4	5	38	40	225	1	27	0	4.23	5	1	0.135	4.51
04/06/2007	5.94	52	31	168	0	5	34	45	192	1	24	1	7.02	9	2	0.207	5.68
03/07/2007	6.08	21	31	167	5	7	34	47	185	0	23	0	12.59	14	2	0.286	6.69
09/08/2007	6.16	32	30	154	0	5	33	53	159	0	21	0	5.97	23	4	0.291	6.22
30/08/2007	6.01	28	28	147	0	5	33	47	149	1	21	1	7.68	19	4	0.393	8.9
25/10/2007	6.21	41	27	137	0	5	34	62	135	3	21	0	7.52	6	1	0.359	7.16
05/12/2007	5.88	20	25	132	0	5	32	42	139	1	20	0	7.64	14	3	0.394	7.47
05/02/2008	5.51	5	24	125	0	4	25	28	142	1	22	0	4.99	14	1	0.153	6.39
02/04/2008	5.61	6	34	299	10	8	64	66	267	0	34	0	7.07	10	4	0.165	6.4
16/07/2008	6	18	33	170	0	5	35	44	191	1	28	0	6.46	5	1	0.187	3.58
01/09/2008	6	24	28	155	0	6	39	58	152	0	24	0	7.5	27	5	0.428	9.93
04/10/2008	5.86	21	27	135	0	4	35	49	139	1	20	2	6.5	14	10	0.402	8.26
09/12/2008	5.86	15	26	128	0	5	30	37	145	1	21	10	2.27	8	1	0.223	5.33
12/01/2009	5.47	4	31	160	0	5	35	35	187	1	25	0	4.15	25	4	0.179	6.04
18/03/2009	5.81	12	32	172	0	4	35	43	199	1	26	0	3.74	15	2	0.141	3.39
27/04/2009	5.76	12	30	173	0	3	32	36	175	0	22	0	3.94	13	5		7.55

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
12/05/2009	5.96	18	31	156	0	4	31	38	176	1	22	0	2.42	12	1		4.16
12/06/2009	5.96	20	30	156	2	5	29	36	174	1	21	1	2.49	10	1	0.271	4.48
15/07/2009	6.03	18	28	145	0	4	29	41	158	2	22	0	1.78	13	0	0.213	4.7
11/08/2009	6.12	22	28	150	2	5	32	44	155	1	21	0	7.56	15	3	0.318	12.77
28/09/2009	5.92	22	22	114	1	3	28	39	106	1	16	0	5.21	8	16	0.358	9.81
16/11/2009	5.82	18	21	100	1	4	26	36	102	2	14	0	5.64	21	2	0.356	5.87
30/04/2010	6.18	39	24	119	0	5	33	61	103	8	18	2	3.54	41	0	0.552	10.43

Table 12 Water chemistry for the recently planted forest site September 2000 - April 2010

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
04/09/2000	7.27	330	58	196	0	12	71	295	157	2	45	0	2.5	5	33	0.068	2.4
08/10/2000	5.89	22	28	160	0	5	46	56	173	0	14	0	2.5	39	8	0.227	6.3
21/11/2000	5.72	19	22	124	0	3	35	46	115	0	18	0	12	58	0	0.437	8.1
09/01/2001	5.73	16	16	87	0	3	24	38	60	1	19	0	17	51	3	0.374	7.9
08/03/2001	5.61	9	21	98	0	6	31	43	95	0	36	0	6	29	0	0.3	6.2
26/04/2001	5.79	19	25	143	4	5	40	57	127	0	32	0	2.5	59	2	0.385	8.8
06/06/2001	5.92	41	24	140	2	2	40	59	101	0	19	3	6	42	14	0.397	8.9
03/07/2001	5.74	37	20	113	0	1	39	63	64	0	12	2	6	108	0	0.752	15.2
23/07/2001	5.89	38	20	107	1	2	43	64	70	2	10	0	6	73	4	0.732	14.8
19/08/2001	5.77	47	20	106	0	3	48	73	69	1	10	14	16	42	34	0.771	17.9
07/10/2001	5.4	9	24	102	0	8	41	52	115	1	15	2	2.5	52	5	0.535	10.9
14/11/2001	5.91	30	19	96	0	6	35	60	80	1	17	2	2.5	31	6	0.408	9.4
10/12/2001	6	35	19	102	0	5	34	55	77	1	19	4	6	32	8	0.4	8.3
22/01/2002	5.52	5	17	101	0	5	27	36	106	0	16	0	2.5	22	1	0.263	6
04/04/2002	5.48	9	36	229	0	8	47	58	255	1	31	0	2.5	14	17	0.224	5.3
07/05/2002	5.76	39	33	210	0	10	43	58	189	0	16	2	6	26	10	0.316	7.3
12/06/2002	5.7	29	26	131	0	3	40	54	80	0	10	2	6	64	10	0.758	
14/07/2002	5.93	71	27	145	0	4	54	80	99	0	10	4	16	36	19	0.646	14.8
31/07/2002	5.67	31	19	95	0	2	45	65	52	0	8	4	18	58	15	0.856	
01/09/2002	6.06	75	25	139	0	3	65	97	118	0	12	0	2.5	41	7	0.619	14.1
29/09/2002	6	111	30	152	0	3	77	94	132	0	12	1	6	8	51	0.385	9.7
21/10/2002	6.1	27	30	146	2	10	57	81	163	0	26	2	26	27	15	0.283	7.9
08/12/2002	5.97	36	22	122	0	5	38	60	97	1	27	1	24	35	6	0.371	8.9
26/01/2003	5.42	4	41	206	0	6	66	77	272	0	35	0	17	22	5	0.18	4.6
03/03/2003	5.66	10	32	171	2	7	43	51	180	0	45	0	7	38	1	0.232	5.2
28/04/2003	5.74	19	33	184	4	4	50	65	189	0	44	0	13	27	5	0.257	6.2
11/06/2003	5.7	28	21	119	0	1	37	53	81	0	9	2	14	48	15	0.668	12.7
21/07/2003	5.68	29	18	97	1	2	37	57	64	0	16	5	10	30	16	0.511	11.8
10/08/2003	5.59	107	30	149	2	5	79	109	102	2	7	6	16	126	5	1.028	19.5
08/09/2003	5.65	126	32	142	0	3	73	109	123	0	12	0	15	23	8	0.304	11.5
27/10/2003	5.89	54	31	162	0	4	72	121	185	1	22	0	7	5	2	0.115	21.7
16/12/2003	6	32	18	108	0	4	32	58	85	0	24	0	17	36	3	0.318	6.68
11/02/2004	5.4	0	32	165	0	6	50	53	208	0	24	0	8	17	3	0.143	2.3
09/04/2004	5.91	20	23	133	0	0	40	59	127	0	21	2	8	26	13	0.271	5.1
20/05/2004	6.01	38	22	129	0	0	41	64	107	1	9	2	9	42	14	0.44	8.2
16/06/2004	5.92	37	18	104		1.9	25.6	58.7	62	0	10	1	12	50	24	0.597	11.1
14/07/2004	6.03	65	22	115.2		1.9	31.2	50.3	73	0	9	3	10	43	15	0.115	9.5
10/08/2004	5.39	12	19	80	0	4	36	54	60	0	14	2		43	16	0.754	12.3
13/09/2004	5.52	15	23	92.5	0	5	40	55	93	0	9	3	16	51	17	0.599	10.8
06/10/2004	5.43	4	18	70	0	9	23	35	88	0	11	2	10	16	8	0.279	4.1
14/12/2004	5.59	7	13	62	0	5	15	22	53	0	16	1	24	17	5	0.38	4.9

Date	pH	Alk 2	Cond	Na	NH4	K	Mg	Ca	Cl	NO3	SO4	PO4-P	Total P	Al-NL	Al-L	Abs-250	TOC
26/01/2005	5.09	-7	74	376	0	8	93	92	525	0	49	0	8	3	13	0.042	1
02/03/2005	5.52	5	41	227	1	7	49	55	282	0	31	1	11	9	7	0.091	1.8
20/04/2005	5.83	22	29	175	0	7	34	36	177	0	15	1	4	35	2	0.251	5.2
06/06/2005	5.55	18	20	113	0	2	23	29	75	0	7	2	5	48	3	0.666	11.5
14/07/2005	5.59	100	30	158	0	3	51	66	108	0	6	1	10	58	6	0.507	10
15/08/2005	6.14	59	27	142	0	3	41	67	133	0	20	0	9	4	1	0.264	6.6
07/09/2005	5.93	30	27	138	0	3	43	60	129	0	12	1	12	38	3	0.379	7.7
04/10/2005	5.48	9	26	130	0	3	39	48	164	0	11	0	7	39	4	0.297	7.5
06/12/2005	5.54	7	28	145	0	3	31	38	170	0	25	0	2	23	9	0.194	5.2
08/02/2006	5.54	11	23	113	0	6	25	34	107	0	25	4	3	26	11	0.331	8.4
26/03/2006	5.78	20	19	102	0	5	21	30	82	1	30	76	13	29	4	0.271	5.5
11/05/2006	5.69	34	28	136	0	4	32	40	138	1	15	5	2.93	44	5	0.26	5.92
07/06/2006	5.58	53	27	144	0	2	37	49	120	0	7	2	4.58	66	10	0.411	10.83
29/06/2006	5.85	56	24	118	19	1	36	41	98	0	12	2	5.19	41	4	0.321	9.77
27/07/2006	5.74	150	33	158	0	5	70	92	109	0	8	5	13.08	21	8	0.452	9.75
21/08/2006	5.73	29	26	124	1	2	34	47	103	0	24	2	7.74	41	5	0.395	11.28
13/09/2006	5.91	46	25	137	2	3	38	53	115	0	10	1	4.34	43	8	0.416	10.95
27/10/2006	5.32	7	22	98	0	11	33	40	90	0	14	0		40	15	0.526	13.61
23/11/2006	5.45	3	26	131	0	6	38	42	167	0	20	2	5.22	19	3	0.192	3.87
10/01/2007	5.28	2	23	115	0	4	26	30	128	0	17	0	4.68	17	5	0.221	6.42
21/02/2007	5.51	6	34	207	7	6	41	47	221	1	30	0	4.94	17	7	0.194	6.23
05/04/2007	5.62	17	37	196	5	7	42	48	241	1	22	0	4.55	12	1	0.121	4.74
04/06/2007	5.59	17	24	143	0	2	26	33	121	0	7	1	9.85	40	12	0.61	12.12
03/07/2007	5.74	38	23	131	4	3	34	46	88	0	7	3	12.63	71	11	0.88	15.93
09/08/2007	5.81	63	26	128	0	3	45	60	95	0	8	3	7.74	11	3	0.609	13.37
30/08/2007	6.38	58	30	137	2	3	60	89	119	2	10	4	10.81	71	35	0.895	19.12
25/10/2007	5.85	64	31	148	0	8	50	64	157	1	9	0	8.28	9	1	0.352	7.92
05/12/2007	5.63	13	20	102	0	6	27	32	101	0	11	0	5.36	17	3	0.444	8.5
05/02/2008	5.54	6	23	116	0	4	26	29	140	0	19	1	5.08	9	3	0.133	5.83
02/04/2008	5.41	4	32	356	13	20	73	78	270	0	28	0	8.33	10	0	0.197	6.94
16/07/2008	5.68	37	26	135	0	3	33	43	101	0	24	0	7.22	35	7	0.367	7.97
01/09/2008	5.42	14	23	120	0	2	34	45	100	0	6	0	7.65	50	20	0.698	16.3
04/10/2008	5.34	5	24	111	0	5	33	37	124	0	9	8	5.15	20	18	0.458	9.73
09/12/2008	5.6	11	22	115	0	2	24	28	117	0	17	0	2.36	16	3	0.225	5.42
12/01/2009	5.33	0.16	25	126	0	3	27	28	147	0	20	0	3.78	13	3	0.172	6.7
18/03/2009	5.55	8	28	147	0	4	27	29	162	1	19	0	2.45	22	2	0.18	4.11
27/04/2009	5.49	9	27	168	1	3	28	31	147	0	10	0	4.32	15	25		11.48
12/05/2009	6.74	90	34	156	0	7	45	78	166	0	20	2	2.05	17	2		4.74
12/06/2009	5.61	54	28	152	0	1	36	42	135	0	3	3	2.68	38	17	0.537	8.1
15/07/2009	5.83	37	22	114	2	3	31	44	86	2	9	4	4.29	31	14	0.474	9.91
11/08/2009	5.63	31	25	125	2	1	43	56	110	0	3	0	6.42	52	6	0.74	24.02
16/11/2009	5.55	13	16	80	0	5	21	27	58	0	9	0	6.33	137	12	0.588	7.96
30/04/2010	6.23	26	21	106	0	4	22	39	105	1	18	1	2.38	17	0	0.237	5.19

N.B. Chemistry for this site funded by MS Pitlochry since 04/2007

Table 13 Diatom taxon list and total abundances – Control Burn.

Taxon	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Achnanthes altaica			2		2					1	1							
Achnanthes austriaca var. helvetica			4					1			1	1			1	1	3	
Achnanthes levanderi					1													
Achnanthes marginulata			4				1		2				1			6		
Achnanthes minutissima	2	4	5	13	8	7	4		5	12		1	15		20	6	5	
Achnanthes modestiformis						3			1		1	2	4	3	8	4	6	3
Achnanthes saxonica	4	1	2	1				2	2			1				1		
Achnanthes sp.			1									1						
Brachysira brebissonii	1		1	2	1	4	7	13		9	2		44	15	15	115	37	6
Brachysira serians								2										
Brachysira vitrea	106	74	72	161	90	122	125	38	60	153	80	43	294	120	232	416	97	89
Cyclotella kuetzingiana																	8	
Cyclotella kuetzingiana var. minor																	70	
Cymbella failaisensis				2														
Cymbella hebridica				2														
Cymbella lunata	2	4	7	15	6	6	5	10	6	16	11	4	25	16	6	47	6	70
Cymbella microcephala								1	1				1					
Cymbella perpusilla							1				2	4		2		7		
Cymbella scotica navicul				1														
Cymbella ventricosa																	1	
Eunotia [sp. 13 (minutissima)]								1										
Eunotia curvata	2	4	5	8	13	8	23	4	4	25	21	28	21	16	27		22	20
Eunotia curvata var. attenuata																		4
Eunotia curvata var. subarcuata			1															
Eunotia denticulata	1			1				1										
Eunotia exigua	27	16	47	20	11	49	19	9	12	13	6	9	5	13	7	37	21	10
Eunotia incisa	16	14	40	18	3	37	100	27	14	28	53	78	48	59	37	221	142	92
Eunotia meisteri			2	1							1							
Eunotia minutissima	1		2			1						1				3		19
Eunotia naegelii		11	2	7	3	12	11	8	6	28	8	24	32	53	16	124	8	11
Eunotia nymanniana					1													2
Eunotia paludosa	1		1									1		1				
Eunotia pectinalis				1	1													
Eunotia pectinalis var. minor	20	6		20	4	2					4	2	11	18	16	4	20	
Eunotia pectinalis var. minor f. impressa	2	6	63	6	8	1	22	6		7						49	190	86
Eunotia rhomboidea	2	2	12	11	1		13		1	29	6	6	2	22	7	7	67	12

Taxon	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Eunotia schwabei		1																
Eunotia sp.	1	3	13	6	3	10	18	15	9	31	33	24	37	32	43	12		
Eunotia tenella		1	1	1												1	2	6
Eunotia triodon											1							
Eunotia vanheurckii		3		2					2									
Eunotia vanheurckii var. intermedia		5		5				1			4			4	11	1	8	
Fragilaria sp.												2						
Fragilaria vaucheriae		1														7		
Fragilaria virescens												4				1		
Frustulia rhomboides		2												13				
Frustulia rhomboides var. saxonica	10	6	7	13	5	25	48	15	8	14	25	11	72	122	20	139	17	36
Frustulia rhomboides var. viridula	1	4	2	9		4	13	4	3	6	5	7	3		6	37	4	10
Gomphonema acuminatum var. coronatum							4						4	4	1	10		
Gomphonema angustatum	3	7				2	11	4				1		8	11	9	21	17
Gomphonema gracile	15	4	4	3	8	2	11	2	8	2	2	1	23	26	4	44		12
Gomphonema minutum	10	2																
Gomphonema parvulum						4		5										
Gomphonema sp.	2			2						2					1	1	1	
Krasskella kriegerana				4									2		1			
Navicula angusta				1				2								1		
Navicula arvensis				1														
Navicula cocconeiformis												1						
Navicula cumbriensis														4		1		
Navicula festiva					2		2					2	1		3	4		1
Navicula leptostriata															1			
Navicula mediocris			3	2	2	3							2	4	2	1		
Navicula pupula var. pupula				1														4
Navicula radiosa var. tenella												2	1	2				
Navicula subtilissima						2	2								1			
Neidium affine var. amphirhynchus																	1	
Neidium glaberrimum			1													1		
Nitzschia angustata			1										6		1		1	6
Nitzschia perminuta		1						4								1		
Nitzschia sp.		1																
Peronia fibula	27	12	25	48	23	26	50	4	4	35	16	52	53	42	29	28	20	8
Pinnularia abaujensis	1																	
Pinnularia biceps		2												1				
Pinnularia						5	4											1

Taxon	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
divergentissima																		
Pinnularia irrorata			4	4	2			2	4	5	2	2	6		4	4	11	5
Pinnularia microstauron			1	2														
Pinnularia sp.							2			2	4	4	2	1	1	1		
Pinnularia subcapitata var. hilseana					3	1		2		1	2	2			1	3		6
Rhizosolenia eriensis var. eriensis									1									
Stauroneis phoenicenteron				1														
Stenopterobia sigmatella				1							1							2
Surirella delicatissima				1						2		1						2
Synedra acus		2	2	4		142	1	6	39	28		4						6
Synedra minuscula	81	560	208	263	389	159	64	380	499	131	423	211	57	49	241	108		135
Synedra sp.			4	1														
Tabellaria flocculosa	651	252	498	348	242	396	392	390	401	381	266	464	298	454	226	341	134	266
Tabellaria quadriseptata								1			1	2	2		3	13	1	

Table 14 Diatom taxon list and total abundances – Experimental Burn.

Taxon	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2006	2007	2008	2009
Achnanthes altaica									3						1	
Achnanthes austriaca var. helvetica		1														
Achnanthes detha									1							
Achnanthes marginulata									1							
Achnanthes minutissima	1	1	5	176		4			3	3	4	3		1		
Achnanthes pseudoswazi				2												
Achnanthes saxonica			1		2											
Brachysira brebissonii	4	2	4		8	5	36	3	4	4	8	14	21	20	18	4
Brachysira serians														1		
Brachysira vitrea	64	58	80	166	129	8	199	153	164	137	18	92	73	233	91	101
Cyclotella kuetzingiana var. minor															24	
Cymbella heteropleura														1		
Cymbella lunata	5	7	20	16	29	5	44	17	24	38	12	6	57	60	34	33
Cymbella microcephala				58				2								
Cymbella minuta				1												
Cymbella perpusilla		1				1	1	1						7		10
Cymbella sp.				1												
Eunotia [vanheurckii var. 1]								2						1	2	6
Eunotia bidentula		4												4		
Eunotia curvata	2	11	2		2	4	7		28	17	26	2	5	2	9	26
Eunotia curvata var. attenuata							2								5	9
Eunotia exgracilis									1							
Eunotia exigua	10	23	6	6	16	16	1	19	23	43	2	7	5	12	16	3
Eunotia fallax		1	2													
Eunotia incisa	12	50	26	5	54	178	33	29	33	31	3	55	28	218	97	136
Eunotia meisteri						2										

Taxon	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2006	2007	2008	2009
Eunotia microcephala var. tridentata															2	
Eunotia minutissima							6							10		2
Eunotia monodon		1														
Eunotia naegelii	21	63	25	14	24	35	75	39	84	53	25	177	80	416	30	59
Eunotia nymanniana				1		2										
Eunotia paludosa		3										1		2		
Eunotia pectinalis	2		1	1												
Eunotia pectinalis var. minor	2	2	9	8	1	1				2		2	5		7	
Eunotia pectinalis var. minor f. impressa	19	101		5	3	2	4	2	13					27	16	28
Eunotia praerupta		1														
Eunotia rhomboidea	2	7	10	2		1	2	3	2	5		7	5	1	21	4
Eunotia sp.	1	4	6	1	6	6	34	69	26	22	2	18	12	9		
Eunotia tenella	1												1	2	5	2
Eunotia vanheurckii			1					2				9				4
Eunotia vanheurckii var. intermedia												3	3			
Fragilaria sp.										6	2					
Fragilaria vaucheriae				1										2		
Frustulia rhomboides		3		3											4	
Frustulia rhomboides var. saxonica	19	50	66	32	131	151	235	35	66	91	44	65	108	265	91	95
Frustulia rhomboides var. viridula	3	9	1	4	9	13	23	9	13	9	3		31	58	16	5
Gomphonema acuminatum				2										3		
Gomphonema angustatum		1	1						2				7		13	
Gomphonema gracile		8		9	3		28	12	15	40	4	3	22	23	2	20
Gomphonema sp.								1								
Krasskella kriegerana					1		1									
Navicula angusta		1					3			1			2	1	2	2
Navicula cumbriensis												1	1	3		
Navicula festiva		5		5		1	2	1		1		1		5		1
Navicula hoefleri						1								4		
Navicula leptostriata														3		2
Navicula mediocris		6			5		1	1				3		6		
Navicula pupula var. pupula															1	
Navicula radiosa var. tenella			1			4	2			3		2		2	2	2
Navicula subtilissima	1				7	56	7		3							1
Peronia fibula	71	105	29	21	95	41	146	173	43	43	19	28	41	35	53	30
Pinnularia abaujensis		1														
Pinnularia biceps						2			1							
Pinnularia divergentissima					2			2								
Pinnularia irrorata														1		
Pinnularia microstauron				2												
Pinnularia sp.						4	1			1	2			1		
Pinnularia subcapitata var. hilseana				2							2			3		
Stenopterobia sigmatella		5	2	2	1	1							1		2	4
Surirella delicatissima			1											1		
Surirella sp.															1	
Synedra acus	1			2			1		4							5
Synedra minuscula	28	2	3	42					1	4		13	2			
Tabellaria binalis f. elliptica								4					1			
Tabellaria fenestrata		1														
Tabellaria flocculosa	50	134	26	64	104	72	54	85	55	104	524	174	116	411	46	56
Tabellaria quadriseptata						26						2		4	2	

Table 15 Diatom taxon list and total abundances – Allt Riabhach na Bioraich Burn.

Taxon	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Achnanthes austriaca var. helvetica		1												
Achnanthes linearis	1													
Achnanthes minutissima	1	1	2	1				4			2		2	
Achnanthes modestiformis		1										1		
Achnanthes sp.														1
Brachysira brebissonii	4	16	20	6	4		4		1	4	35	36	4	8
Brachysira serians						1								
Brachysira vitrea	45	160	179	120	148	114	92	44	267	251	280	330	97	322
Cyclotella kuetzingiana													5	
Cyclotella kuetzingiana var. minor													67	
Cymbella heteropleura												1		
Cymbella lunata	4	15	4	4	21	5	5	2	2	12	8	16	18	30
Cymbella perpusilla	1								4					4
Eunotia [vanheurckii var. 1]	1				2									
Eunotia bidentula													2	
Eunotia curvata	37	12	29	33	11	7	14	6	18	4	9		28	38
Eunotia curvata var. attenuata													4	18
Eunotia exigua	7	23		2	5	2	5	48	12	4	8	12	27	7
Eunotia incisa	11	9	15	17	8	7	7	38	15	17	24	50	69	27
Eunotia minutissima		4		3								2		20
Eunotia monodon													2	
Eunotia naegelii	31	41	31	33	25	19	30	33	63	54	26	107	46	45
Eunotia pectinalis var. minor				1				2	1	5	1	8	1	
Eunotia pectinalis var. minor f. impressa	5			1									48	24
Eunotia rhomboidea	2		2		7	2	2	4	6			3	10	
Eunotia sp.	1	6	7	4	1	2	6	9	6	8	9	8	1	
Eunotia tenella	1												1	1
Eunotia vanheurckii var. intermedia											1			
Fragilaria vaucheriae												6		
Fragilaria virescens var. exigua				2								2		
Frustulia rhomboides										8		1		
Frustulia rhomboides var. saxonica	7	14	35	26	21	7	15	4	32	38	42	84	50	69
Frustulia rhomboides var. viridula		1	1	4	1		3	1	4		8	24	24	1
Gomphonema acuminatum var. coronatum													14	2
Gomphonema angustatum			3			1		4			7	6	24	16
Gomphonema gracile	14	9	9	32	11	4	18		21	19	51	66	4	21
Gomphonema sp.						2								
Navicula angusta			2										3	
Navicula contenta													2	
Navicula festiva	2								1					
Navicula hoefleri												4		
Navicula leptostriata							2							
Navicula mediocris			1	2	2							2		
Navicula radiosa var. tenella										1		1		
Navicula subtilissima					1									5
Neidium affine												1		
Nitzschia gracilis								2						
Nitzschia sp.					2									
Peronia fibula	80	12	37	28	27	21	13	6	44	9	13	41	55	29
Pinnularia divergentissima			2											

Taxon	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Pinnularia irrorata	2			1	2						2			
Pinnularia sp.			4			2			4				2	
Pinnularia subcapitata var. hilseana			7			4					2	2	4	3
Surirella delicatissima											1			
Synedra acus		3											8	
Synedra minuscula	20	2	2		52	10	7	1	9	118	168			55
Tabellaria binalis f. elliptica												1		
Tabellaria flocculosa	690	617	594	676	670	815	747	725	472	501	279	917	362	267
Tabellaria quadriseptata											1	2	11	

Table 16 Macroinvertebrate taxon list and total abundances – Control Burn.

TAXON	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004	2006	2007	2008	2009	2010
NEMATODA			1													
OLIGOCHAETA	22	6	8	3	5	2	1	3	3	2	3		4	3		3
TUBIFICIDAE												1	3			3
ENCHYTRAEIDAE												1	3	1		2
LUMBRICULIDAE										1		1				3
Stylodrilus heringianus																2
LUMBRICIDAE										1			2			1
HYDRACARINA						1		4	6		18	8				6
COLLEMBOLA																1
SIPHLONURIDAE										1						
Siphlonurus sp.												1				
Siphlonurus lacustris								1	4	2	5					
Ameletus inopinatus	11	4			1	1	3						3	6		
BAETIDAE									4	2						
Baetis sp.				52							23		6	19	2	1
Baetis rhodani	5		7		39	30	20	142	138	34		12	50	34	9	40
Baetis muticus	3	2	3				1	1				12		1		
Baetis niger													22	3	3	
HEPTAGENIIDAE					9					1	1				1	
Heptagenia sp.									2							
Heptagenia lateralis	3	18	11	9	2	3	13	10	16	4	5			1	1	
Ecdyonurus sp.					1											
Ecdyonurus dispar				1												
Leptophlebia marginata			1			1										
Leptophlebia vespertina													2	1		1
Brachyptera risi								1								
Protonemura praecox							1									
Amphinemura sulcicollis	168	32	27	17	52	54	103	57	76	69	38	26	161	91	12	87
Nemurella picteti				1												
Nemoura sp.												1				
LEUCTRIDAE					1											
Leuctra sp.									9	2	19	2	7			
Leuctra inermis	41	6	1	5	3	22	30	2	8	2	3	5	10	18	3	20
Leuctra hippopus		1														
Perlodes microcephala	2					1								2		
Isoperla grammatica	106	4	8	9	20	25	25	32	17	5	6	14	21	24	9	12
Siphonoperla torrentium	109	48	54	2	61	29	30	29	23	12	6	4	49	51	11	11
Chloroperla tripunctata				11												4

TAXON	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004	2006	2007	2008	2009	2010
Cordulegaster boltonii																1
Velia sp.											1					
Oreodytes rivalis	18	36	7	1												
Platambus maculatus		1														
HYDROPHILIDAE									1							
Hydraena gracilis								2								
Elodes sp.	1															
Elmis aenea	17		1		88	2	1	1			2					
Esolus sp.																
Esolus parallelepipedus												9	1			
Limnius volckmari	129	16	46	17		34	65	32	54	56	37	39	59	43	9	54
Oulimnius sp.					3				83	11		68	5	21	6	40
Oulimnius tuberculatus	55	22	21	5		14	8	27			91					
Sialis lutaria																1
Rhyacophila sp.								1		2						1
Rhyacophila dorsalis	1		1	2		4	2	1			1					
POLYCENTROPODIDAE									4			7	4	4		2
Plectrocnemia conspersa	6	1	5	3	2			4	8	1	6	1	3	2	2	3
Plectrocnemia geniculata		2														
Polycentropus sp.						2										
Polycentropus flavomaculatus		2	3		4			1	2	4	13	11	8	8	2	2
Tinodes sp.											1					
Hydropsyche siltalai	1				1					1		2	6	3		
HYDROPTILIDAE										2						
Agraylea sp.													1			
Hydroptila sp.		2									19	9				2
Oxyethira sp.		1										5	1			
LIMNEPHILIDAE	10	7	6		3	3	4	1	3		4	5	9	8	1	8
Potamophylax sp.										1						
Potamophylax cingulatus																1
Halesus sp.								1					1			
Halesus radiatus												2		1		1
Chaetopteryx villosa											2		7			
DIPTERA					2				1	2		3	3			3
TIPULIDAE	2	1						2	1	3	7		1	1		
Dicranota sp.	8	2	3	3	1	5	1	8	4	3		2	12	7		11
Psychodidae	1															
CHIRONOMIDAE	26	17	28	13	6	11	4	40	12	15	157	59	24	12	5	53
SIMULIIDAE	23		1	23	3	11	1	5	3	2	39		5	6	1	2
EMPIDIDAE						2		1			1	1	1		1	3

Table 17 Macroinvertebrate taxon list and total abundances – Experimental Burn.

TAXON	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NEMATODA	2		1	1													
Pisidium sp.		1												1			
OLIGOCHAETA	14	10	26		3			3	1		8	1			3	1	2
NAIDIDAE																1	1
TUBIFICIDAE																	1
ENCHYTRAEIDAE										4			1				1

TAXON	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
LUMBRICULIDAE														1	1		
Stylodrilus heringianus															1		
LUMBRICIDAE												2		2		1	
HYDRACARINA					1			1	8		7	1	4			1	
COLLEMBOLA					1				1			2				1	1
Siphlonurus sp.													1				
Siphlonurus lacustris			35				1		1			2					
Baetis sp.		1									1			3	4		2
Baetis rhodani				1	1	1			3			1	1	1			1
Baetis muticus	9		3														
Baetis niger														1			
LEPTOPHLEBIIDAE														2	17	1	5
Leptophlebia sp.									1		21	4	8				
Leptophlebia marginata	16	19	6			7	5	3		2		6			8	1	1
Leptophlebia vespertina	20	61	9	9		7	15	42	5	2		25	35	62	47	24	23
Protonemura meyeri	1																
Amphinemura sulcicollis	20	1	2	14	7	7	12	1	4	2	1	3		3	2		1
Nemurella picteti				1													
Nemoura sp.							1										
Nemoura avicularis		2				1			1	1							
Nemoura cambrica	2		1			1		3				6	4	16	6	2	1
Leuctra sp.									1		5				1		
Leuctra inermis	1																
Leuctra hippopus					1		1	1									
Leuctra nigra	1																
Isoperla grammatica	7				2	4	6	1	1			3		2	7		2
Siphonoperla torrentium	23	5		5	3	1	2				6	6	3	1	1		2
ODONATA												1					
Pyrrhosoma nymphula	1	1				1											
Cordulegaster boltonii	1														1		
VELIIDAE									3					3			
Velia sp.											2						
Dytiscidae undet. (larvae)		1		1													
Agabus guttatus	1																
Anacaena globulus			1											1			1
Elodes sp.															1		
Elmis aenea																	1
Esolus parallelepipedus													1	1			
Limnius volckmari	2	5		17	1	1	1	2		2	2			1	2	1	1
Oulimnius sp.					9				27	20		14	10	6	12	11	1
Oulimnius tuberculatus	151	98	19	15		12	20	14			78						
POLYCENTROPODIDAE									5	1	7	8	9	7	6	2	7
Plectrocnemia conspersa	13	9	9	15	1	2	5	35	9	5	6	8	5	4	8	2	1
Plectrocnemia geniculata		1															
Polycentropus sp.						2	6										
Polycentropus flavomaculatus	23	6	6		3	5		13	13	6	16	15	21	8	11	4	19
Polycentropus irroratus												3					
Hydropsyche sp.								1									
HYDROPTILIDAE	38				2				1	5							
Hydroptila sp.			1								2				1		
Oxyethira sp.		29				4		2			1	2	2	3			1
LIMNEPHILIDAE	66	2	7	4	17	41	47	5	6	15	29	19	10	14	24	17	16

TAXON	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Potamophylax rotundipennis					1												
Halesus sp.							1					1				2	1
Halesus radiatus			6					4				5			2	1	
Halesus digitatus								1									
Chaetopteryx villosa											14			2			
DIPTERA					2				2	1				1	1		
TIPULIDAE	1			1				1		1	3	1					1
Dicranota sp.	6	2	1	3	2	2	3	1				1		3	3		1
CERATOPOGONIDAE														1			
CHIRONOMIDAE	56	86	104	15	24	36	22	89	33	33	93	27	32	30	52	9	28
SIMULIIDAE	2		1	1	5	6	11	3	8	14	1	16		57	10	1	5
Simulium latipes		3															
EMPIDIDAE					2	1					1				1		
Clinocera sp.							1										
ANISOPTERA														1			
GERRIDAE								1									

Table 18 Macroinvertebrate taxon list and total abundances – Allt Riabhach na Bioraich Burn

TAXON	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NEMATODA	1												1		
Pisidium sp.												1			
OLIGOCHAETA	12		5	12	1	13	1		2	2	2	6	7		1
NAIDIDAE							1				1		1		
TUBIFICIDAE										1	1	1			
ENCHYTRAEIDAE								2			1	6	10		4
LUMBRICULIDAE							2	1			2	1	3		1
Stylodrilus heringianus								2			1		7	1	1
LUMBRICIDAE								1				2			1
HYDRACARINA						2	6		14	9	9	5	1	5	1
COLLEMBOLA								1							
Siphlonurus sp.							1					1			
Siphlonurus lacustris	17					3			9		11	3			
Ameletus inopinatus										1					4
BAETIDAE												3		1	
Baetis sp.									45	1		1			1
Baetis rhodani			8	4		8	16	21		57	14	46	123	27	44
Baetis muticus											1				
Baetis niger															1
HEPTAGENIIDAE									1						
Heptagenia lateralis	2	1	2	1	2										1
Leptophlebia sp.									1			1			
Leptophlebia vespertina	5										9	3	1	1	
Brachyptera risi				1											1
Amphinemura sulcicollis	9	23	28	25	99	45	27	85	14	51	26	92	178	17	74
Nemoura sp.		2													
Nemoura cambrica				1									1	1	
Leuctra sp.						6	3	1	13	19	5	15	3	1	1
Leuctra inermis		2	14	27	17	3	5	12	1	14	2	4	17	5	33

TAXON	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Leuctra hippopus															1
Perlodes microcephala															1
Isoperla grammatica	3	46	45	36	74	79	37	55	14	76	2	27	58	17	19
Siphonoperla torrentium	7	8	33	24	20	8	3	4	2	9	3	4	18	1	26
Chloroperla tripunctata		5													6
Cordulegaster boltonii								1							
Dytiscidae undet. (larvae)	1														
Oreodytes rivalis	1														
Oreodytes sanmarkii				1		1									
Agabus arcticus												1			
Anacaena globulus												1		1	
Elodes sp.										1					
Elmis aenea															1
Limnius volckmari	3	7	9	18	22	20	19	18	27	31	14	32	76	6	81
Oulimnius sp.			1				79	25		36	20	18	39	11	17
Oulimnius tuberculatus	9	10		4	56	40			23						
Sialis fuliginosa								1					2		
Rhyacophila sp.						3				2	2	1	4	1	1
Rhyacophila dorsalis				1		2	1								
Rhyacophila obliterata									1						
POLYCENTROPODIDAE									1	1		3	3		
Plectrocnemia conspersa	11	1	1	1	2	3	4	4	5	4	14	3	3	1	
Polycentropus flavomaculatus	1			3			6	4	15	7	3	7	2	4	4
Hydropsyche siltalai															7
HYDROPTILIDAE														1	
Hydroptila sp.									1		1	3		3	
Oxyethira sp.									2				1		
LIMNEPHILIDAE	6	3	6	5	8	6	4	8	3	2	11	18	24	3	14
Ecclisopteryx guttulata			1										2		
Halesus sp.									6			1	1		
Halesus radiatus								2		2	5	4		1	
Halesus digitatus						2									
Chaetopteryx villosa									2			5			
DIPTERA			1	1				6		4	8	5	3	2	2
TIPULIDAE							1	3	6			1	1	1	1
Dicranota sp.	7		5	9		5	3	8		20	4	9	11	1	7
CHIRONOMIDAE	14	7	10	18	6	186	8	18	81	26	33	31	18	12	8
SIMULIIDAE		12	1	76	1	2	7	1	7	8		3	5		
EMPIDIDAE								2	2				13	1	
ANISOPTERA												4			

Table 19 Control Burn macroinvertebrate summary statistics

Year	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Count	768	231	256	178	307	257	314	409	428	241	508	667	311	494	371	78	385
Total no. of taxa	24	22	27	19	21	23	18	26	19	21	23	20	19	18	16	12	19
RICHNESS (rareftn 100)	17	17	18	15	12	17	13	15	14	17	17	14	16	13	13	12	14
HILL'S N1	11.5	11.9	12.8	10.6	8.0	11.8	7.8	8.9	8.7	9.0	10.3	9.5	11.0	8.5	9.5	9.5	9.7
HILL'S N2	8.4	9.0	9.0	7.5	5.9	9.3	5.6	5.8	6.2	6.0	6.6	7.2	8.1	6.0	7.6	9.2	7.5
EVENNESS (E5)	0.71	0.73	0.68	0.68	0.69	0.76	0.67	0.61	0.68	0.63	0.60	0.73	0.71	0.66	0.78	0.97	0.75
BMWP	110	99	125	88	88	118	93	108	88	104	116	101	84	104	103	77	103
ASPT	6.4	6.6	6.6	6.3	6.3	6.6	6.1	6.7	6.8	6.5	6.4	6.7	6.5	6.5	6.9	7.0	6.4

Table 20 Experimental Burn macroinvertebrate summary statistics

Year	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Count	477	231	247	110	96	142	162	227	134	114	313	183	147	238	233	83	128
Total no. of taxa	25	20	20	18	20	22	19	22	18	14	18	19	13	19	16	10	19
RICHNESS (rareftn 100)	18	14	14	16	19	19	16	13	16	13	13	16	12	14	12	9	17
HILL'S N1	11.3	7.9	7.7	11.4	11.9	9.8	10.1	6.6	9.0	8.5	7.6	10.1	6.5	6.4	6.7	6.2	8.3
HILL'S N2	6.9	5.4	4.6	10.0	8.5	6.4	7.3	4.5	6.7	6.7	5.6	8.1	5.1	5.2	4.9	5.3	6.3
EVENNESS (E5)	0.57	0.64	0.54	0.87	0.69	0.61	0.69	0.67	0.71	0.76	0.70	0.78	0.75	0.59	0.68	0.82	0.72
BMWP	108	83	82	67	94	84	93	80	79	52	88	79	69	74	92	44	84
ASPT	6.4	5.5	5.9	6.1	6.3	6.5	7.0	5.7	6.6	5.2	5.9	6.6	6.2	6.2	6.6	5.5	6.0

Table 21 Allt Riabhach na Bioraich Burn macroinvertebrate summary statistics

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Count	109	128	171	268	315	437	234	286	316	384	205	372	637	126	365
Total no. of taxa	17	13	16	22	13	20	18	20	21	15	18	20	18	18	20
RICHNESS (rareftn 100)	17	12	13	16	10	13	15	16	17	12	16	15	12	16	15
HILL’S N1	12.6	7.6	8.8	10.3	6.6	6.7	9.1	9.9	11.9	9.2	12.3	10.8	8.6	10.7	10.2
HILL’S N2	11.9	5.5	6.8	7.5	5.1	4.2	6.0	6.7	8.7	8.0	10.0	8.2	6.6	8.8	7.8
EVENNESS (E5)	0.94	0.67	0.74	0.69	0.73	0.57	0.62	0.64	0.70	0.84	0.80	0.74	0.73	0.80	0.74
BMWP	89	78	83	105	75	95	80	85	121	80	96	111	100	96	115
ASPT	6.9	7.1	6.4	6.6	6.1	6.3	6.7	6.1	6.7	6.7	6.9	6.5	6.3	6.4	6.8

Table 22 Control Burn aquatic macrophyte percentage cover

	1992	1993	1994	1995	1996	1997	1998	1999	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Batrachospermum sp.	+	0.7	+		+				+	+			+					+
Lemanaea sp.																		+
Marsupella emarginata var *aquatica*	4.4	4.0	4.9	0.4	1.5	0.2	1.9	1.2	+	0.6	1.0	0.5	0.7		4.2	4.3	6.9	8.4
Scapania undulata	2.8	3.7	1.7	0.9	2.0	1.9	3.7	3.3	2.9	3.2	3.8	2.1	10.7		3.1	7.1	11.3	4.1
Racomitrium aciculare	0.3	+	2.1	0.4	+	+		0.7	0.1	0.6	1.1	+	1.7	+	+	0.1	3.3	1.4
Blindia acuta																0.5	0.5	0.7
Juncus bulbosus var *fluitans*	0.1	+												+		0.1		
TOTAL COVER (excluding filamentous green algae)	7.6	8.4	8.7	1.7	3.5	2.2	5.6	5.2	3.0	4.4	5.9	2.6	13.1	+	7.3	12.1	22.0	14.6
Filamentous green algae	+	10.7	+	0.1	+	+	+	1.3	+	0.8	0.3	+	+	+	+	+	+	+

Sampling stretch 50m long.

- 137 -

Table 23 Experimental Burn aquatic macrophyte percentage cover

	1993	1994	1995	1996	1997	1998	1999
Batrachospermum sp.	33.3	12.7	54.2	32.8	35.0	28.8	17.8
Marsupella emarginata var *aquatica*	38.0	37.3	9.4	27.4	23.2	25.7	26.7
Scapania undulata		5.0	21.7	12.0	11.8	15.2	22.1
Juncus bulbosus var *fluitans*	2.6	9.0	2.7	6.6		3.3	0.2
TOTAL COVER (excluding filamentous green algae)	73.9	64.0	88.0	78.8	70.0	73.0	66.8
Filamentous green algae	68.0	+					

Sampling stretch 20m long. Sampling ceased in 1999.

Table 24 Allt Riabhach na Bioraich Burn aquatic macrophyte percentage cover

	1996	1997	1998	1999	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Batrachospermum sp.		1.6	0.3	0.3	0.4	+				+				+
Lemanaea sp.													+	
Marsupella emarginata var *aquatica*	+											+	0.1	
Scapania undulata	0.4	0.2	0.7	0.5	0.9	1.0	0.4	0.3	1.5	1.2	0.5	0.8	1.9	1.5
Racomitrium aciculare			0.2	0.2	0.2	0.2	0.2		0.1	0.1	+	0.2	0.4	0.4
Blindia acuta												+	0.4	+
TOTAL COVER (excluding filamentous green algae)	0.4	1.8	1.2	1.0	1.5	1.2	0.6	0.3	1.6	1.3	0.5	1.0	2.8	1.9
Filamentous green algae	0.4		+	+	+	0.2	3.9		+		0.3	+	+	+

Sampling stretch 50m long.

- 138 -

Table 25 Fish population data

Site	Year	Area Fished (m^2)	Density (no. m^{-2})	
			Age 0+	Age> 0+
Control Burn	1993	115	0.25	0.14
Control Burn	1994	115	0.35	0.02
Control Burn	1995	118	0.33	0.05
Control Burn	1996	87	1.51	0.26
Control Burn	1997	109	0.20	0.11
Control Burn	1998	101	0.42	0.05
Control Burn	1999	117.5	0.29	0.04
Control Burn	2000	114	0.06	0.02
Control Burn	2001	116	0.56	0.03
Control Burn	2002	106	0.40	0.21
Control Burn	2003	104	0.15	0.13
Control Burn	2004	120	0.11	0.08
Control Burn	2005	135	0.07	0.01
Control Burn	2006	107	0.15	0.03
Control Burn	2009	107	0.10	0.03
Experimental Burn	1993	32	0.97	0.13
Experimental Burn	1994	32	0.14	0.28
Experimental Burn	1995	36	0.34	0.03
Experimental Burn	1996	38	0.78	0.03
Experimental Burn	1997	45	0.31	0.07
Experimental Burn	1998	44	0.36	0.14
Experimental Burn	1999	31	0.32	0.13
Experimental Burn	2000	42	0.14	0.21
Experimental Burn	2001	45	0.55	0.11
Experimental Burn	2002	32	0.40	0.12
Experimental Burn	2003	38	0.03	0.24
Experimental Burn	2004	47	0.19	0.19
Experimental Burn	2005	44	0.21	0.20
Experimental Burn	2006	37	0.24	0.22
Experimental Burn	2009	31	0.26	0.06
ARnB Burn	1995	79	0.54	0.05
ARnB Burn	1996	57	0.63	0.24
ARnB Burn	1997	73	0.21	0.07
ARnB Burn	1998	71	0.27	0.18
ARnB Burn	1999	63	0.60	0.13
ARnB Burn	2000	75	0.04	0.05
ARnB Burn	2001	73	0.36	0.07
ARnB Burn	2002	63	0.85	0.21
ARnB Burn	2003	65	0.19	0.08
ARnB Burn	2004	77	0.20	0.03
ARnB Burn	2005	73	0.22	0.10
ARnB Burn	2006	61	0.64	0.08
ARnB Burn	2009	62	0.24	0.13

Table 26 Biology sampling dates

Sampling Year	Fish	Macroinvertebrates	Epilithic Diatoms	Aquatic Macrophytes
1992 *			15 Aug	15 Aug
1993	29 Sept	3 May	29 Sept	29 Sept
1994	27 Sept	12 may	25 Aug	25 Aug
1995	27 Sept	No sample	25 Aug	25 Aug
1996	24 Sept	15 May	28 Aug	28 Aug
1997	17 Sept	21 May	23 July	23 July
1998	1 Oct		1 Aug	1 Aug
1999	6 Oct		19 Aug	19 Aug
2000	20 Nov		4 Aug	4 Aug
2001	28 Sept	18 May	30 Jul	30 Jul
2002	24 Sept	15 May	28 Aug	28 Aug
2003	16 Sept	2 May	10 Aug	10 Aug
2004	2 Nov	13 May	12 Aug	12 Aug
2005	20 Oct	10 May	21 Aug	21 Aug
2006	10 Oct	9 May	9 Aug	9 Aug
2007	N/A	10 May	14 Aug	14 Aug
2008	N/A	30 April	13 Nov	13 Nov
2009	25 Sept	12 May	14 Aug	14 Aug
2010	N/A	30 April	11 Aug	11 Aug

* Only control burn sampled in 1992