Environmental Change Research Centre

Research Report No.103

Land-Use Experiments in the Loch Laidon Catchment:

Ninth Report on Stream Water Quality to the Rannoch Trust

E. M. Shilland, D. T. Monteith, J. Keay, P. Collen & A. Kreiser.

May 2005

ISSN: 1366-7300

Environmental Change Research Centre
University College London
26 Bedford Way
London, WC1H 0AP

Land-Use Experiments in the Loch Laidon Catchment:

Ninth Report on Stream Water Quality to the Rannoch Trust

E. M. Shilland[1], D. T. Monteith[1], J. Keay[2], P. Collen[2] & A. Kreiser[1]

May 2005

1. Environmental Change Research Centre
University College London
26 Bedford Way
London, WC1H 0AP

2. Freshwater Environment Group
FRS Freshwater Laboratory
Faskally, Pitlochry
Perthshire, PH16 5LB

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

Cover photo: Looking west down Loch Laidon with the mountains of Glencoe in the distance. All photos © ECRC except Figure 6. © Lord Pearson of Rannoch.

EXECUTIVE SUMMARY

1. This is the ninth report presenting the results from the Stream Water Quality component of the Loch Laidon catchment land-use experiment which began 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 integrated chemical and biological water quality monitoring programme now represents over fourteen continuous years of data. This is a unique record of surface water quality for this region of central Scotland and its scientific value will increase even further as monitoring continues.

3. The catchment of a small stream, the “Experimental Burn” was fenced and cattle were introduced in a summer grazing regime whilst the neighbouring catchment and the “Control Burn” were left ungrazed by cattle.

4. 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.

5. In the previous report it was demonstrated that levels of phosphorus and nitrogen (in the form of soluble reactive phosphorus and nitrate) had increased recently in the Experimental Burn relative to that of the Control Burn. These changes were consistent with grazing effects on water chemistry.

6. Peak summer levels of the biologically available nutrient soluble reactive phosphorus (SRP) did not continue to increase in the Experimental Burn relative to the Control Burn in 2004. However there is now evidence that SRP concentrations have risen in all three burns since circa 2000. We have no immediate explanation for this effect, which must result either from changes in the chemistry of deposition or changes in climate.

7. Nitrate concentrations were largely recorded as being below detection limits in 2004. There was limited evidence however that levels continued to be slightly elevated in the Experimental Burn when compared to the Control Burn.

8. Cattle poaching and trampling continues to be apparent in the catchments and by the edges of the experimentally grazed burns. This may be having a significant effect on the hydrology of the grazed catchments and might account for the progressive trend in nitrate described above.

9. Multivariate statistics applied to the diatom and macroinvertebrate assemblage time series data from all three burns did not demonstrate any significant temporal changes during the period of monitoring. Similarly the fish and aquatic macrophytes do not appear to have undergone any major changes that can be linked with the cattle grazing regime.

1 INTRODUCTION

This report presents and summarises data from the Stream Water Quality project instigated by the Rannoch Trust in 1992. The project comprises the aquatic monitoring part of the Loch Laidon catchment land-use experiment, which is investigating the effects of summer cattle grazing on the terrestrial and aquatic upland environment. Allott *et al* (1994) described the project rationale and background whilst progress reports (Monteith *et al.* 1995;Monteith *et al.* 1996;Monteith *et al.* 1997;Monteith *et al.* 1999;Shilland *et al.* 2001;Shilland *et al.* 2003;Shilland *et al.* 2004) have provided ongoing updates of the accumulating chemical and biological datasets. Results for the period January 2004 to December 2004 are discussed in the context of the longer time series.

2 METHODOLOGY

Chemical and biological sampling methodologies follow those of Allott *et al.* (1994). The sampling area is shown in Figure 1. 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 fenced experimental plot (see Figure 2) from mid July to late September 1993 and a similar grazing period has been observed in subsequent years. Stocking levels were reduced by one cow and one calf in 1994.

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 lacked sufficient similarity 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 points (a) and (b) 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 outwith the fenced area. 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 downstream from a recently planted area of 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 include the Allt Riabhach na Bioraich Burn. Accordingly, stocking densities were increased overall, to 40 cattle in 2002 and 36 cattle in 2003. An area of approximately fifteen hectares in the North West 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.) Aquatic macroinvertebrates were not surveyed in 1995 nor aquatic macrophytes in 2000. Biological sampling dates are provided in Appendix 19. Photographs of the survey stretches are shown in Figures 3 to 5 and the area of grazing can be seen clearly in Figure 6.

3 DATA ANALYSIS AND PRESENTATION

Data are held on a central Access database at the Environmental Change Research Centre (ECRC) and in this report are presented as raw 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 ratios between the 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 a constant ratio (i.e. any deviation away from a horizontal line).

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.

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%.

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).

4 RESULTS

4.1 CHEMISTRY

Summaries of the chemical data are presented in Appendix 1. Full chemistry is shown in Appendices 2 to 8. The assessment below concentrates primarily on evidence for a temporal departure in the relationship between the chemistry of the Control and Experimental sites.

4.1.1 COMPARISON OF THE CONTROL AND UPPER EXPERIMENTAL BURN

The upper chemical sampling station on the Experimental Burn is, because of its position unlikely to respond strongly to grazing effects but it does represent the longest time series available for comparison. The relationships between concentrations of key chemical determinands in the Control and upper Experimental Burn are provided in Figures 8 to 12.

Previous reports have demonstrated strong seasonal variation in Control:Experimental ratios for alkalinity and conductivity concentrations and this has persisted during 2004. Concentrations tend to be very similar in the two streams for much of the year until summer periods of low flow occur. At these times the alkalinity and conductivity of the Experimental Burn rise consistently above those of the Control Burn. The difference during the dry summer periods may reflect a stronger ground water influence in the Experimental Burn or a slight difference in the underlying geology of the two catchments. At other times of year the overland and soil components of the runoff appear to dominate the stream chemistry. The relationship between stage board height and the ratio between Experimental Burn/Control Burn alkalinity is shown in Figure 12 and demonstrates that alkalinity is generally higher in the Experimental Burn when stage board height is less than about 25cm. Concentrations of conductivity dropped to unusually low levels in both streams towards the end of 2004, tracing similar drops in calcium, magnesium, sodium and chloride.

Nitrate concentrations at both sampling stations largely fell below detection limits throughout 2004 and the normal seasonality, whereby peak values are recorded towards the end of winter, was not observed in either stream. Levels of soluble reactive phosphorus (SRP) – the biologically available component of the total phosphorus concentration- were highest overall in the Control Burn in early summer but were otherwise broadly similar at both sampling points during the rest of the year. This pattern resembles that of 2003 whereas between 1999 and 2003 SRP had tended to be more elevated in the Experimental Burn during the summer months`.

4.1.2 COMPARISON OF THE CONTROL AND LOWER EXPERIMENTAL BURN

Figures 13 to 20 illustrate the relationships of selected chemical determinands between the Control Burn and the Lower Experimental Burn. The time series available from the lower sampling station on the Experimental Burn is shorter than that from the upper station but, encompassing more of the catchment, should be more sensitive to any land use changes.

Alkalinity concentrations were similar in the Control and lower Experimental Burns during most of 2004 with the exception of the summer peak which was greater in the latter burn. The apparent rising trend in the ratio of alkalinity between the two sites, identified in 2003 (Shilland *et al.* 2003), and investigated statistically in 2004 (Shilland *et al.* 2004), does not appear to have continued in the 2004 data, bearing out the conclusions drawn in the last report that the effect probably resulted from short term climatic variability. Strong seasonality continued to be apparent in conductivity and concentrations of calcium and potassium and, as in previous years, values were generally higher in the lower Experimental Burn than the Control Burn. Low potassium levels were recorded in both burns in late spring 2004.

Time series graphs of the ratio and difference between nitrate at these two stations are shown in Figures 13 and 14. A continuation of the trend whereby in the second part of monitoring - 1998 onwards - nitrate concentrations tend to be higher in the lower Experimental Burn is also apparent in 2004. The data should be interpreted with caution however as most of the 2004 samples were below the laboratory detection limits.

In 2004 soluble reactive phosphorus rose during the summer months in both burns, following the seasonal pattern observed in most years since the onset of the monitoring programme. The trend of an increasing difference between the peak summer concentrations, as shown by the ratio between the burns in Figure 20, did not continue in 2004. As in 2003 the highest summer value recorded was actually in the Control Burn.

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

Time series plots of alkalinity, conductivity, nitrate, soluble reactive phosphorus and total organic carbon comparing the Allt Riabhach na Bioraich, the Control and the Lower Experimental burns are given in Figures 21 to 25.

In 2004 the Allt Riabhach na Bioraich Burn continued to demonstrate distinct seasonality in measured concentrations of most chemical determinands. Similar to the other sampling stations however this annual cyclicity was not seen in the nitrate data as concentrations were again below detection limits. The chemistry of the Allt Riabhach na Bioraich Burn continues to more closely resemble the Control Burn in comparison with the Experimental Burn. The Experimental Burn had higher peaks of both conductivity and alkalinity than the other two burns in summer 2004, maintaining the long term norm. Conductivity, alkalinity and total organic carbon have not increased or decreased significantly in the Allt Riabhach na Bioraich Burn, relative to the Control Burn, since the new grazing regime began in 2002. In all three burns soluble reactive phosphorus concentrations were similar to the slightly elevated levels observed over the previous three years.

4.2 BIOLOGY

4.2.1 EPILITHIC DIATOMS

The data for epilithic diatoms are provided graphically in Figures 26, 27 and 28 and trend test statistics are shown in Table 1. Due to the length of time required for diatom analysis the results discussed here are from 2003.

Two species of diatom formed the majority of the 2003 sample in the Control Burn: *Tabellaria flocculosa* and *Synedra minuscula.* The acid species *T. flocculosa* has had relatively stable abundances throughout the monitoring period whilst those of *S. minuscula* show greater inter-annual variation. The proportion of *Brachysira vitrea,* which has been relatively abundant in previous years, fell within the sample in 2003. *Peronia fibula* and *Eunotia incisa* were the most abundant of the other species present.

The Experimental Burn diatom assemblage in 2003 continued to show the most variability of any of the study burns. Most notable in this year is the large increase in abundance of *Tabellaria flocculosa* which constituted over 75% of the sample. Consequently relative abundances of the five other taxa that have tended to predominate in the burn, *Brachysira vitrea, Peronia fibula, Eunotia naegelii*, *Eunotia incisa* and *Frustulia rhomboides* var. *saxonica*, dropped significantly. We have no evidence to link *T. flocculosa* with grazing activity and further years of data will be required to ascertain whether this represents a sustained ecological change at this site.

In 2003 the relatively impoverished diatom flora of the Allt Riabhach na Bioraich Burn maintained the stability of species abundances it has shown during the monitoring period. Dominated again by *Tabellaria flocculosa,* with *Brachysira vitrea* and *Eunotia naegelii* present in much lesser numbers, the sample shows slight increases in two species rare in previous years, *Eunotia incisa* and *Eunotia exigua*. Again further years of sampling are required to determine whether this represents the early stages of a sustained ecological shift.

First axis eigenvalues from 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. Table 1 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 small relative to variance on the first Principal Component. Subsequent Monte Carlo permutation tests demonstrated that there is no significant linear trend in the species assemblages of any of the three burns at the $P > 0.05$ level. As with similar statistics performed in the previous two reports (Shilland *et al.* 2003;Shilland *et al.* 2004) this result implies that cattle grazing is not having a measurable effect on the diatom flora of the Experimental Burn to date.

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	0.07	0.22	0.07
Experimental Burn	0.22	0.09	0.41	0.30
Allt Riabhach na Bioraich Burn	0.26	0.10	0.38	0.29

4.2.2 MACROINVERTEBRATES

Macroinvertebrate data are provided in Appendices 9 to 11 and Figures 29, 30 and 31. Appendices 12 to 14 and Figures 32, 33 and 34 detail macroinvertebrate summary statistics.

The macroinvertebrate fauna of the Control Burn has varied considerably between years during the monitoring period but 2004 saw a sample largely dissimilar from most previous years. The acid sensitive mayfly *Baetis rhodani,* which had increased between 1997 and 2003, was virtually absent in 2004. Stoneflies also decreased in relative abundance with *Amphinemura sulcicollis* being the only species to occur at above 5% of the sample. The beetles *Limnius volckmari* and *Oulimnius volckmari* between them accounted for 25% of the sample but, for the first time in the Control Burn, the most abundant group was the Chironomids (a group of non biting midges), registering over 30% of the invertebrates collected. Summary statistics for the Burn show that the number of individuals sampled was relatively high and, perhaps consequently, a slight increase in the number of taxa present was recorded. Diversity and water quality indices (Appendix 12) remained relatively unchanged with the exception of a slight drop in the Average Score Per Taxon (ASPT).

In the Experimental Burn the 2004 macroinvertebrate assemblage was broadly similar to that recorded in previous years and also to that found in the Control Burn in 2004. Chironomids and the beetle *Oulimnius tuberculatus* dominated but various caddis species, such as *Polycentropus flavomaculatus*, *Chaetopteryx villosa* and Limnephilidae were also characteristic. Mayflies and stoneflies continued to be less common than in samples from some previous years earlier in the monitoring exercise. Again, similar to the Control Burn, total numbers of individuals sampled and the total number of species recorded increased. According to the Hill's indices (Appendix 13) sample diversity was slightly lower than in some previous years, as was the ASPT.

Echoing the faunistic composition of the other two burns the Allt Riabhach na Bioraich Burn was dominated by Chironomids in 2004. Similarly the beetles *Limnius volckmari* and *Oulimnius tuberculatus* were also relatively abundant. Stoneflies, particularly *Amphinemura sulcicollis* and *Isoperla grammatica*, were present but at levels much reduced from previous years. Low levels of caddis larvae were recorded. The mayfly family *Baetis* sp. exhibited a marked increase in abundance, reaching greater than 10% of the total sample. Summary statistics show that the total number of individuals sampled and the number of species found were relatively high but within the limits of previous samples. Diversity indices show a slight increase for the year as does the BMWP water quality index (Appendix 14).

Statistical results from the analysis on the macroinvertebrate data are presented in Table 2. The gradient lengths obtained using Detrended Canonical Correspondence Analysis on the macroinvertebrate data from the three study burns confirmed their suitability for subsequent Principal Components Analysis. The variance explained by time in all three streams is small compared to variance on the Principal Component. Subsequent significance tests suggest that there are no time trends at any of the three sites and therefore, similar to the analysis performed in previous reports, demonstrate that cattle do not seem to have had a detectable effect on the macroinvertebrate fauna of the Experimental Burn or the Allt Riabhach Na Bioraich Burn.

Table 2 Macroinvertebrate trend test statistics

	λ_1^{PCA}	λ_1^{RDA}	$\lambda_1^{RDA}/\lambda_1^{PCA}$	**Restricted P Value**
Control Burn	0.32	0.16	0.50	0.24
Experimental Burn	0.33	0.14	0.42	0.30
Allt Riabhach na Bioraich Burn	0.32	0.17	0.53	0.33

4.2.3 AQUATIC MACROPHYTES

Appendices 15, 16 and 17 summarise aquatic macrophyte data for the three study burns and Figures 3 to 5 illustrate the survey stretches. Due to physical erosion of the restricted survey stretch available, sampling of the Experimental Burn ceased after 1999. As is common for acid oligotrophic upland streams bryophytes - mosses and liverworts – continue to dominate the species assemblages in both the Control and Allt Riabhach na Bioraich Burns. In 2004 the Control Burn saw abundances of the liverworts *Marsupella emarginata* var. *aquatica* and *Scapania undulata* and the moss *Racomitrium aciculare* decline relative to 2003. The shift from dominance of *M. emarginata* var. *aquatica* to *S. undulata* identified in the last report (Shilland *et al.* 2004) persisted however. Total cover was low but remained above the minimums recorded in 1995 and 1997. In the Allt Riabhach na Bioraich Burn total cover was the lowest recorded since the start of monitoring. The liverwort *S undulata* decreased slightly from its already low 2003 levels and the moss *R. aciculare* was not found at all.

4.2.4 FISH

Data for the fish populations in the three study burns are presented in Figures 35 to 37 and Appendix 18. Trout continue to be the only species recorded. In 2004 recruitment of juvenile fish occurred in all three burns. Numbers of these young 0+ fish increased in the Experimental Burn, stayed equal in the Allt Riabhach na Bioraich Burn and decreased slightly in the Control Burn relative to the previous year. The broad pattern of absolute densities and their change through time continue to be markedly similar for 0+ fish in the Control and Experimental burns however. This contrasts with patterns for the older cohort of >0+ fish which resemble each other more strongly in the Control and the Allt Riabhach na Bioraich burns through time. Densities of >0+ fish returned to levels below those of 0+ fish in all the burns in 2004 after having been slightly higher in the Experimental Burn in 2003. Overall there would still appear to be little evidence of any consistent trends within the fish data nor signs of any effect, positive or negative, from the presence of cattle in the Experimental and Allt Riabhach na Bioraich catchments.

5 DISCUSSION

The water chemistry data for all burns in 2004 generally fell within limits previously observed during earlier monitoring. The main exceptions to this were the reduced concentrations of sodium, magnesium, calcium and chloride recorded at the end of the year at all sampling stations and the reduced levels of potassium recorded at most stations in spring. As these minima were seen at both grazed and ungrazed sampling points it is clear they are unrelated to the experimental grazing regime of the project.

Nutrient enrichment effects on burns are often ascribed to riparian cattle grazing (Hooda *et al.* 1997a, Hooda *et al.* 1997b, Lemly 1982, Scrimgeour and Kendall 2002). The trend observed in the previous report, that peak summer levels of soluble reactive phosphorus (SRP) were increasing in the lower Experimental Burn relative to the Control Burn, and pointing towards a process possibly unique to the experimental catchment, has not persisted in the more recent data. This is consistent with a movement of cattle away from the Experimental Burn due to the effects of burning in 2002 and it will be interesting to observe the ratio between the streams as the cattle begin to return. Moderately elevated concentrations of SRP, relative to the early stages of monitoring, have continued to be observed within all three catchments. This data is difficult to interpret but may be due to changes in deposition chemistry, climate or both.

Nitrate concentrations were below detection limits in many samples during 2004, and levels have not been so low since 1998. The switch from generally higher levels in the Control Burn pre 1998 to the Experimental Burn thereafter that was identified in the previous report persisted nonetheless. This interesting trend could be attributed to the physical impact of cattle, as poaching and trampling (Figure 7), commonly reported effects (Belsky, Matzke, and Uselman 1999;Scrimgeour and Kendall 2002;Sovell *et al.* 2000;Wohl and Carline 1996), restrict rainwater percolation and increase the direct delivery of rainfall into stream channels. Nitrate within rainfall would thus be less subject to biological processes within the soils of the experimental catchment.

The application of multivariate statistics on the macroinvertebrate and diatom time series data did not demonstrate any significant temporal trends. This suggests that longer term cattle grazing in the catchment of the Experimental Burn and post 2002 cattle grazing in the Allt Riabhach na Bioraich Burn catchment is having no effect on these two biological groups. An increased abundance of the diatom *Tabellaria flocculosa* in the Experimental Burn and two *Eunotia* species within the Allt Riabhach na Bioraich Burn require further monitoring data to establish the likelihood of significant ecological change. Similar to the diatoms and macroinvertebrates, evidence is lacking within the streams for grazing induced changes in the aquatic macrophyte assemblages and the trout densities.

The Loch Laidon land use experiment continues to accumulate an invaluable long term chemical and biological dataset and fulfils the criteria Larsen *et al*. (1998) describe as being key to successful cattle grazing studies. The longer the experimental design is maintained the greater the power of the unique study to identify cattle induced trends, however subtle, within the project area.

6 ACKNOWLEDGEMENTS

Funding for this work comes from the Rannoch Trust. Scottish Natural Heritage also contributed in earlier stages of the study. Special thanks go to Nicholas Thexton for the collection of water samples.

7 REFERENCES

Belsky, A. J., Matzke, A. and Uselman, S. **(1999)** Survey of livestock influences on stream and riparian ecosystems in the western United States. *Journal of Soil and Water Conservation*, **54**, 419-431.

Hooda, P. S., Moynagh M., Svoboda, I.F., Thurlow, M. Stewart, M. Thomson, M. and Anderson, H. A. **(1997a)** Soil and land use effects on phosphorus in six streams draining small agricultural catchments in Scotland. *Soil Use Management,* **13** (4), 196-204.

Hooda, P. S., Moynagh M., Svoboda, I.F., Thurlow, M. Stewart, M. Thomson, M. and Anderson, H. A. **(1997b)** Streamwater nitrate concentrations in six agricultural catchments in Scotland. *Science of the Total Environment* , **201**, 63-78.

Larsen, R. E., Krueger, W. C., George, M. R., Barrington, M. R., Buckhouse, J. C. and Johnson, D. .E. **(1998)** Viewpoint: Livestock influences on riparian zones and fish habitat: Literature classification. *Journal of Range Management*, **51**, 661-664.

Lemly. A. D. **(1982)** Modification of benthic insect communities in polluted streams: Combined effects of sedimentation and nutrient enrichment. *Hydrobiologia,* **87**, 229-245.

Monteith, D. T., Allott, T. E. H., Harriman, R., Morrison, B.R. S., Collen, P. and Patrick, S. T. **(1995)** Land-Use Experiments in the Loch Laidon Catchment: Second Report on Stream Water Quality to the Rannoch Trust and Scottish Natural Heritage. Research Report No. 11. Environmental Change Research Centre, University College London, London.

Monteith, D. T., Allott, T. E. H., Harriman, R., Morrison, B. R. S., Collen, P. and Patrick, S. T. **(1996)** Land-Use Experiments in the Loch Laidon Catchment: Third Report on Stream Water Quality to the Rannoch Trust and Scottish Natural Heritage. Research Report No. 24. Environmental Change Research Centre, University College London, London.

Monteith, D. T., Allott, T. E. H., Harriman, R., Morrison, B. R. S., Collen, P. and Patrick, S. T. **(1997)** Land-Use Experiments in the Loch Laidon Catchment: Fourth Report on Stream Water Quality to the Rannoch Trust and Scottish Natural Heritage. Research Report No. 42. Environmental Change Research Centre, University College London, London.

Monteith, D. T., Allott, T. E. H., Harriman, R., Morrison, B. R. S., Collen, P., Kreiser, A. and Patrick, S. T. **(1999)** Land-Use Experiments in the Loch Laidon Catchment: Fifth Report on Stream Water Quality to the Rannoch Trust and Scottish Natural Heritage. Research Report No. 56. Environmental Change Research Centre, University College London, London.

Patrick, S. T., Monteith, D. T., and Jenkins, A. **(1995)** UK Acid Waters Monitoring Network: The first five years. Analysis and interpretation of results, April 1988 - March 1993. 1-320., ENSIS Publishing, London.

Scrimgeour, G. J. and Kendall, S. **(2002)** Consequences of livestock grazing on water quality and benthic algal biomass in a Canadian natural grassland plateau. *Environmental Management*, **29**, 824-844.

Shilland, E. M., Monteith, D. T., Harriman, R., Morrison, B. R. S., Collen, P. and Kreiser, A. **(2001**) Land-use experiments in the Loch Laidon catchment. Sixth Report on Stream Water Quality to the Rannoch Trust. Research Report No. 80, 1-53. Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T., Harriman, R., Morrison, B. R. S., Collen, P., and Kreiser, A. **(2003)** Land-use experiments in the Loch Laidon catchment. Seventh Report on Stream Water Quality to the Rannoch Trust. Research Report No. 86, 1-62., Environmental Change Research Centre, University College London, London.

Sovell, L. A., Vondracek, B., Frost, J. A. and Mumford, K. G. (**2000)** Impacts of rotational grazing and riparian buffers on physicochemical and biological characteristics of southeastern Minnesota, USA, streams. *Environmental Management,* **26**, 629-641.

ter Braak, C. J. F., Smilauer, P. **(1998)** CANOCO reference manual and user's guide to Canoco for Windows: software for canonical community ordination (version 4), 1-352, Microcomputer Power, Ithaca, NY, USA.

Wohl, N. E. and Carline, R. F. **(1996)** Relations among riparian grazing, sediment loads, macroinvertebrates, and fishes in three central Pennsylvania streams. *Canadian Journal of Fisheries and Aquatic Sciences*, **53**, 260-266.

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

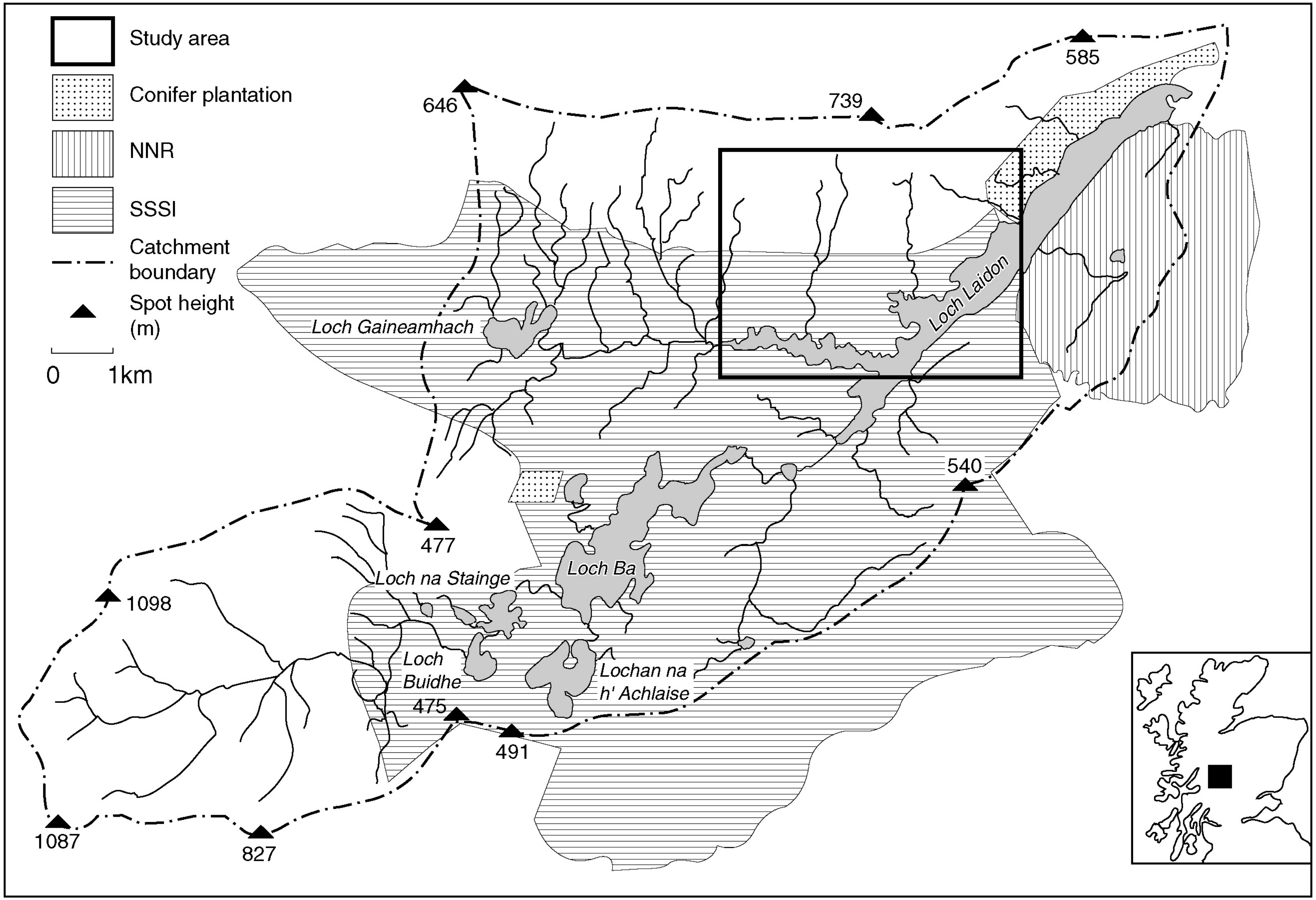


Figure 2 Loch Laidon study area.

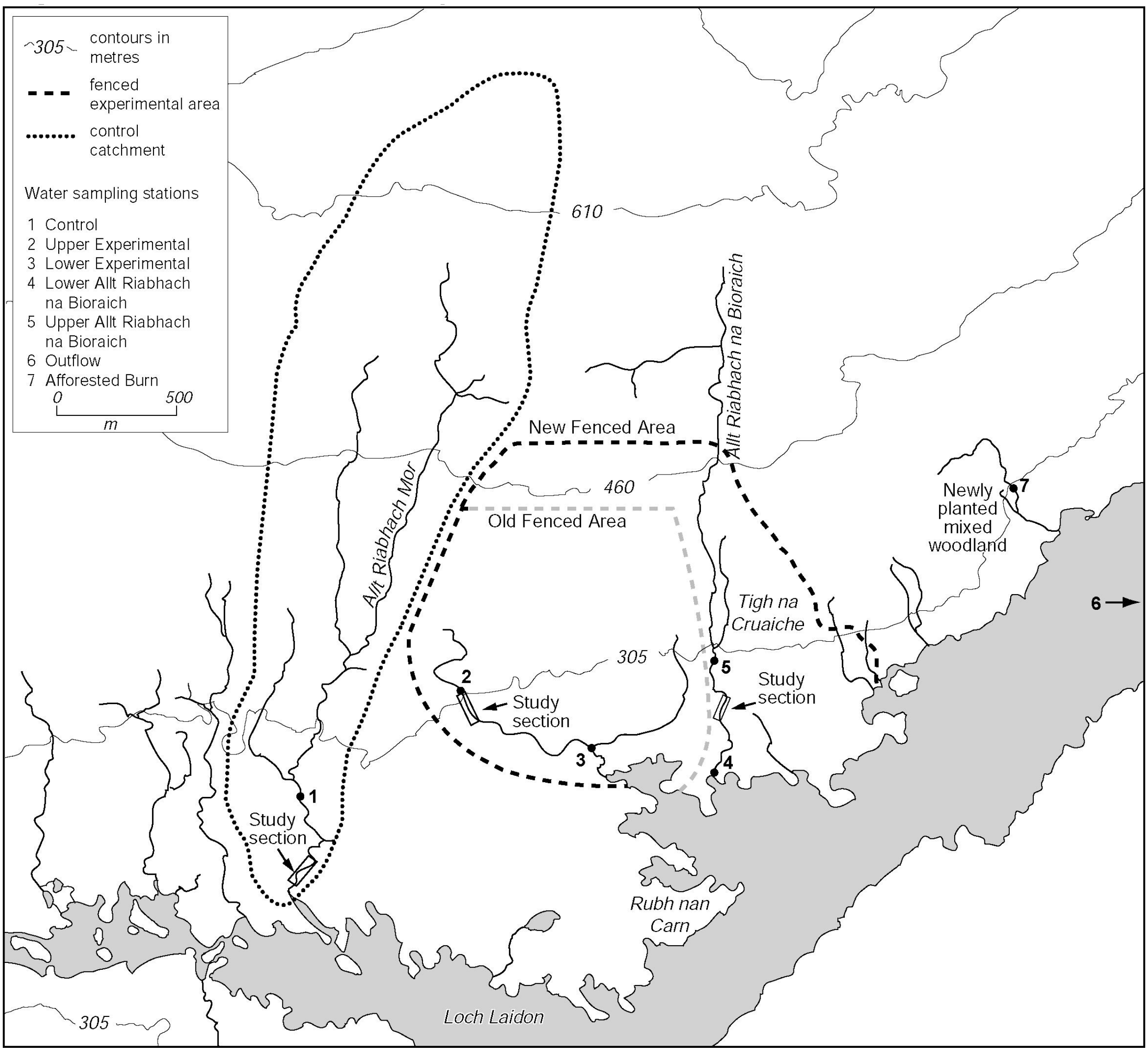


Figure 3 Control Burn

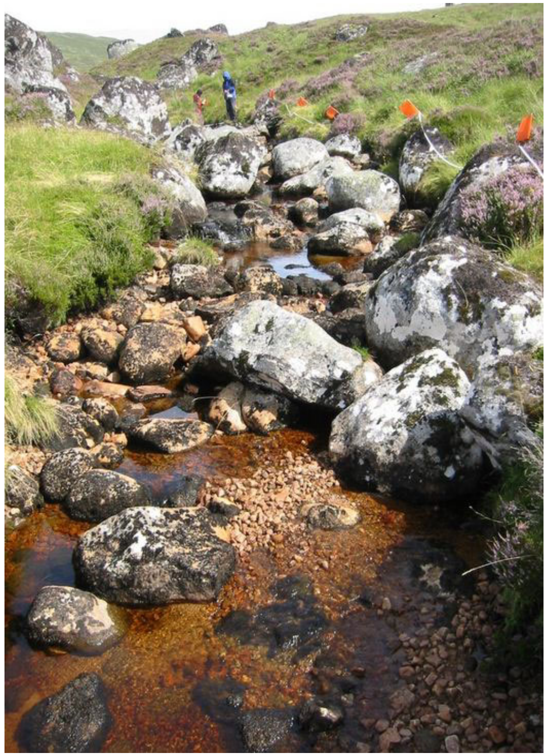


Figure 4 Experimental Burn

Figure 5 Allt Riabhach na Bioraich Burn

Figure 6 The experimentally grazed area

Figure 7 Cattle poaching of the bank of the Allt Riabhach na Bioraich Burn

Figure 8 The ratio of alkalinity and its temporal variability in spot samples between the Experimental and Control Burns, August 1992 – December 2004.

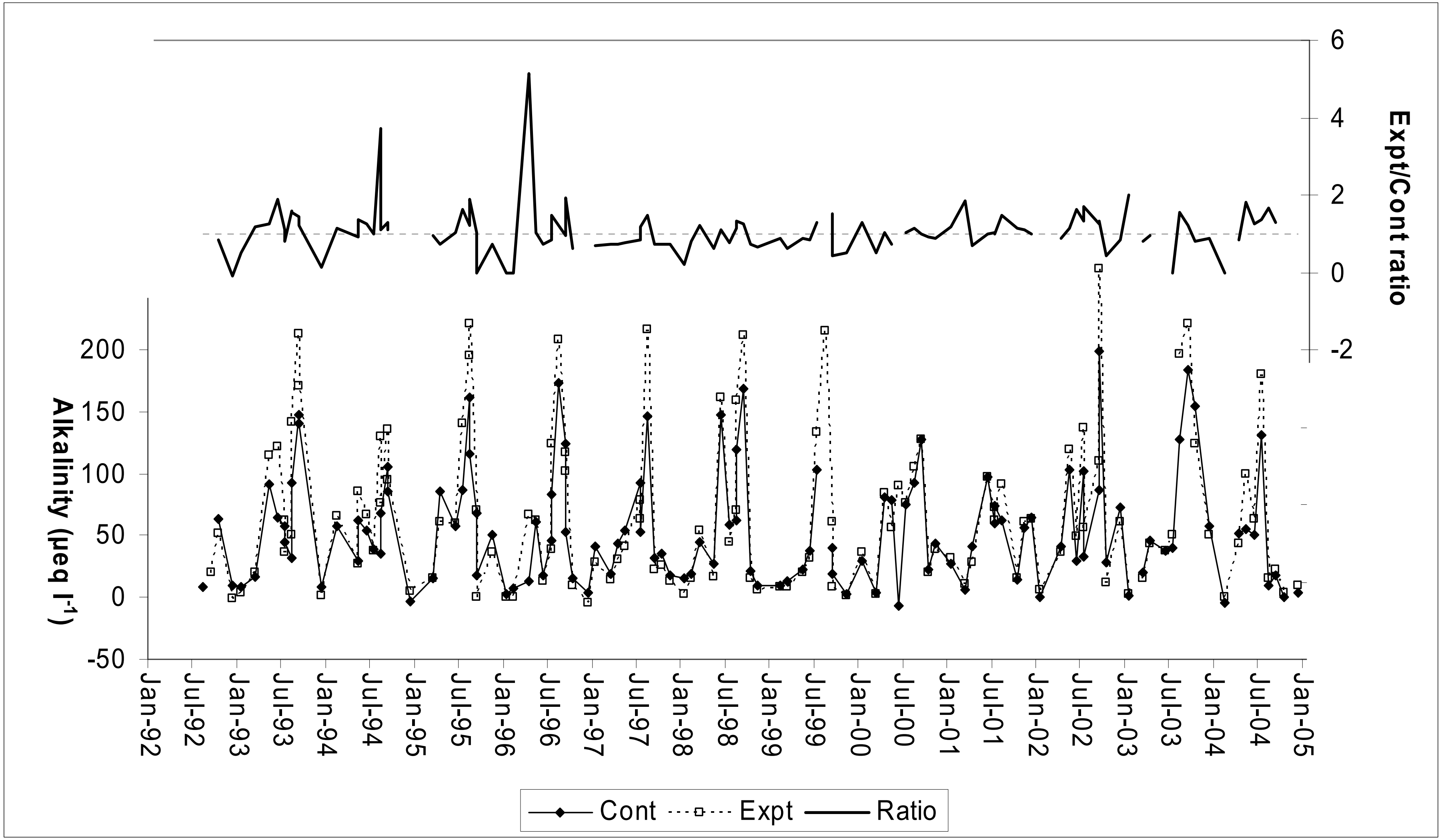


Figure 9 The ratio of conductivity and its temporal variability in spot samples between the Experimental and Control Burns, August 1992 – December 2004.

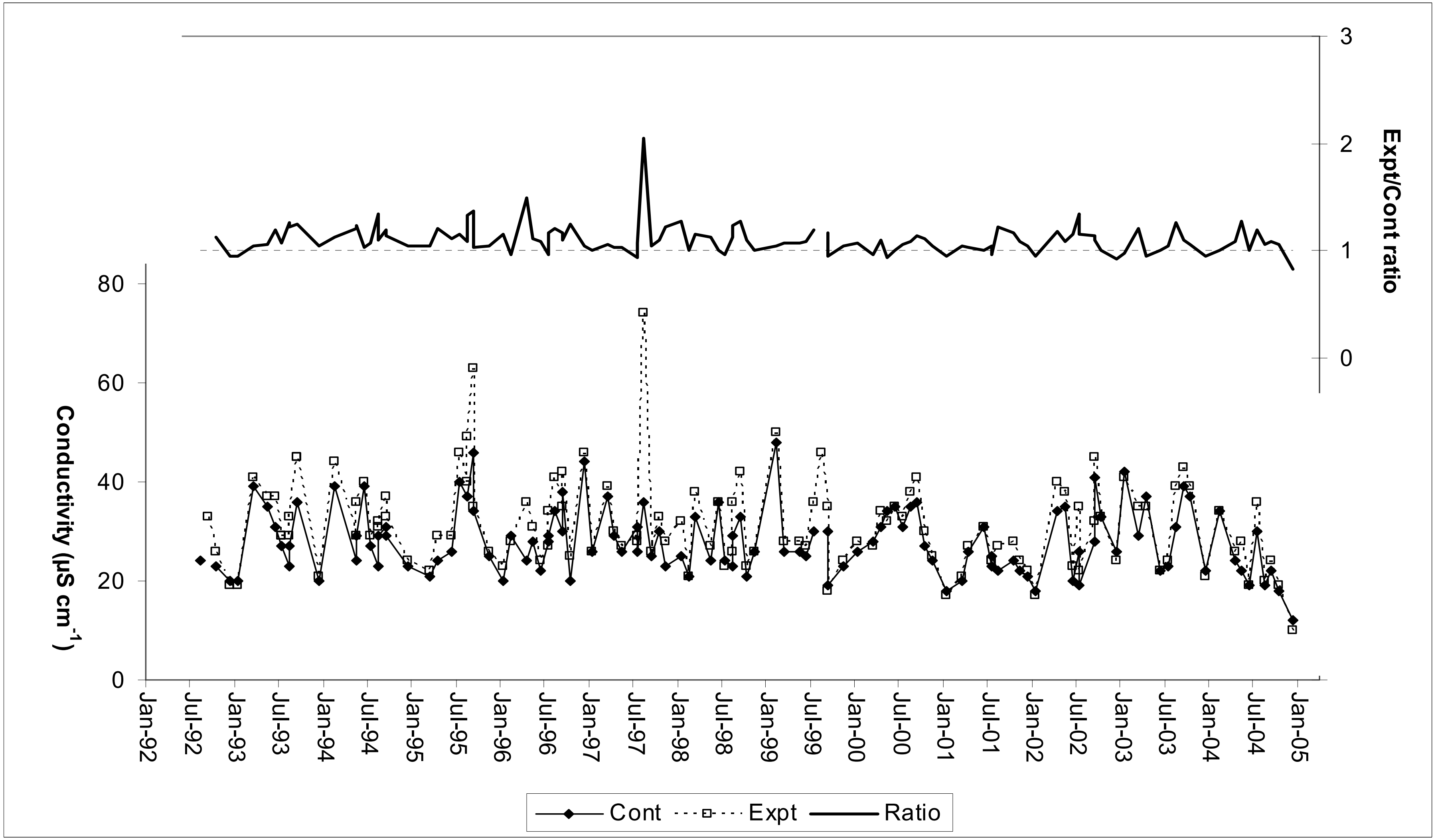


Figure 10 Temporal variability of nitrate in spot samples from the Experimental and Control Burns, August 1992-December 2004.

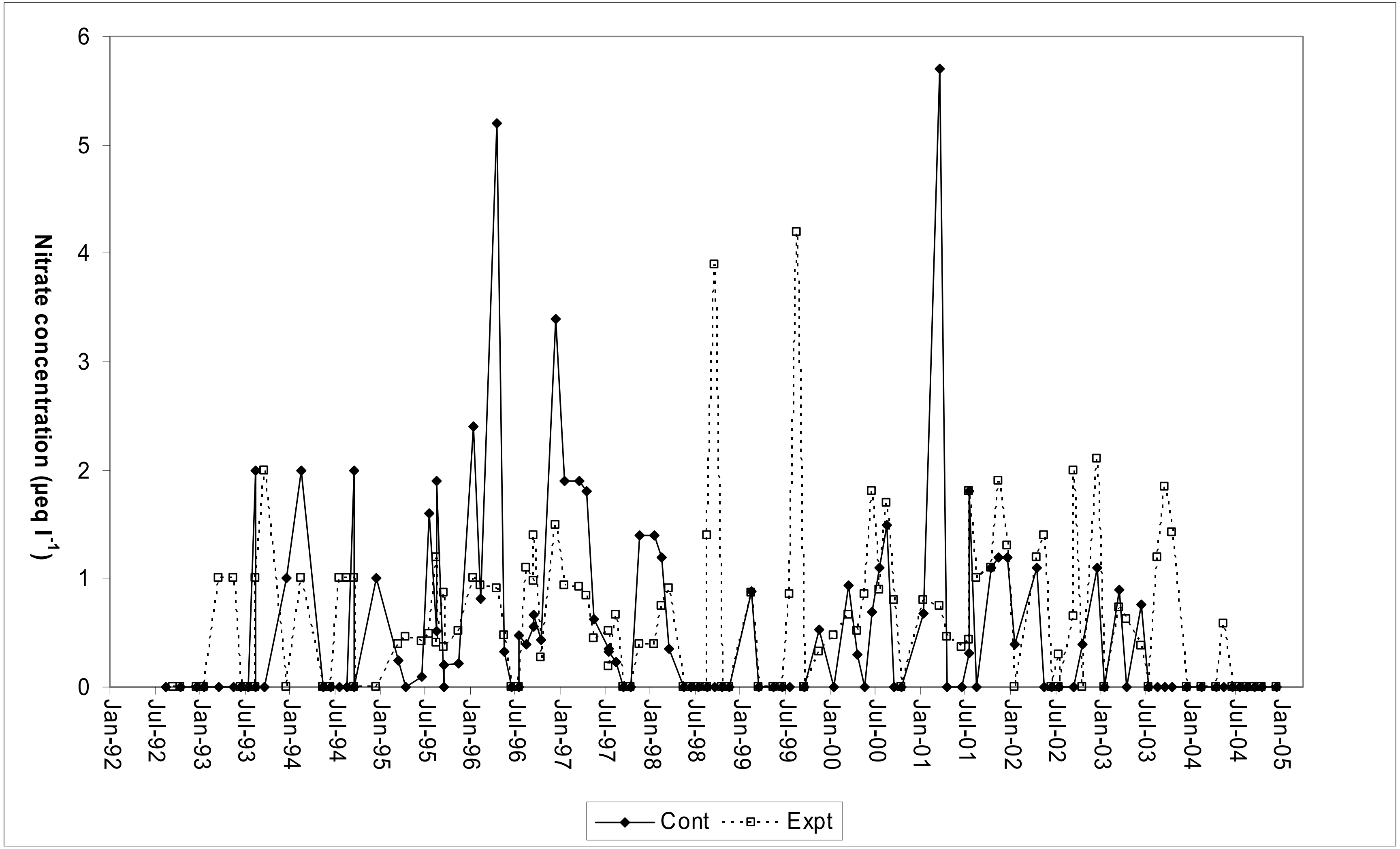


Figure 11 Temporal variability of soluble reactive phosphorus in spot samples from the Experimental and Control Burns, August 1992- December 2004

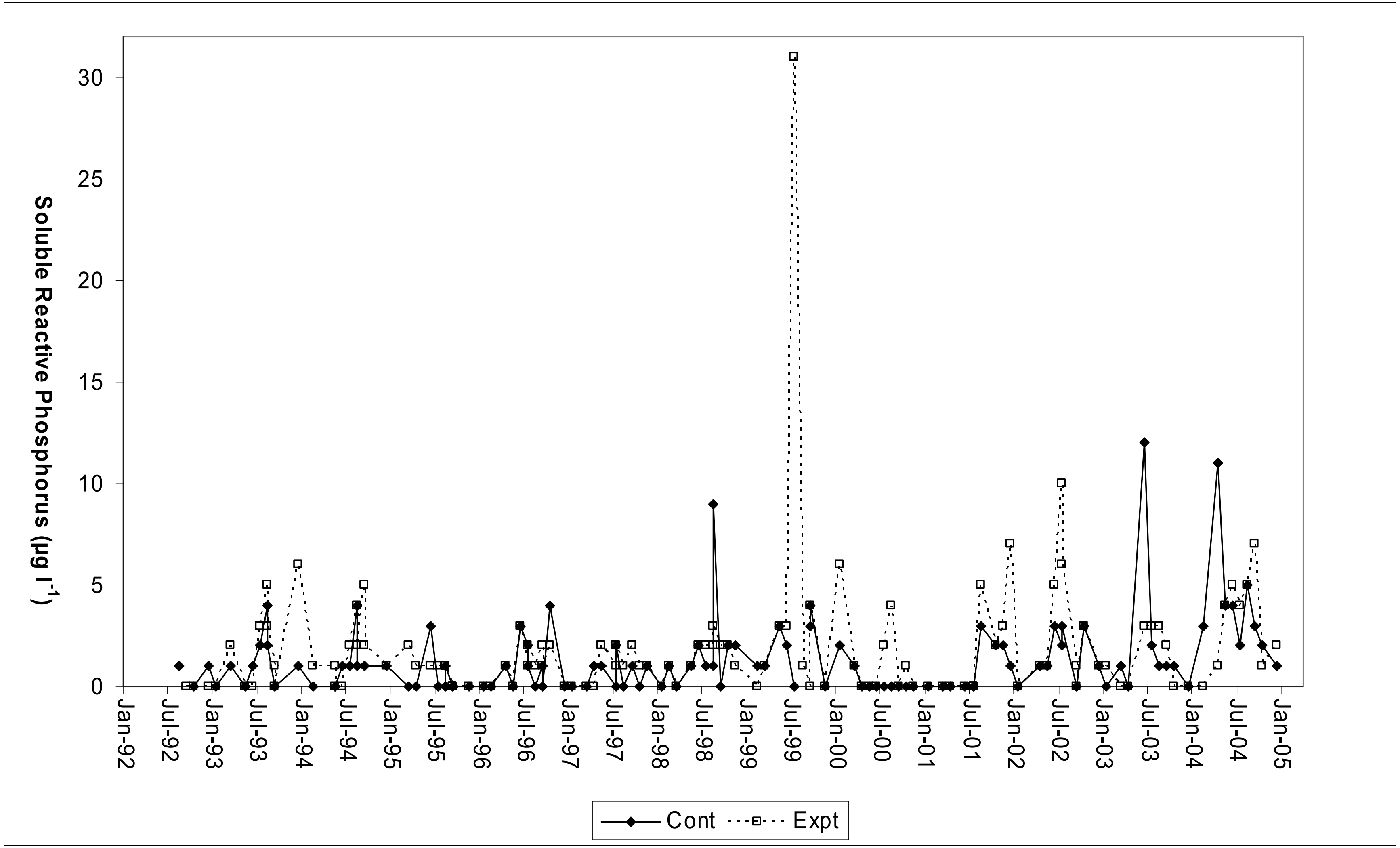


Figure 12 The relationship between the ratio of alkalinity in spot samples from the Experimental and Control Burns and the stage board height of the Control Burn over the period August 1992 – December 2004.

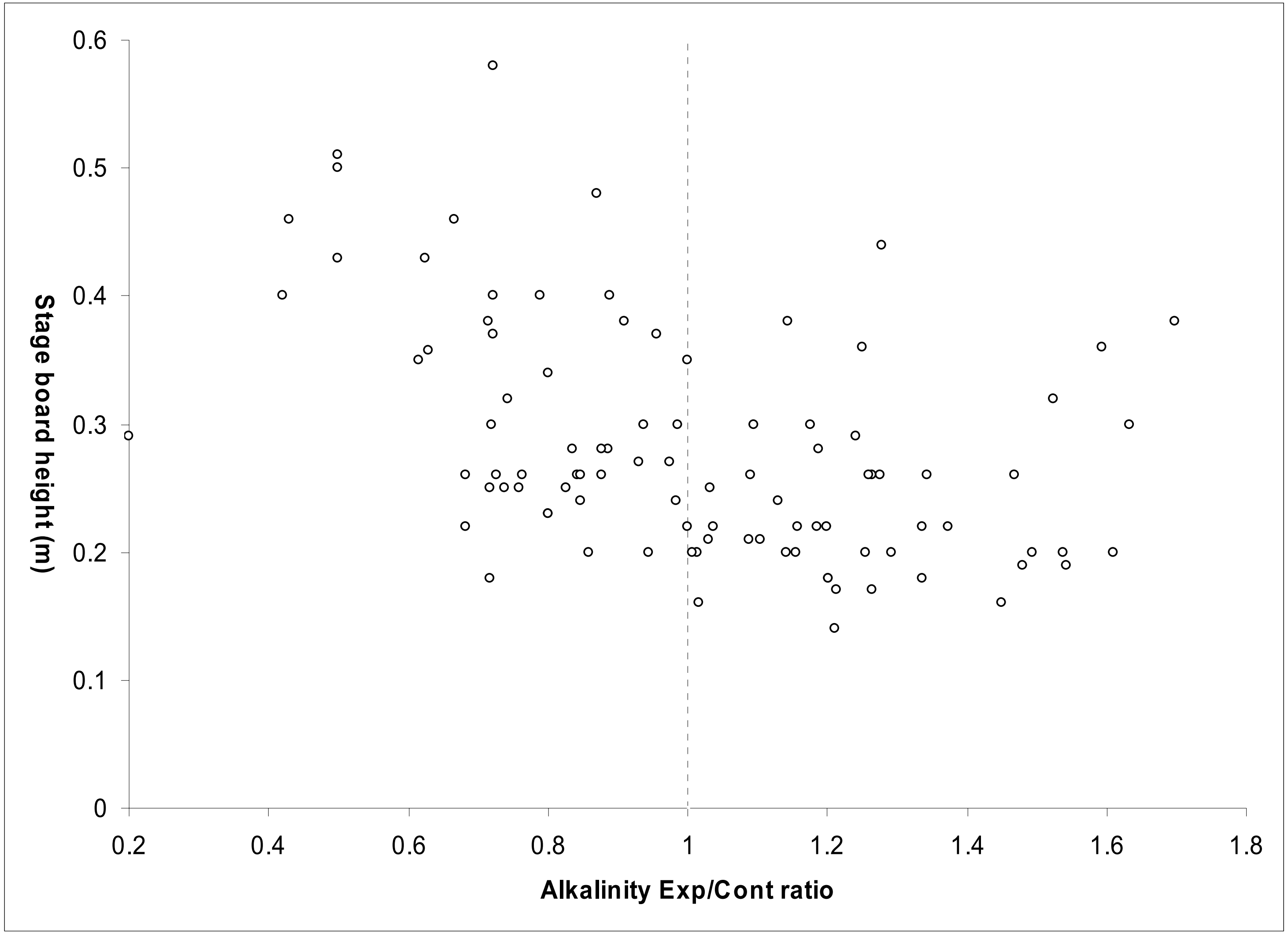
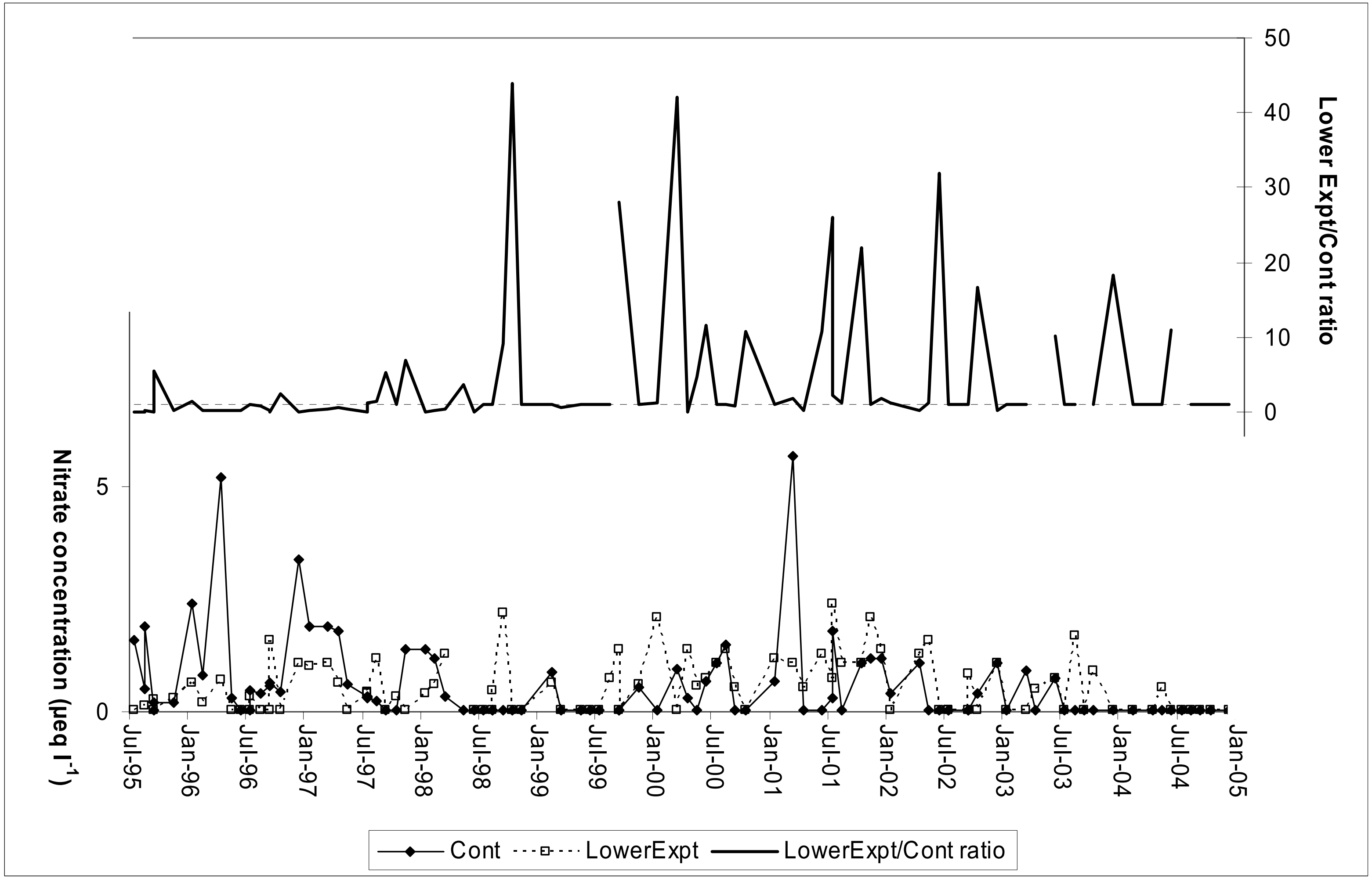


Figure 13 The ratio of nitrate and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – December 2004.



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 – December 2004.

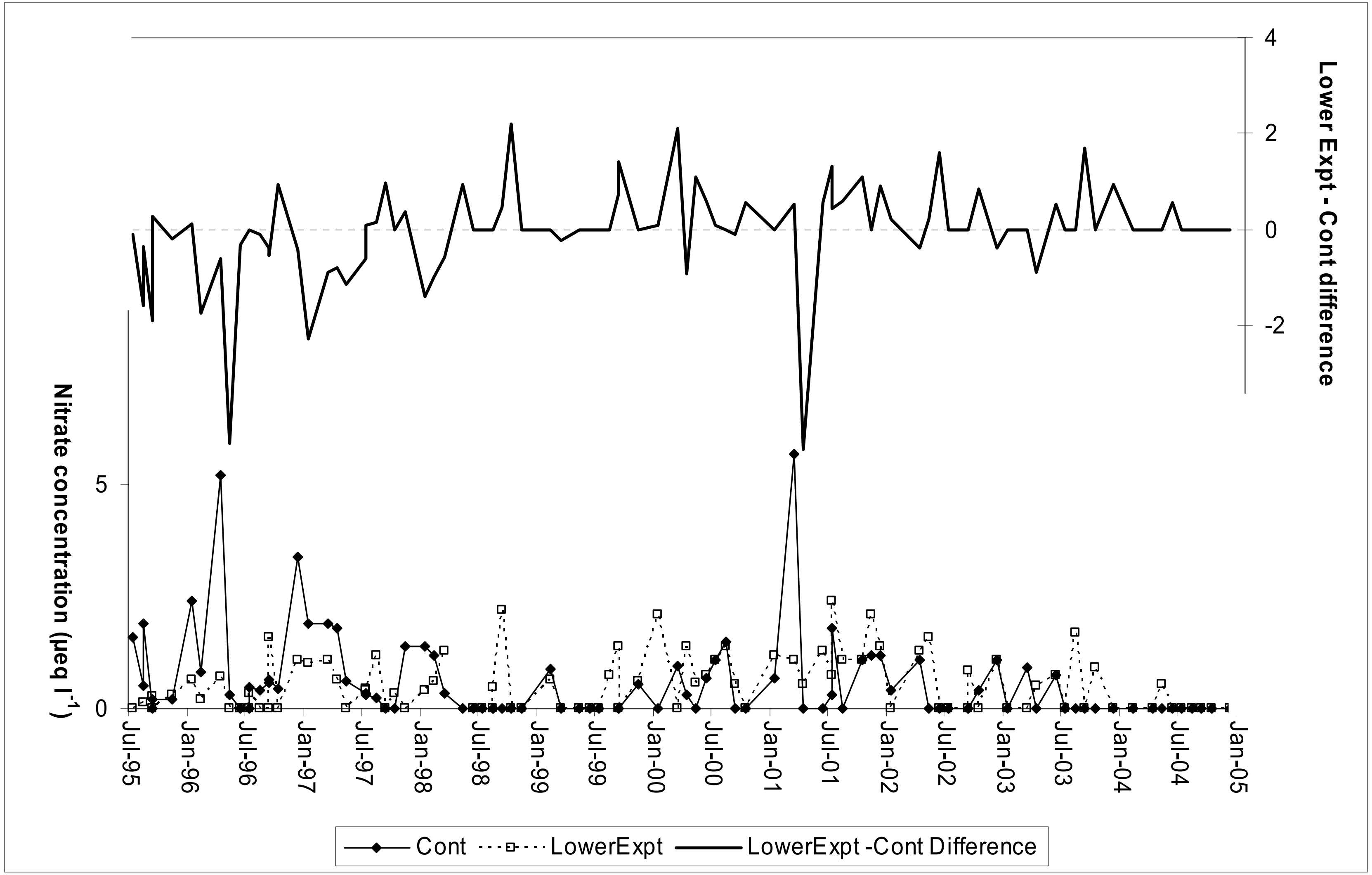


Figure 15 The ratio of alkalinity and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – December 2004.

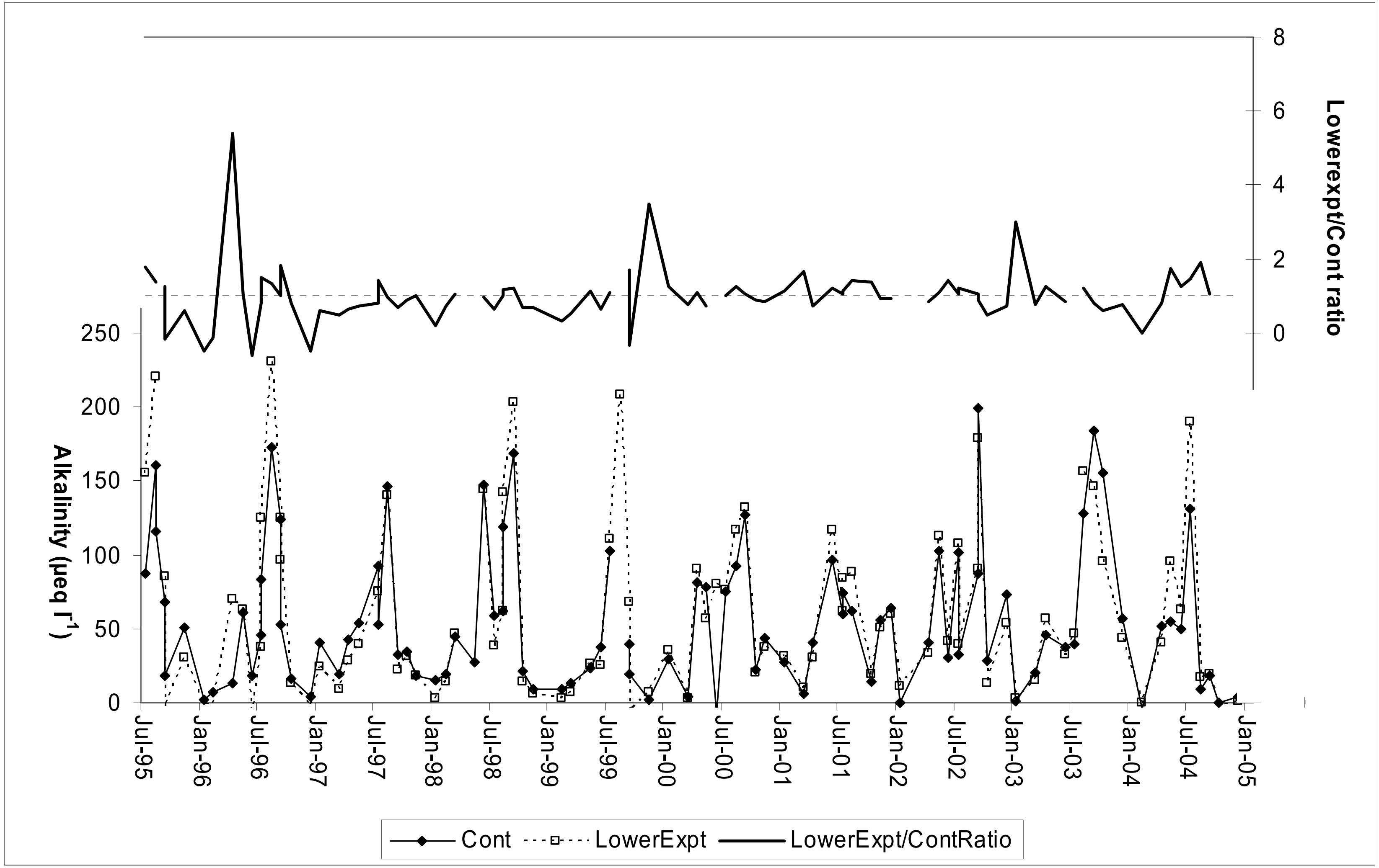


Figure 16 The ratio of calcium and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – December 2004.

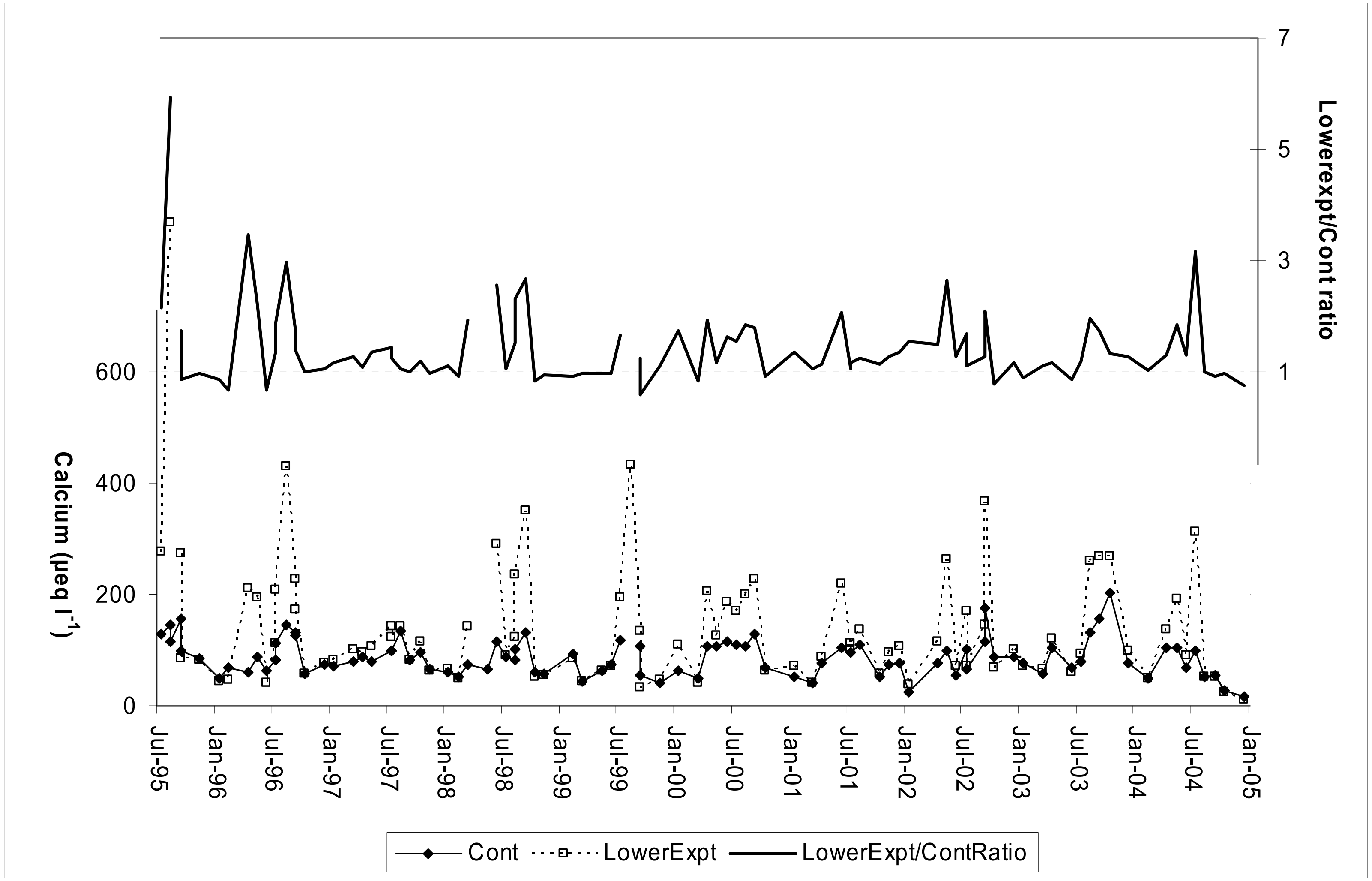


Figure 17 The ratio of magnesium and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – December 2004.

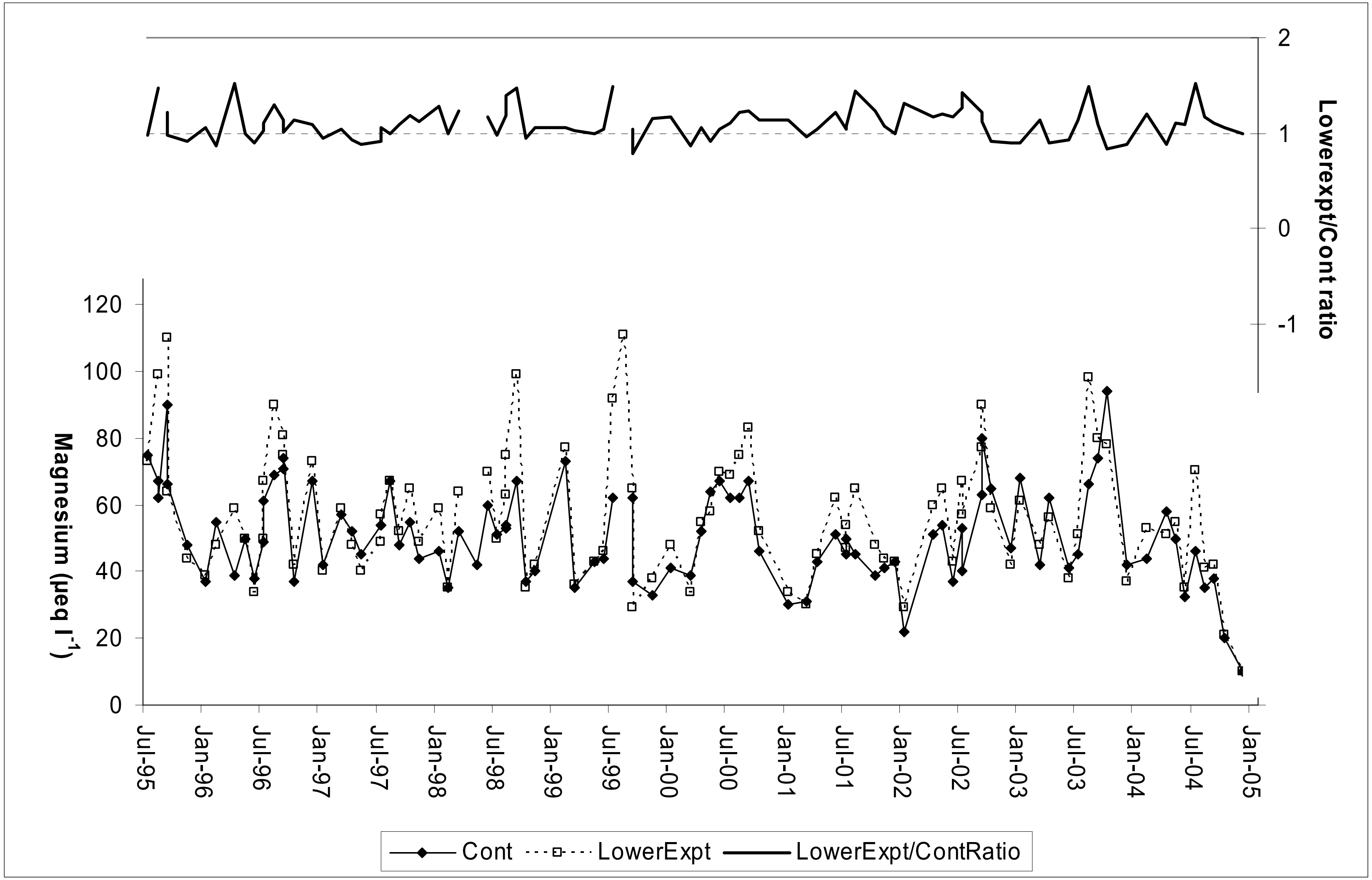


Figure 18 The ratio of potassium and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – December 2004.

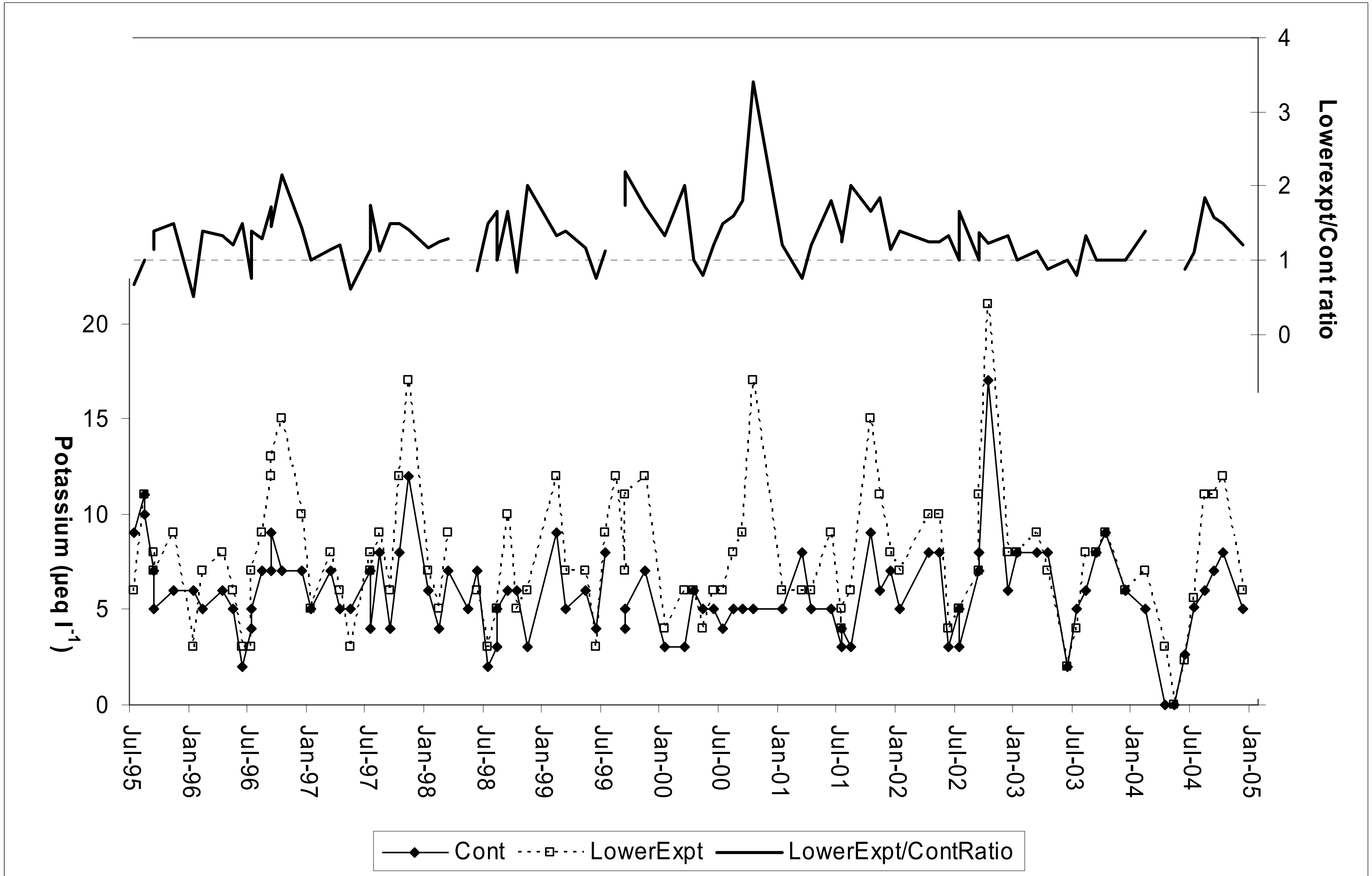


Figure 19 The ratio of conductivity and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – December 2004

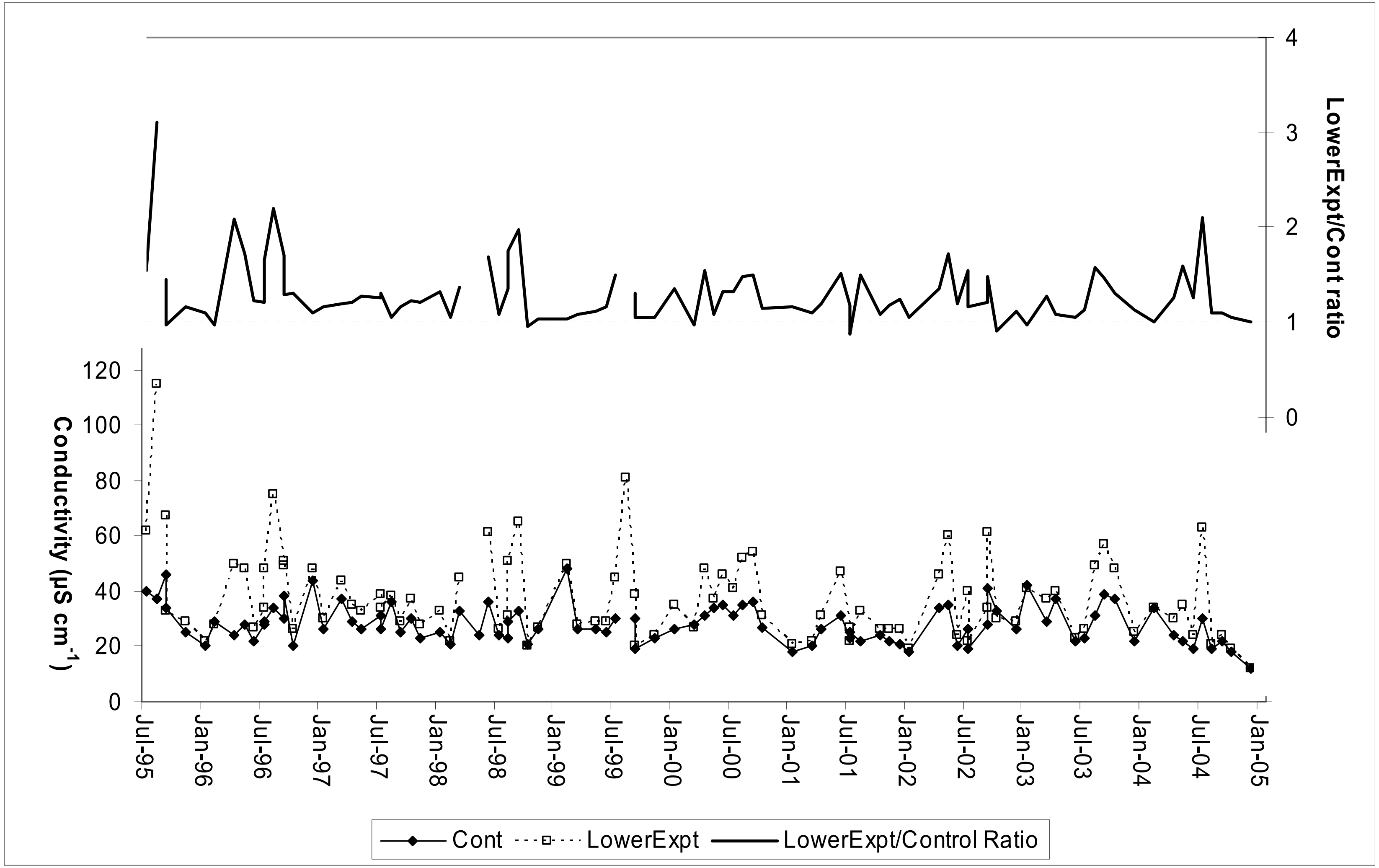
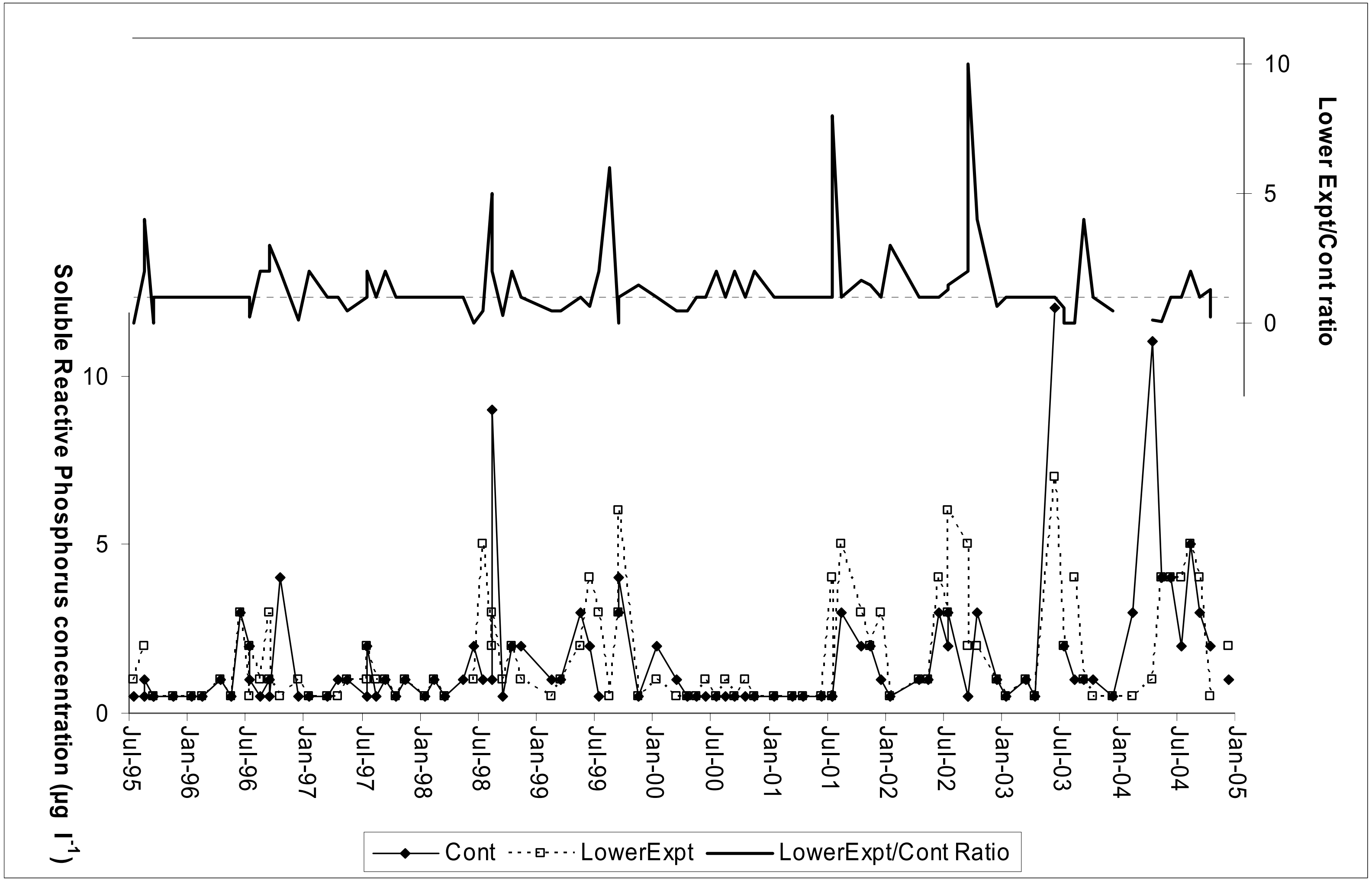


Figure 20 The ratio of soluble reactive phosphorus and its temporal variability in spot samples between the Control and Experimental Burn (Lower site) June 1995 – December 2004.



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

Figure 21 A comparison of alkalinity in spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – December 2004.

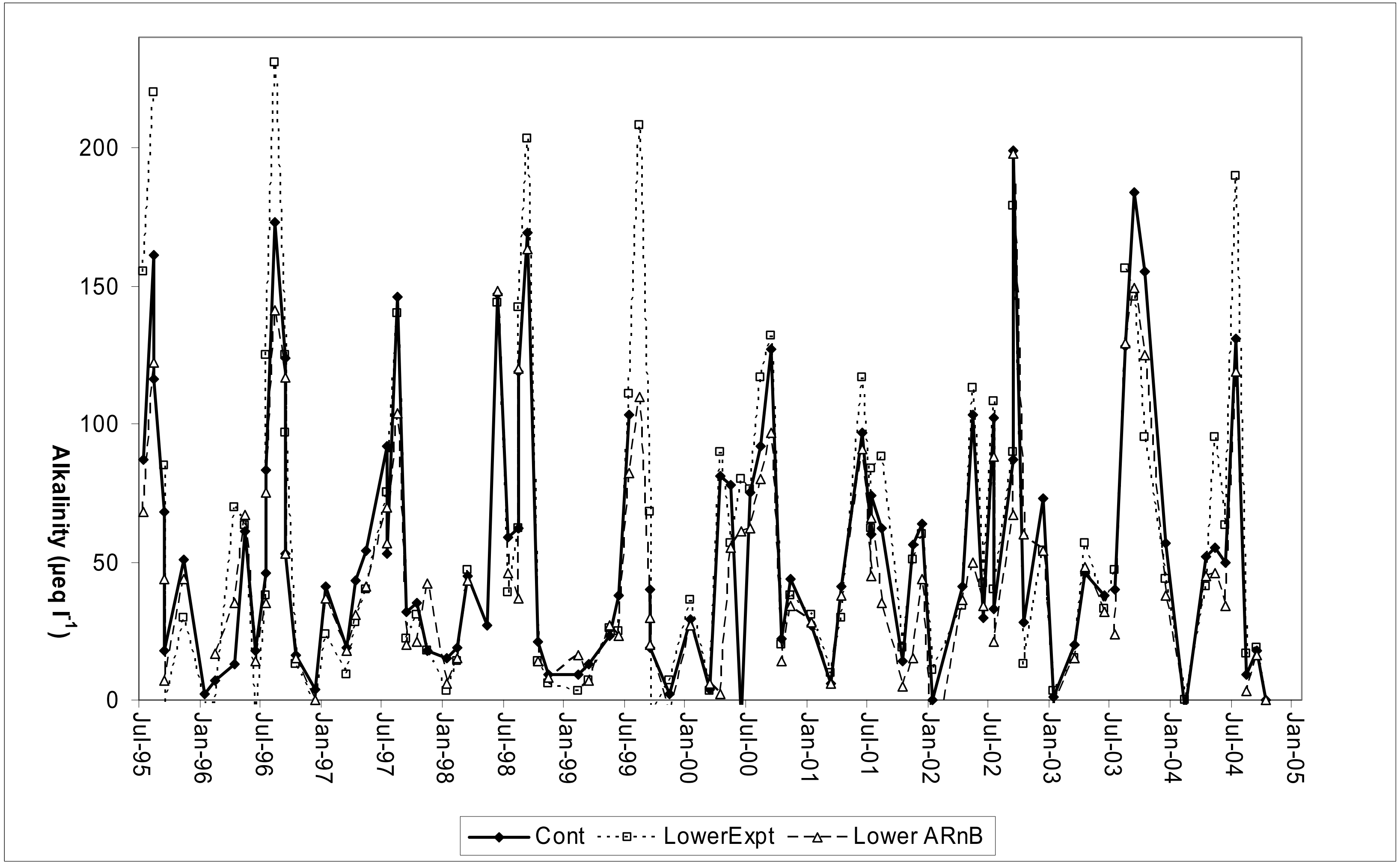


Figure 22 A comparison of conductivity of spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – December 2004.

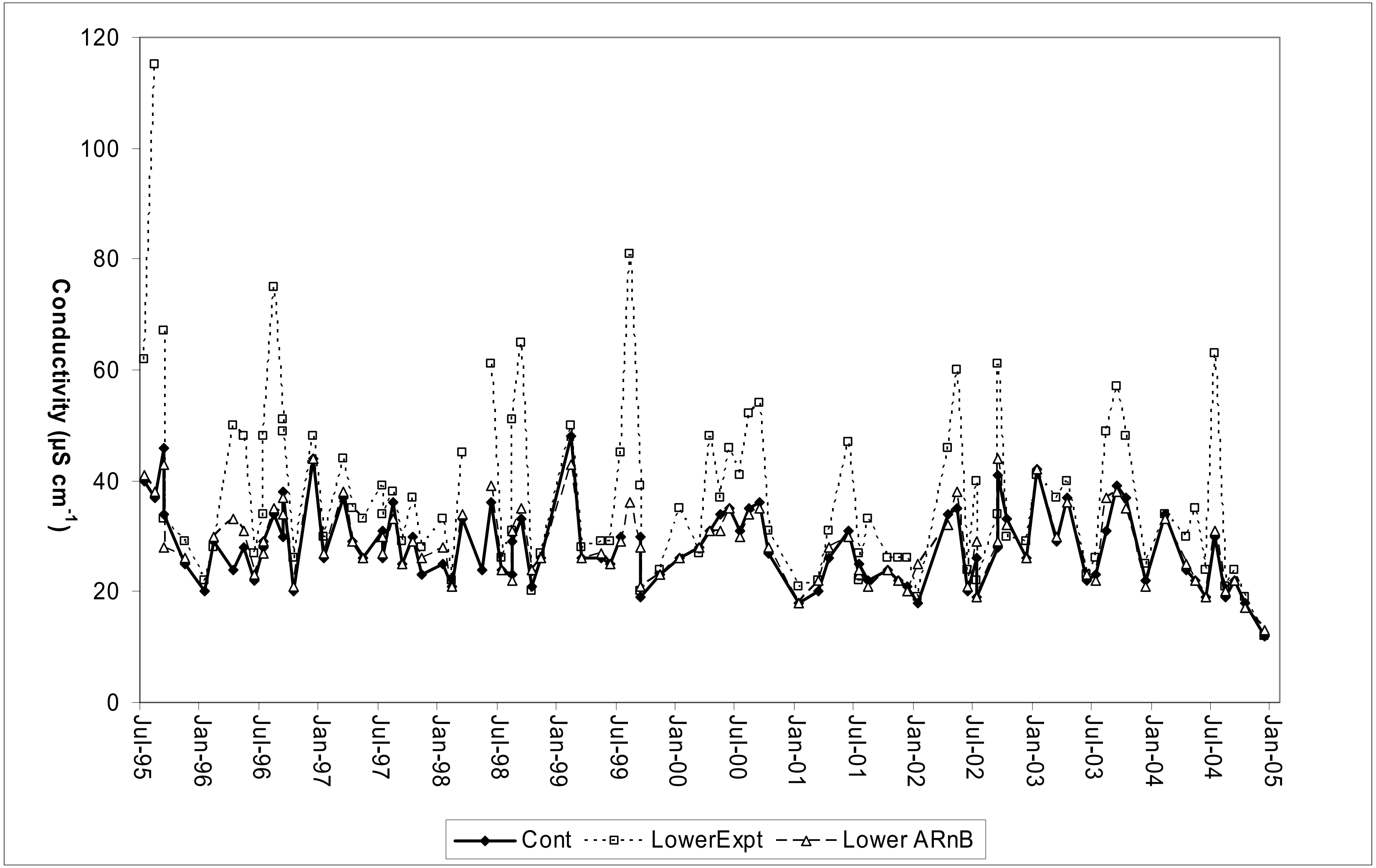


Figure 23 A comparison of nitrate concentrations of spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – December 2004.

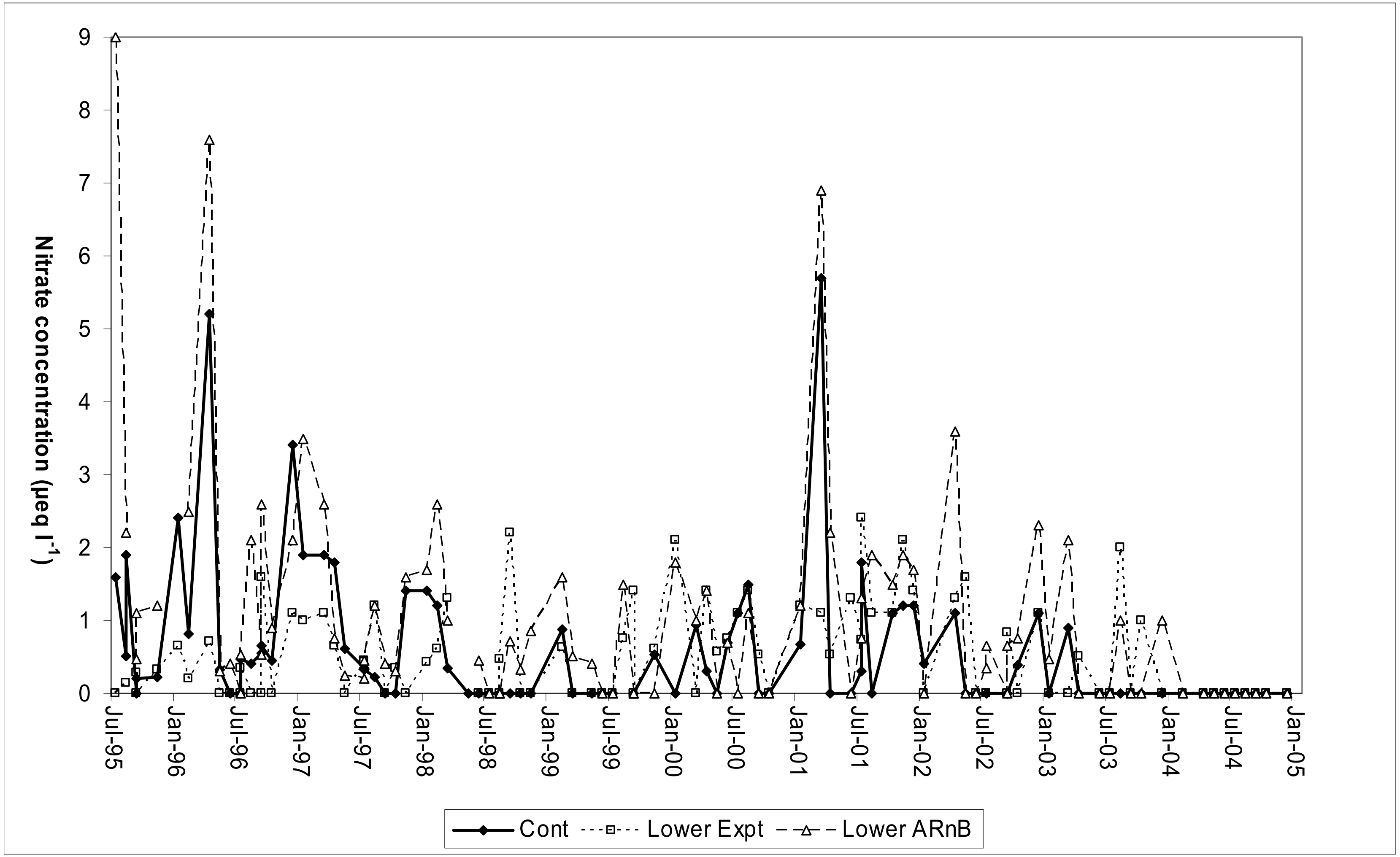


Figure 24 A comparison of soluble reactive phosphorus concentrations of spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – December 2004.

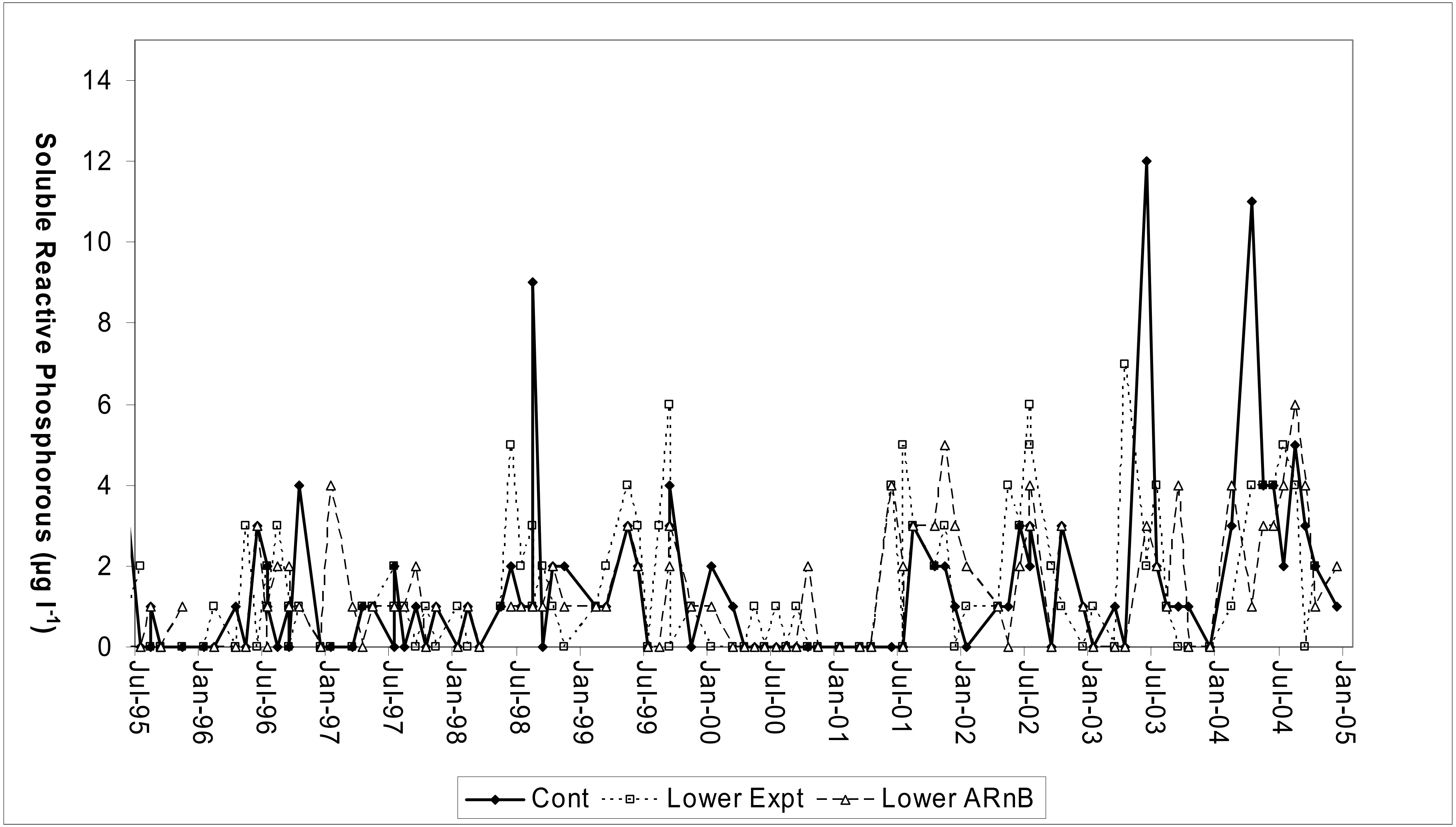


Figure 25 A comparison of total organic carbon concentrations of spot samples from the Control Burn, Experimental Burn (Lower site) and the Allt Riabhach na Bioraich, June 1995 – December 2004.

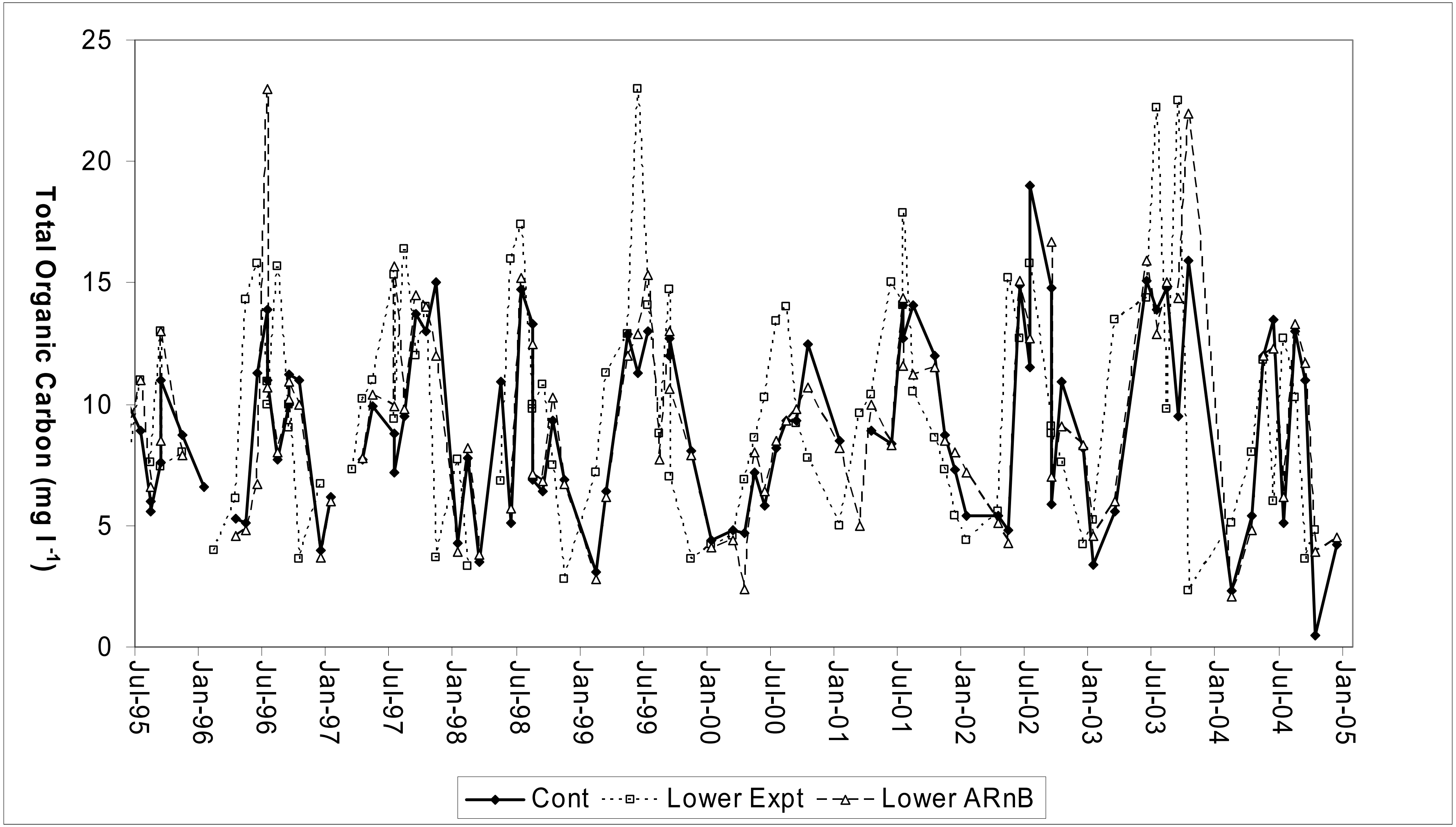


Figure 26 Control Burn diatom percentage abundances

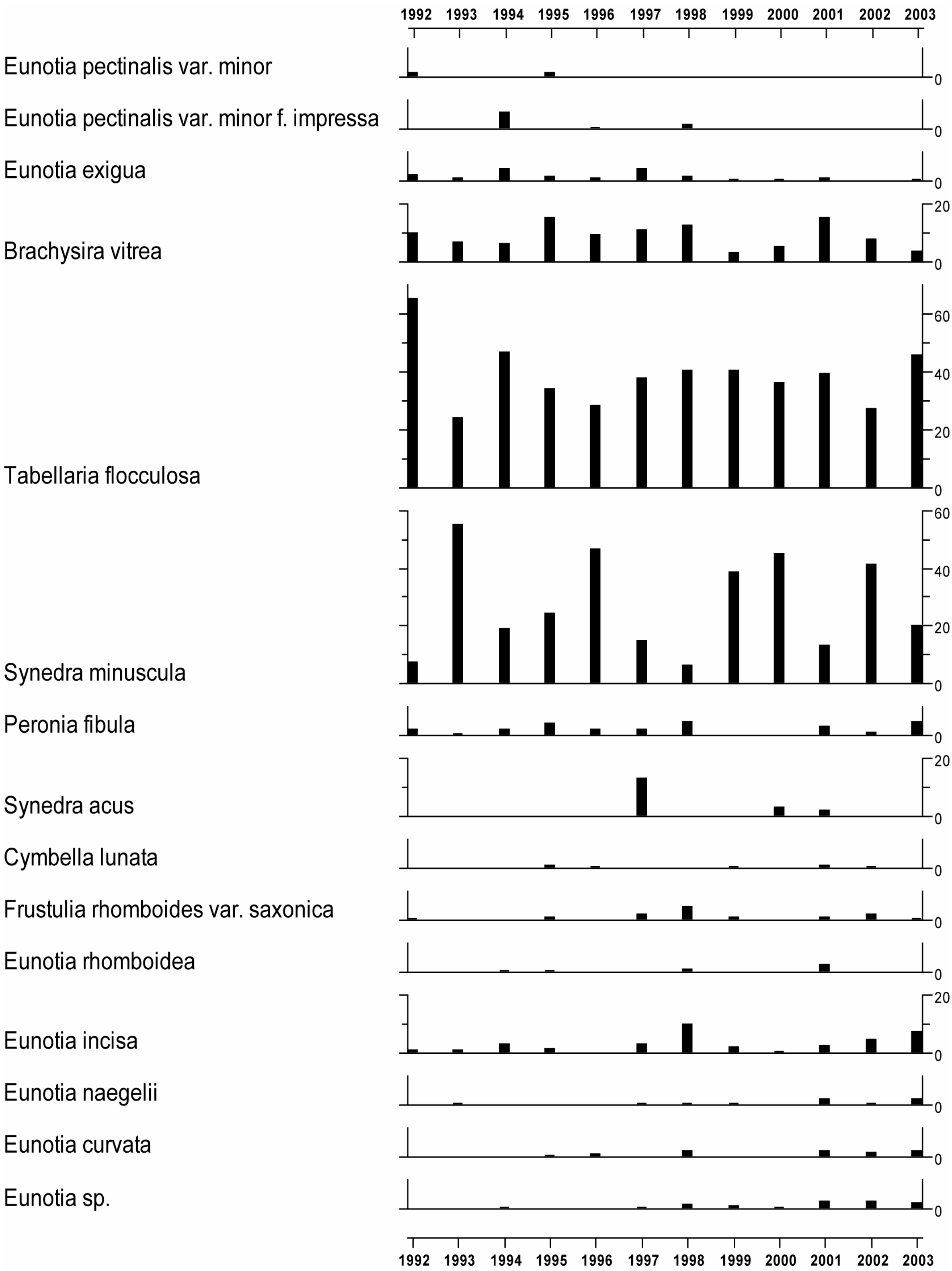


Figure 27 Experimental Burn diatom percentage abundances

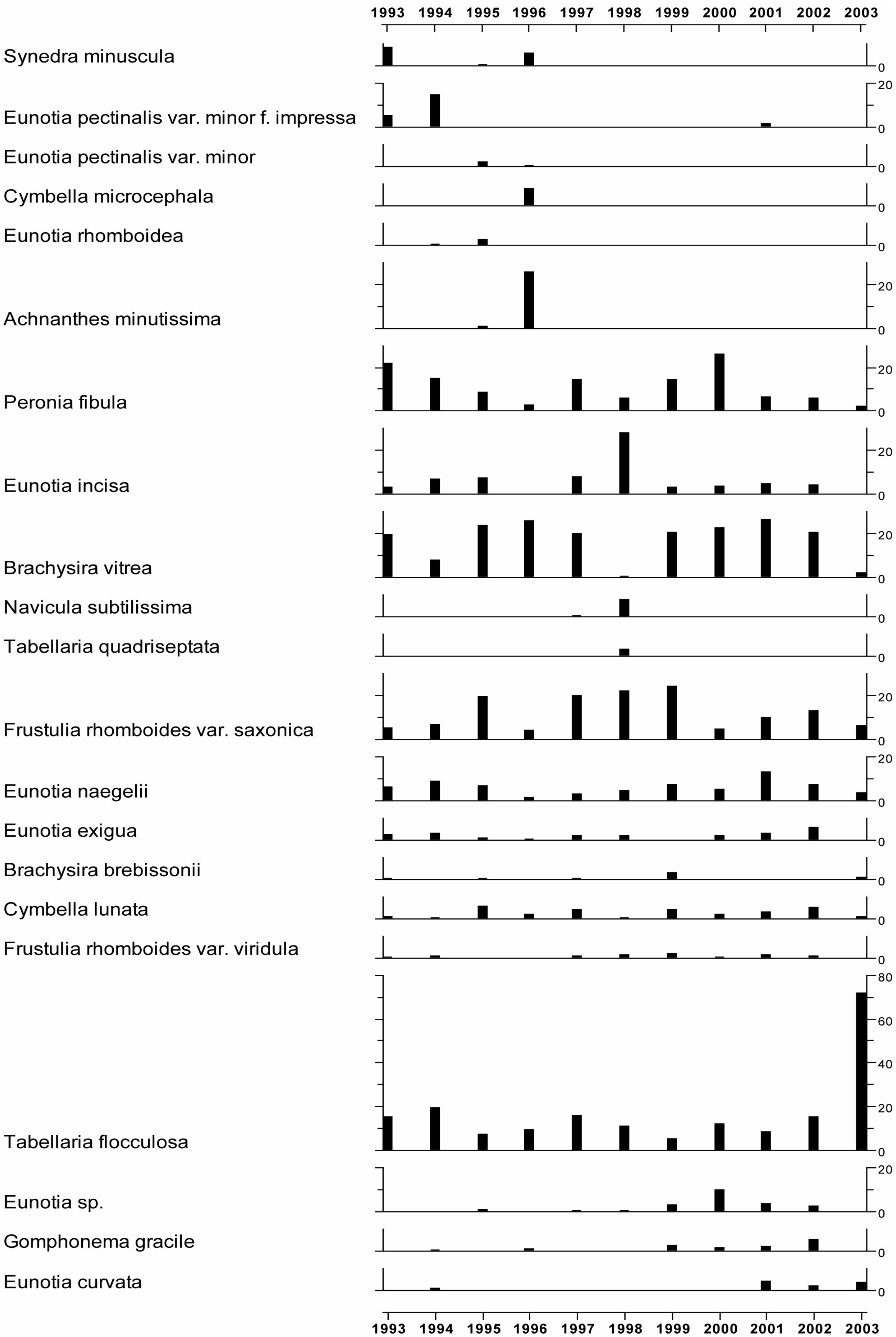


Figure 28 Allt Riabhach na Bioraich diatom percentage abundances

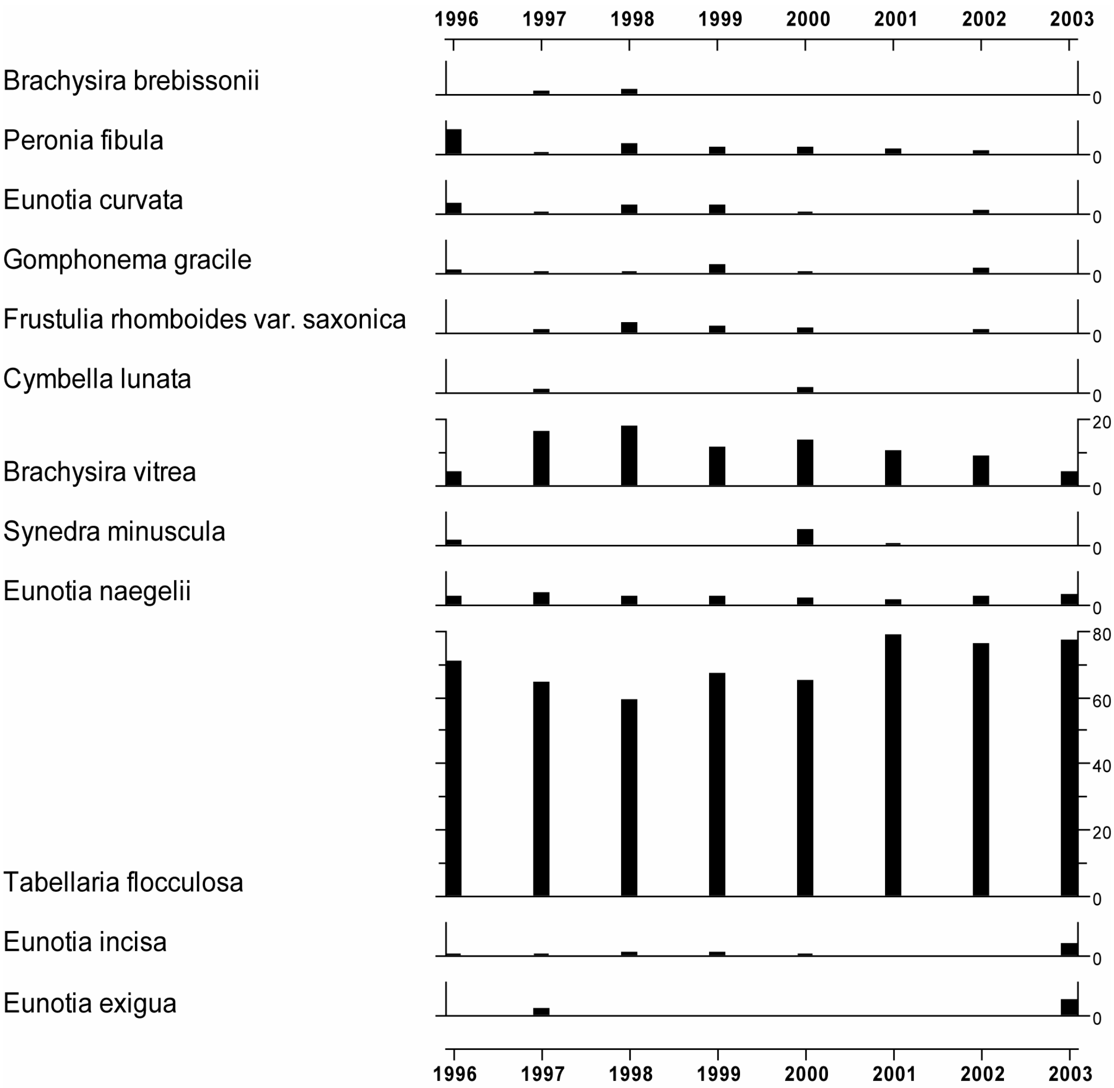


Figure 29 Control Burn macroinvertebrate percentage abundances

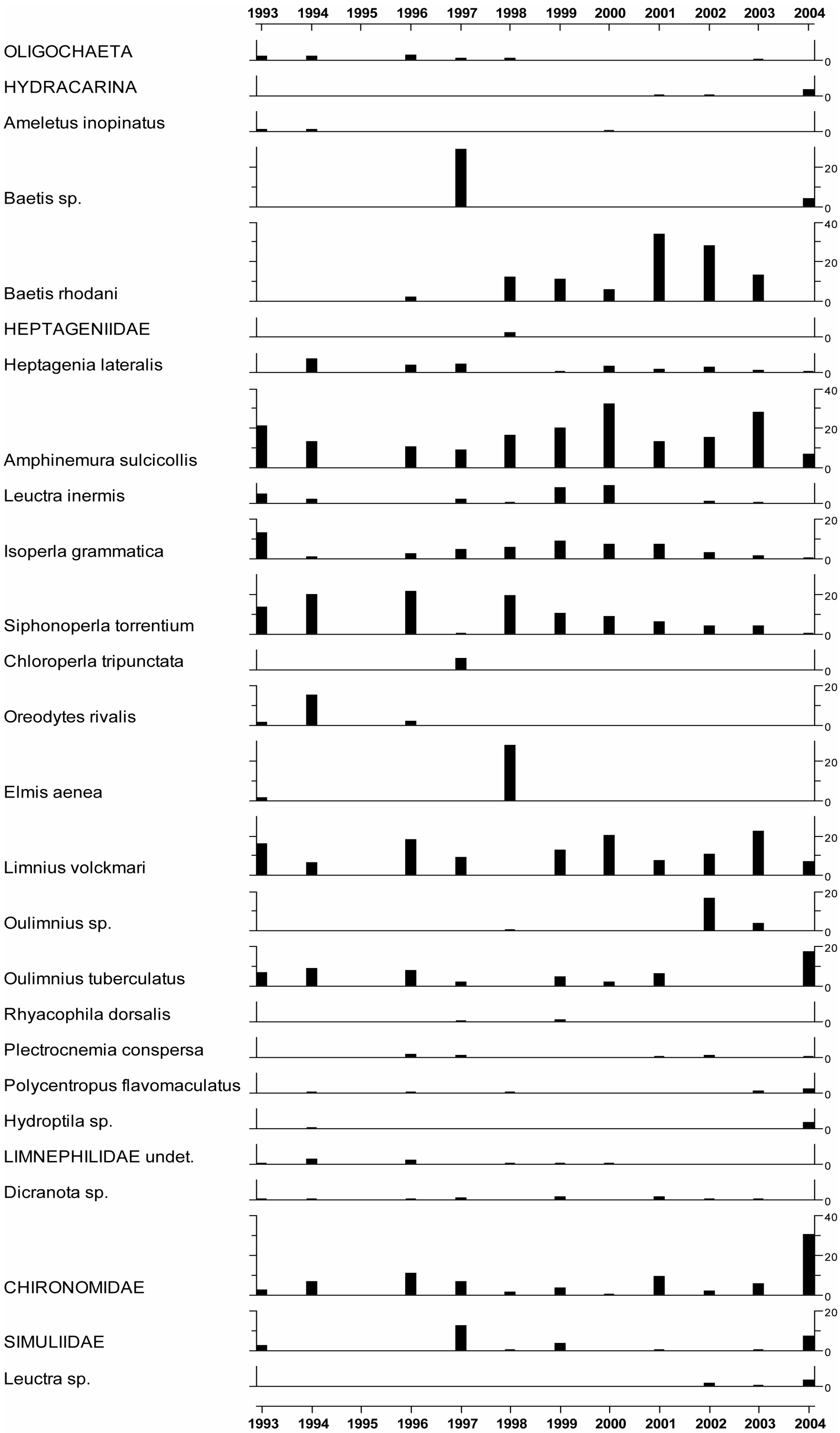


Figure 30 Experimental Burn macroinvertebrate percentage abundances

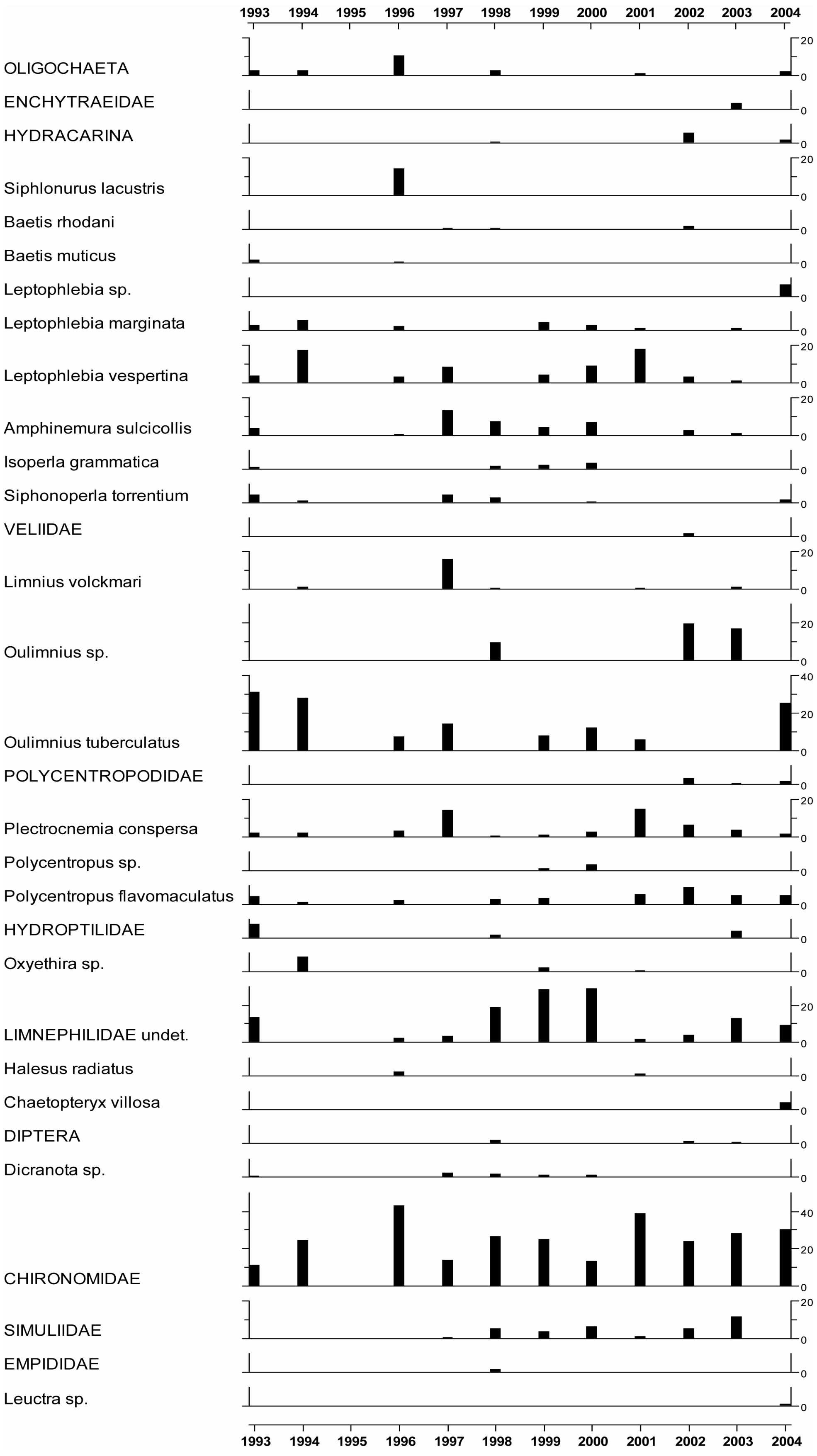


Figure 31 Allt Riabhach na Bioraich Burn macroinvertebrate percentage abundances

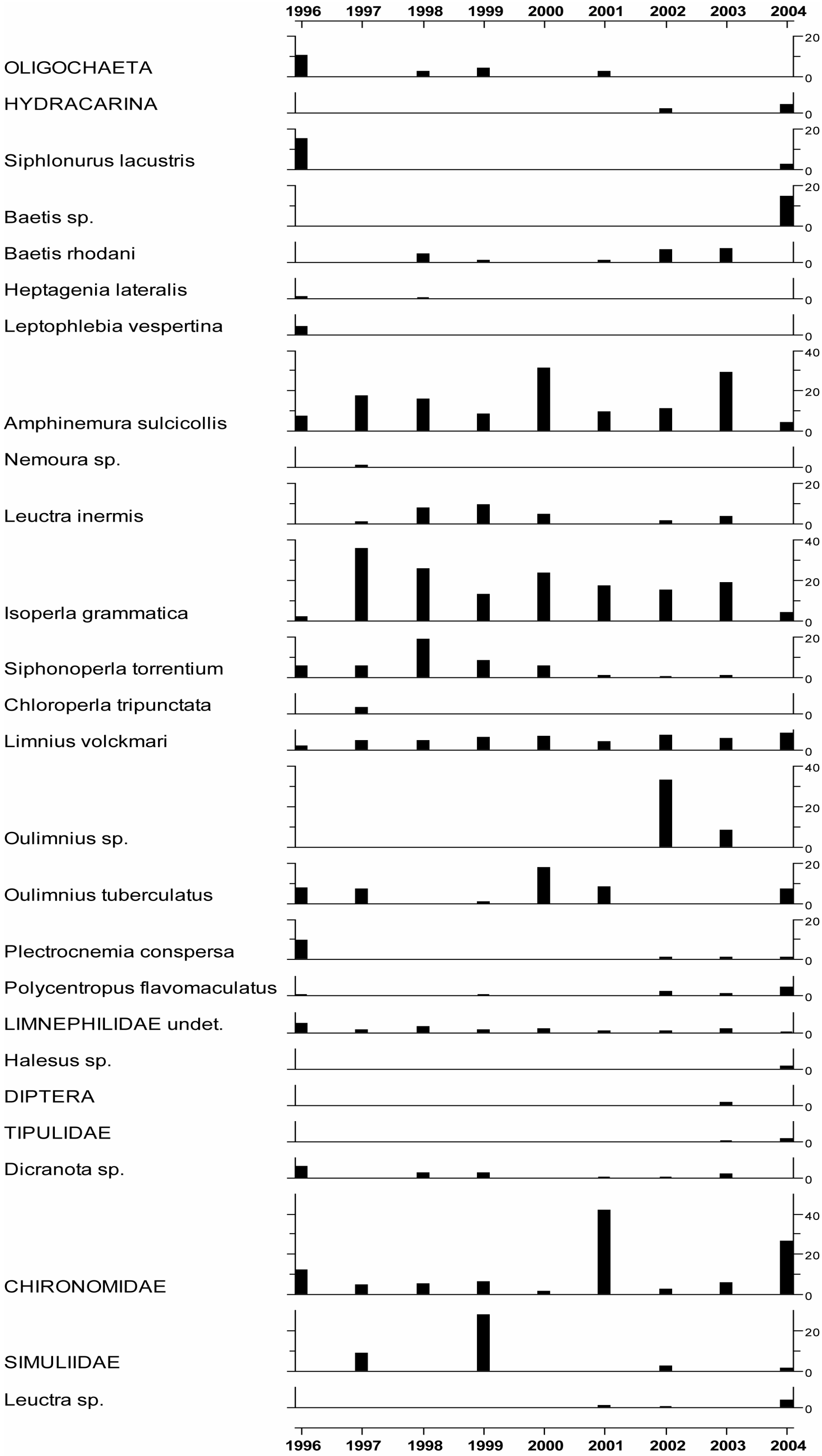


Figure 32 Selected Control Burn macroinvertebrate summary statistics

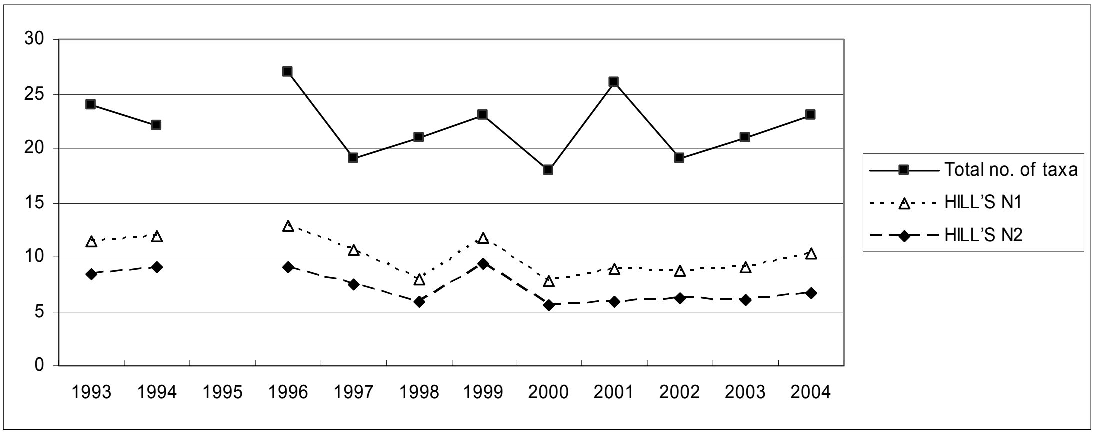


Figure 33 Selected Experimental Burn macroinvertebrate summary statistics

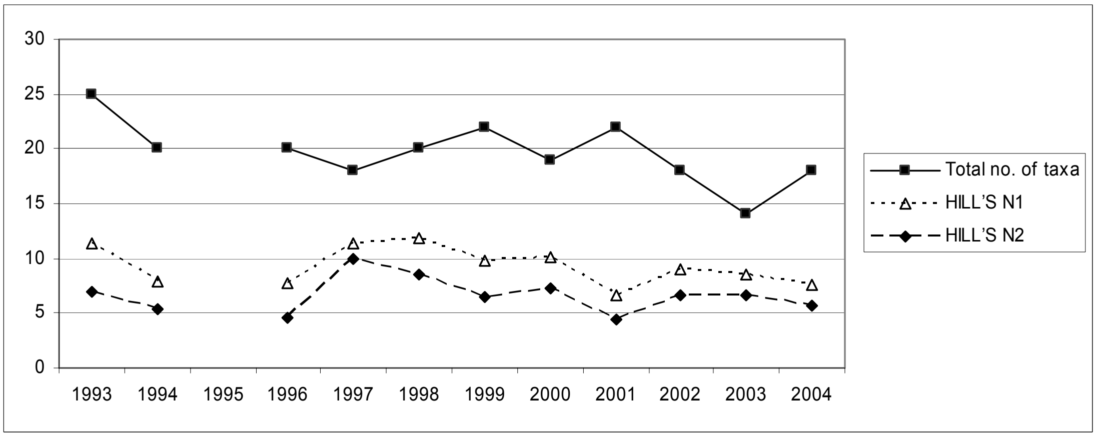


Figure 34 Selected Allt Riabhach na Bioraich macroinvertebrate summary statistics

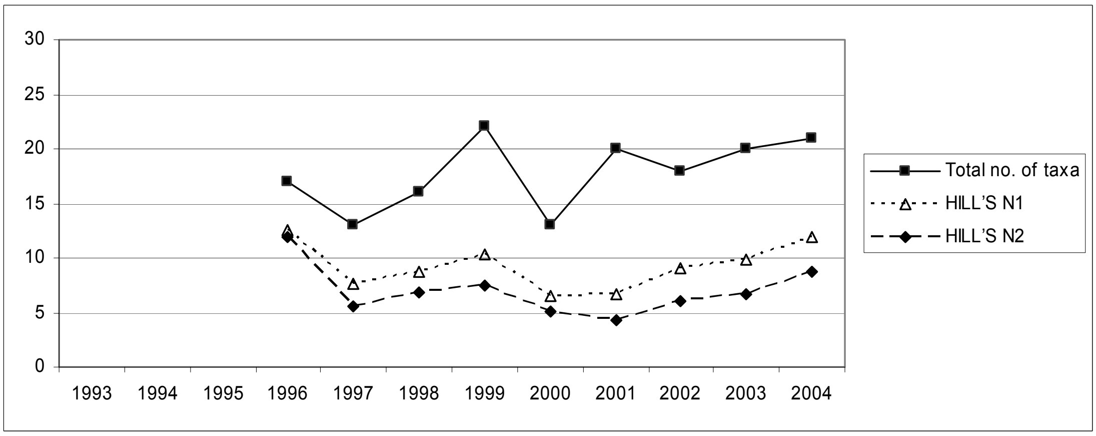


Figure 35 Control Burn fish densities

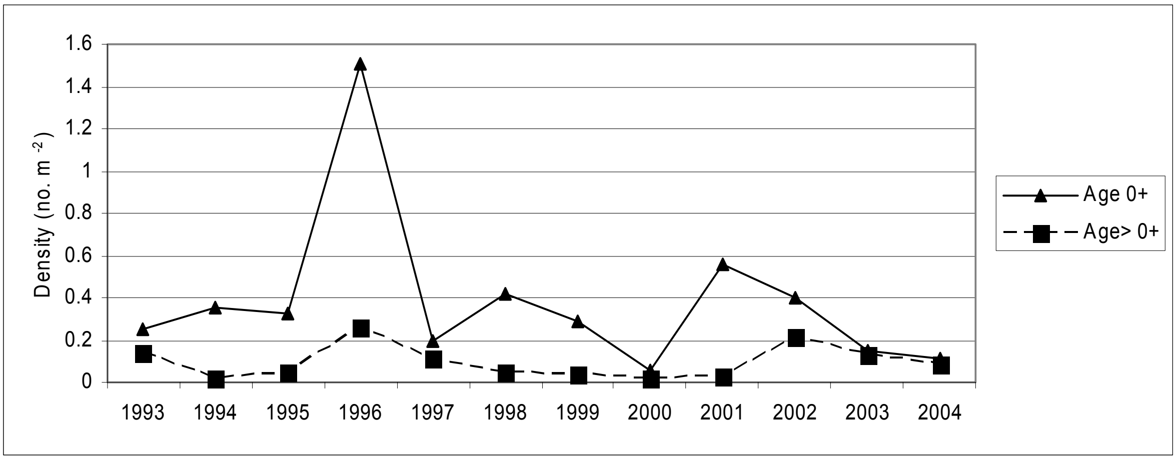


Figure 36 Experimental Burn fish densities

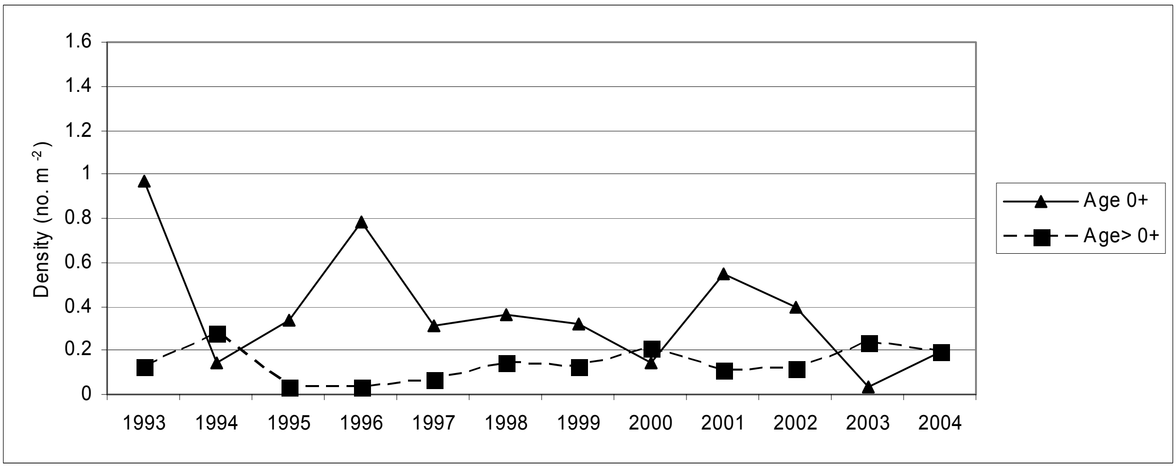
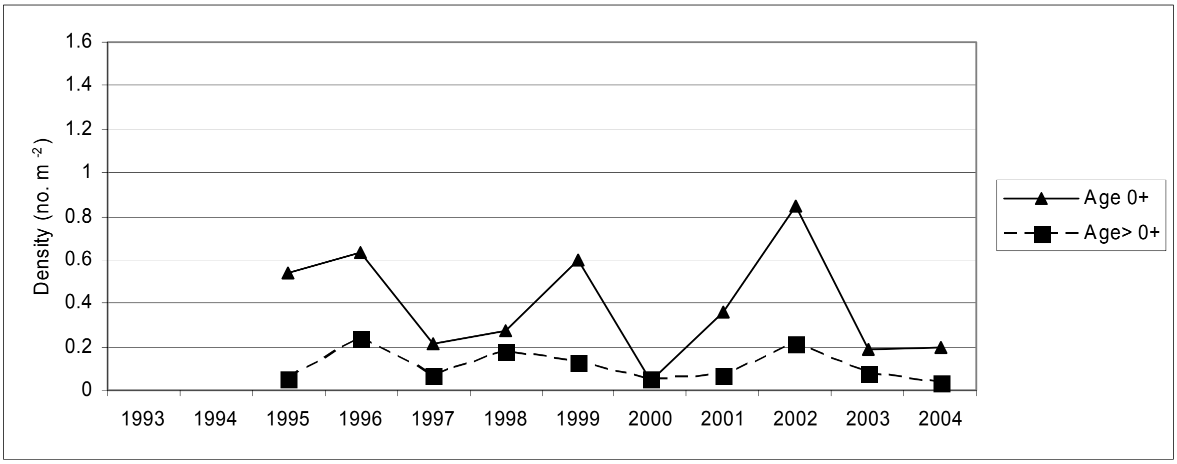


Figure 37 Allt Riabhach na Bioraich fish densities



8 APPENDICES

Appendix 1 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 Phosphorous (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	8	63	22	20	24	0	0	0	26	25	28				8	2	18
CONTROL	1993	6.23	5.59	6.91	64	8	147	29	20	39	0	0	2	28	11	44	22.5	19.0	26.0	6	0	29
CONTROL	1994	6.22	5.18	6.68	53	-3	105	29	23	39	1	0	2	34	23	85	18.9	2.5	58.0	4	0	17
CONTROL	1995	6.42	5.72	7.02	73	16	161	32	21	46	1	0	2	62	18	175	3.1	2.5	6.0	5	0	28
CONTROL	1996	6.03	5.39	6.9	50	2	173	29	20	44	1	0	5	41	18	62	3.3	2.5	10.0	4	0	10
CONTROL	1997	6.32	5.65	6.94	53	18	146	29	23	37	1	0	2	26	13	43	2.9	2.5	6.0	5	0	10
CONTROL	1998	6.19	5.61	6.82	63	9	169	27	21	36	0	0	1	22	13	35	3.3	2.5	11.0	5	0	16
CONTROL	1999	5.86	5.29	6.53	31	2	103	28	19	48	0	0	1	25	10	54	5.0	2.5	6.0	4	2	7
CONTROL	2000	6.33	5.46	6.75	55	-7	127	31	24	36	1	0	2	28	16	59	2.9	2.5	6.0	5	0	13
CONTROL	2001	6.18	5.56	6.63	50	6	97	23	18	31	1	0	6	22	13	34	6.9	2.5	21.0	9	1	24
CONTROL	2002	6.22	5.32	6.84	70	0	199	28	18	41	0	0	1	21	9	33	10.5	2.5	27.0	3	0	21
CONTROL	2003	6.24	5.34	6.93	74	1	184	31	22	42	0	0	1	31	11	63	11.6	6.0	19.0	3	0	10
CONTROL	2004	5.83	5.22	6.89	35	-4	131	22	12	34	0	0	0	15	9	26	8.8	4.0	12.0	8	0	16
UPPER EXPT	1992	5.71	5.23	6.19	24	-1	52	26	19	33	0	0	0	44	23	82				0	0	1
UPPER EXPT	1993	6.04	5.29	6.6	85	1	213	33	19	45	1	0	2	24	8	45	20.5	19.0	22.0	3	0	9
UPPER EXPT	1994	6.19	5.47	6.78	73	5	136	34	24	44	1	0	1	27	13	51	18.9	0.0	60.0	3	0	7
UPPER EXPT	1995	6.14	5.21	6.81	89	0	221	38	22	63	0	0	1	74	13	302	3.0	2.5	6.0	3	0	7
UPPER EXPT	1996	5.86	5.16	6.75	62	-4	208	33	23	46	1	0	2	37	16	75	2.6	2.5	3.0	4	0	13
UPPER EXPT	1997	5.90	5.46	6.5	53	13	216	34	26	74	1	0	1	42	9	233	2.5	2.5	2.5	2	0	10
UPPER EXPT	1998	5.92	5.44	6.46	69	3	212	30	21	42	1	0	4	19	9	29	2.8	2.5	6.0	2	0	5
UPPER EXPT	1999	5.79	5.29	6.49	54	1	215	32	18	50	1	0	4	21	7	46	4.7	2.5	6.0	3	0	10
UPPER EXPT	2000	6.09	5.33	6.43	64	2	128	32	25	41	1	0	2	21	10	32	4.3	2.5	6.0	5	0	9
UPPER EXPT	2001	6.03	5.58	6.31	53	11	97	25	17	31	1	0	2	19	10	39	6.4	2.5	11.0	4	0	12
UPPER EXPT	2002	6.08	5.5	6.51	85	6	266	31	17	45	1	0	2	17	6	26	12.2	2.5	21.0	4	0	10
UPPER EXPT	2003	6.06	5.36	6.6	82	2	221	33	21	43	1	0	2	25	10	48	14.5	6.0	35.0	2	0	5
UPPER EXPT	2004	5.89	5.33	6.66	49	0	180	24	10	36	0	0	0	13	8	24	10.4	6.0	18.0	4	0	14
LOWER EXPT	1995	6.13	5.13	6.77	97	-3	220	61	29	115	0	0	0	291	55	749	5.3	2.5	11.0	2	0	4
LOWER EXPT	1996	5.82	4.98	6.67	62	-11	231	42	22	75	0	0	2	105	21	278	3.1	2.5	6.0	5	0	12
LOWER EXPT	1997	5.91	5.54	6.67	46	9	140	35	28	44	0	0	1	52	28	80	5.6	2.5	17.0	2	0	7
LOWER EXPT	1998	5.85	5.44	6.34	67	3	203	38	20	65	0	0	2	88	20	232	3.2	2.5	6.0	8	0	42
LOWER EXPT	1999	5.70	4.97	6.29	50	-6	208	38	20	81	0	0	1	67	10	312	5.4	2.5	8.0	4	0	9
LOWER EXPT	2000	6.15	5.63	6.39	65	3	132	40	27	54	1	0	2	78	18	128	4.3	2.5	6.0	4	0	13
LOWER EXPT	2001	6.03	5.6	6.37	55	10	117	28	21	47	1	1	2	52	19	133	5.3	2.5	6.0	5	0	16
LOWER EXPT	2002	6.02	5.65	6.37	68	11	179	37	19	61	1	0	2	73	13	199	12.4	2.5	24.0	3	0	11
LOWER EXPT	2003	5.92	5.4	6.21	66	3	156	38	23	57	0	0	2	78	20	178	11.9	6.0	18.0	6	0	16
LOWER EXPT	2004	5.80	5.2	6.76	47	-2	190	29	12	63	0	0	0	50	9	210	10.8	7.0	18.0	6	2	11
LOWER ARnB	1995	6.16	5.41	6.8	55	7	122	34	25	43	2	0	9	84	26	156	3.4	2.5	6.0	3	0	8
LOWER ARnB	1996	5.97	5.26	6.69	52	0	141	31	21	44	2	0	8	47	22	88	2.7	2.5	4.0	7	1	29
LOWER ARnB	1997	6.02	5.64	6.63	44	18	104	29	25	38	1	0	4	31	20	49	2.9	2.5	6.0	4	0	10
LOWER ARnB	1998	5.95	5.46	6.52	60	6	163	28	21	39	1	0	3	33	18	62	2.5	2.5	2.5	3	0	12
LOWER ARnB	1999	5.79	5.02	6.56	34	-6	110	29	21	43	1	0	2	29	14	51	3.8	2.5	6.0	4	0	20
LOWER ARnB	2000	6.02	5.47	6.59	44	2	97	30	24	35	1	0	2	32	20	47	4.3	2.5	6.0	6	2	15
LOWER ARnB	2001	5.97	5.3	6.45	37	5	91	23	18	30	2	0	7	27	18	37	5.2	2.5	6.0	7	0	15
LOWER ARnB	2002	5.97	4.59	6.6	58	-24	198	30	19	44	1	0	4	28	10	45	12.8	2.5	25.0	6	0	22
LOWER ARnB	2003	5.99	5.25	6.62	62	-1	149	32	21	42	0	0	2	39	14	59	11.3	5.0	19.0	15	2	76
LOWER ARnB	2004	5.71	5.17	6.66	30	-3	119	22	13	33	0	0	0	17	10	27	13.6	8.0	35.0	7	1	23
UPPER ARnB	1995	6.19	5.56	6.59	44	9	84	31	23	41	3	0	8	77	20	158	3.4	2.5	6.0	2	0	8
UPPER ARnB	1996	5.94	5.28	6.67	38	-1	114	28	20	43	2	0	7	43	21	82	2.8	2.5	4.0	5	1	11
UPPER ARnB	1997	6.05	5.63	6.51	49	7	202	29	24	46	1	0	4	26	17	44	2.9	2.5	6.0	7	0	28
UPPER ARnB	1998	6.02	5.54	6.68	44	6	130	25	20	32	1	0	2	23	14	33	3.1	2.5	6.0	7	0	27
UPPER ARnB	1999	5.82	5.22	6.46	27	-2	85	28	19	45	0	0	2	25	15	39	4.1	1.0	10.0	4	0	13
UPPER ARnB	2000	6.14	5.54	6.51	40	5	79	28	23	32	1	0	2	27	17	46	4.3	2.5	6.0	2	0	6
UPPER ARnB	2001	6.02	5.44	6.38	37	4	71	22	18	27	2	0	7	23	14	36	9.7	2.5	35.0	9	0	22
UPPER ARnB	2002	6.13	5.32	6.91	53	0	152	26	17	36	1	0	3	20	10	33	12.9	2.5	28.0	6	0	14
UPPER ARnB	2003	6.03	5.23	6.57	49	-2	119	29	20	41	0	0	2	29	14	55	13.8	6.0	25.0	6	1	18
UPPER ARnB	2004	5.75	5.17	6.67	26	-5	94	22	13	32	0	0	0	15	9	24	11.0	7.0	19.0	7	1	20
LAIDONOFLOW	1995	5.93	5.71	6.15	19	14	24	24	23	24	2	2	2	39	35	43	2.5	2.5	2.5	1	0	2
LAIDONOFLOW	1996	5.92	5.52	6.27	19	6	35	26	18	32	4	2	6	49	34	91	3.1	2.5	6.0	2	0	7
LAIDONOFLOW	1997	5.91	5.51	6.31	15	2	26	29	25	33	2	1	5	31	27	34	3.4	2.5	10.0	2	0	8
LAIDONOFLOW	1998	5.93	5.63	6.15	19	10	28	25	22	28	2	1	3	29	24	34	4.3	2.5	17.0	3	1	6
LAIDONOFLOW	1999	5.87	5.48	6.09	17	2	23	28	24	36	1	0	3	25	12	31	4.3	2.5	6.0	2	0	12
LAIDONOFLOW	2000	5.86	5.3	6.11	14	-1	23	31	25	39	1	1	2	29	22	34	5.0	2.5	17.0	2	0	5
LAIDONOFLOW	2001	6.02	5.67	6.31	25	10	34	22	20	24	4	2	8	28	22	32	6.7	2.5	14.0	2	0	3
LAIDONOFLOW	2002	5.96	5.64	6.27	20	10	33	30	21	41	1	0	3	29	25	37	9.6	2.5	25.0	4	0	9
LAIDONOFLOW	2003	5.99	5.83	6.28	21	12	36	27	24	30	2	1	3	31	29	34	10.8	6.0	20.0	2	0	6
LAIDONOFLOW	2004	5.93	5.5	6.26	21	9	33	24	22	27	1	0	4	23	19	29	16.6	10.0	27.0	5	0	15
FOREST	2000	6.29	5.72	7.27	124	19	330	36	22	58	1	0	2	26	14	45	5.7	2.5	12.0	14	0	33
FOREST	2001	5.78	5.4	6	28	9	47	21	16	25	1	0	2	19	10	36	7.1	2.5	17.0	8	0	34
FOREST	2002	5.82	5.48	6.1	43	5	111	27	17	36	0	0	1	17	8	31	11.0	2.5	26.0	15	1	51
FOREST	2003	5.70	5.42	6	45	4	126	28	18	41	0	0	2	24	7	45	12.4	7.0	17.0	7	1	16
FOREST	2004	5.69	5.39	6.03	22	0	65	21	13	32	0	0	0	14	9	24	12.1	8.0	24.0	13	3	24

Appendix 2 Water chemistry for the Control Burn August 1992 – December 2004

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
06/12/1992	5.7	10	20	104		3	17	43	103	0	25	1		33	2	0.25	3.5
04/01/1993	5.63	8	20	105		4	25	41	101	0	44	0		21	3	0.27	3.8
30/03/1993	5.91	17	39	203		5	44	67	278	0	41	1		20	3	0.17	3.1
03/05/1993	6.57	91	35	177		6	42	97	186	0	35	0		9	5	0.17	3.3
18/06/1993	6.38	64	31	145		4	39	88	130	0	30	1	19	15	29	0.55	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	0.78	11
09/08/1993	5.91	32	23	114		3	33	72	98	2	11	4		92	13	0.88	
22/08/1993	6.54	92	27	148		4	42	91	141	0	18	2		39	4	0.48	
04/09/1993	6.76	147	36	168		7	46	111	151	0	26	0		17	1	0.29	
29/09/1993	6.91	141	36	161		6	47	114	155	0	31	0		26	5		
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	
08/07/1994	5.98	39	27	151	0	6	52	83	111	0	35	1		80	0	0.632	
07/08/1994	6.12	35	23	140	0	5	46	71	109	0	26	4	58	60	2		
25/08/1994	6.47	68	29	152	0	5	61	113	118	0	27	1		41	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			28	2	0.238	
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					
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
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

Appendix 3 Water chemistry for the Experimental Burn (Upper site) September 1992 - December 2004

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	0.41	
30/10/1992	6.19	52	26	130		3	32	61	128	0	26	0		15	0	0.27	4.4
06/12/1992	5.23	-1	19	93		2	14	27	88	0	23	0		27	0	0.26	3.4
04/01/1993	5.43	4	19	98		2	21	31	86	0	35	0		12	0	0.27	3.8
30/03/1993	5.86	20	41	230		5	44	64	296	1	45	2		9	3	0.17	2.9
03/05/1993	6.42	115	37	204		7	44	95	192	1	29	0		5	2	0.26	4.2
18/06/1993	6.33	122	37	202		4	44	100	156	0	16	0	19	19	9	0.51	8.2
10/07/1993	6.05	62	29	164		4	35	76	139	0	18	3	22	46	1	0.7	9.5
25/07/1993	5.71	36	29	156		2	42	73	130	0	12	3		48	9	0.86	13
09/08/1993	5.93	51	29	151		4	42	76	131	0	8	5		54	0	0.88	
22/08/1993	6.36	142	33	186		6	60	108	159	1	14	3		28	2	0.65	
04/09/1993	6.47	213	45	210		7	68	159	171	2	22	1		10	2	0.41	
29/09/1993	6.6	171	45	209		15	64	135	207	2	28	0		20	0		
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	
08/07/1994	5.75	38	29	178	0	3	53	75	122	1	24	2		45	1	0.836	
07/08/1994	6.78	130	31	181	0	13	78	137	141	1	19	4	60	17	6		
25/08/1994	6.29	76	32	177	0	7	71	111	141	1	18	2		28	3		
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			19	8	0.237	
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
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					
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

Appendix 4 Water chemistry for the Experimental Burn (Lower site) July 1995 - December 2004

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			19	12	0.167	
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					
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
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	
11/06/2003	5.68	33	23	126	0	2	38	60	88	0	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		19	0	0.305	
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	0	67	4	11	24	6	0.423	8
16/06/2004	6.12	63	24	125	0	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	0	5.6	70.1	312	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

Appendix 5 Water chemistry for the Allt Riabhach na Bioraich (Lower site) June 1995 - December 2004

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			29	1	0.213	
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
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					
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
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	
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		34	2	0.326	
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	0	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	0	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

Appendix 6 Water chemistry for the Allt Riabhach na Bioraich (Upper site) June 1995 - December 2004

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			30	2	0.196	
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						
30/04/1997	5.99	27	28	153	0	5	47	71	145	0	23	0	2.5	44	1	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
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	
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		31	1	0.288	
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	0	3.1	31	66	59	0	12	3	11	59	16	0.757	13.1
14/07/2004	6.67	94	27	140.5	0	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
14/12/2004	5.49	7	13	55	0	7	14	20	52	0	16	5	14	16	3	0.33	4.4

Appendix 7 Water chemistry for the Loch Laidon outflow September 1995 - December 2004

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			29	1	0.271	
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	2	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
10/03/1997	5.51	2	32	171	0	5	45	55	196	2	34						
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
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	
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		29	2	0.3	
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	0	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	0	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

Appendix 8 Water chemistry for the recently planted forest site September 2000 - December 2004

Date	pH	Alk	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	334	330	58	196	0	12	71	295	157	2	45	0	2.5	5	33	0.068	2.4
08/10/2000	5.89	29	22	28	160	0	5	46	56	173	0	14	0	2.5	39	8	0.227	6.3
21/11/2000	5.72	26	19	22	124	0	3	35	46	115	0	18	0	12	58	0	0.437	8.1
09/01/2001	5.73	23	16	16	87	0	3	24	38	60	1	19	0	17	51	3	0.374	7.9
08/03/2001	5.61	17	9	21	98	0	6	31	43	95	0	36	0	6	29	0	0.3	6.2
26/04/2001	5.79	29	19	25	143	4	5	40	57	127	0	32	0	2.5	59	2	0.385	8.8
06/06/2001	5.92	46	41	24	140	2	2	40	59	101	0	19	3	6	42	14	0.397	8.9
03/07/2001	5.74	40	37	20	113	0	1	39	63	64	0	12	2	6	108	0	0.752	15.2
23/07/2001	5.89	42	38	20	107	1	2	43	64	70	2	10	0	6	73	4	0.732	14.8
19/08/2001	5.77	50	47	20	106	0	3	48	73	69	1	10	14	16	42	34	0.771	17.9
07/10/2001	5.4	15	9	24	102	0	8	41	52	115	1	15	2	2.5	52	5	0.535	10.9
14/11/2001	5.91	36	30	19	96	0	6	35	60	80	1	17	2	2.5	31	6	0.408	9.4
10/12/2001	6	42	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	
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	0	22	0	7	5	2	0.115	21.7
16/12/2003	6		32	18	108	0	4	32	58	85	0	24	0		36	3	0.318	
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	0	9	2	9	42	14	0.44	8.2
16/06/2004	5.92		37	18	104	0	2	25.6	58.7	62	0	10	1	12	50	24	0.597	11.1
14/07/2004	6.03		65	22	115	0	2	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

Appendix 9 Macroinvertebrate taxon list and total abundances – Control Burn.

TAXON	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004
NEMATODA			1								
OLIGOCHAETA	22	6	8	3	5	2	1	3	3	2	3
LUMBRICULIDAE										1	
LUMBRICIDAE										1	
HYDRACARINA						1		4	6		18
SIPHLONURIDAE										1	
Siphlonurus lacustris								1	4	2	5
Ameletus inopinatus	11	4			1	1	3				
BAETIDAE									4	2	
Baetis sp.				52							23
Baetis rhodani	5		7		39	30	20	142	138	34	
Baetis muticus	3	2	3				1	1			
HEPTAGENIIDAE					9					1	1
Heptagenia sp.									2		
Heptagenia lateralis	3	18	11	9	2	3	13	10	16	4	5
Ecdyonurus sp.					1						
Ecdyonurus dispar				1							
Leptophlebia marginata			1			1					
Brachyptera risi								1			
Protonemura praecox							1				
Amphinemura sulcicollis	168	32	27	17	52	54	103	57	76	69	38
Nemurella picteti				1							
LEUCTRIDAE					1						
Leuctra inermis	41	6	1	5	3	22	30	2	8	2	3
Leuctra hippopus		1									
Perlodes microcephala	2					1					
Isoperla grammatica	106	4	8	9	20	25	25	32	17	5	6
Siphonoperla torrentium	109	48	54	2	61	29	30	29	23	12	6
Chloroperla tripunctata				11							
Velia sp.											1
Oreodytes rivalis	18	36	7	1							
Platambus maculatus		1									
HYDROPHILIDAE									1		
Hydraena gracilis								2			
HELODIDAE	1										
Elmis aenea	17		1		88	2	1	1			2
Limnius volckmari	129	16	46	17		34	65	32	54	56	37
Oulimnius sp.					3				83	11	
Oulimnius tuberculatus	55	22	21	5		14	8	27			91
Rhyacophila sp.								1		2	
Rhyacophila dorsalis	1		1	2		4	2	1			1
POLYCENTROPODIDAE									4		
Plectrocnemia conspersa	6	1	5	3	2			4	8	1	6
Plectrocnemia geniculata		2									
Polycentropus sp.						2					
Polycentropus flavomaculatus		2	3		4			1	2	4	13
Tinodes sp.											1
Hydropsyche siltalai	1				1					1	

TAXON	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004
HYDROPTILIDAE										2	
Hydroptila sp.		2									19
Oxyethira sp.		1									
LIMNEPHILIDAE undet.	10	7	6		3	3	4	1	3		4
Potamophylax sp.										1	
Halesus sp.								1			
Chaetopteryx villosa											2
DIPTERA					2				1	2	
TIPULIDAE	2	1						2	1	3	7
Dicranota sp.	8	2	3	3	1	5	1	8	4	3	
Psychodidae	1										
CHIRONOMIDAE	26	17	28	13	6	11	4	40	12	15	157
SIMULIIDAE	23		1	23	3	11	1	5	3	2	39
EMPIDIDAE						2		1			1
Leuctra sp.									9	2	19

Appendix 10 Macroinvertebrate taxon list and total abundances – Experimental Burn.

TAXON	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004
NEMATODA	2		1	1							
Pisidium sp.		1									
OLIGOCHAETA	14	10	26		3			3	1		8
ENCHYTRAEIDAE										4	
HYDRACARINA					1			1	8		7
COLLEMBOLA					1				1		
Siphlonurus lacustris			35				1		1		
Baetis sp.		1									1
Baetis rhodani				1	1	1			3		
Baetis muticus	9		3								
Leptophlebia sp.									1		21
Leptophlebia marginata	16	19	6			7	5	3		2	
Leptophlebia vespertina	20	61	9	9		7	15	42	5	2	
Protonemura meyeri	1										
Amphinemura sulcicollis	20	1	2	14	7	7	12	1	4	2	1
Nemurella picteti				1							
Nemoura sp.							1				
Nemoura avicularis		2				1			1	1	
Nemoura cambrica	2		1			1		3			
Leuctra inermis	1										
Leuctra hippopus					1		1	1			
Leuctra nigra	1										
Isoperla grammatica	7				2	4	6	1	1		
Siphonoperla torrentium	23	5		5	3	1	2				6
Pyrrhosoma nymphula	1	1				1					
Cordulegaster boltonii	1										
VELIIDAE									3		
Velia sp.											2
Dytiscidae undet. (larvae)		1		1							
Agabus guttatus	1										
Anacaena globulus			1								
Limnius volckmari	2	5		17	1	1	1	2		2	2
Oulimnius sp.					9				27	20	
Oulimnius tuberculatus	151	98	19	15		12	20	14			78
POLYCENTROPODIDAE									5	1	7
Plectrocnemia conspersa	13	9	9	15	1	2	5	35	9	5	6
Plectrocnemia geniculata		1									
Polycentropus sp.						2	6				
Polycentropus flavomaculatus	23	6	6		3	5		13	13	6	16
HYDROPTILIDAE	38				2				1	5	
Hydroptila sp.			1								2
Oxyethira sp.		29				4		2			1
LIMNEPHILIDAE undet.	66	2	7	4	17	41	47	5	6	15	29
Potamophylax rotundipennis					1						
Halesus sp.							1				
Halesus radiatus			6					4			
Halesus digitatus								1			

TAXON	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004
Chaetopteryx villosa											14
DIPTERA					2				2	1	
TIPULIDAE	1			1				1		1	3
Dicranota sp.	6	2	1	3	2	2	3	1			
CHIRONOMIDAE	56	86	104	15	24	36	22	89	33	33	93
SIMULIIDAE	2		1	1	5	6	11	3	8	14	1
Simulium latipes		3									
EMPIDIDAE					2	1					1
Clinocera sp.							1				
Leuctra sp.									1		5
GERRIDAE								1			
Hydropsyche sp.								1			

Appendix 11 Macroinvertebrate taxon list and total abundances – Allt Riabhach na Bioraich Burn

TAXON	1996	1997	1998	1999	2000	2001	2002	2003	2004
NEMATODA	1								
OLIGOCHAETA	12		5	12	1	13	1		2
NAIDIDAE							1		
ENCHYTRAEIDAE								2	
LUMBRICULIDAE							2	1	
Stylodrilus heringianus								2	
LUMBRICIDAE								1	
HYDRACARINA						2	6		14
COLLEMBOLA								1	
Siphlonurus sp.							1		
Siphlonurus lacustris	17					3			9
Baetis sp.									45
Baetis rhodani			8	4		8	16	21	
HEPTAGENIIDAE									1
Heptagenia lateralis	2	1	2	1	2				
Leptophlebia sp.									1
Leptophlebia vespertina	5								
Brachyptera risi				1					
Amphinemura sulcicollis	9	23	28	25	99	45	27	85	14
Nemoura sp.		2							
Nemoura cambrica				1					
Leuctra inermis		2	14	27	17	3	5	12	1
Isoperla grammatica	3	46	45	36	74	79	37	55	14
Siphonoperla torrentium	7	8	33	24	20	8	3	4	2
Chloroperla tripunctata		5							
Cordulegaster boltonii								1	
Dytiscidae undet. (larvae)	1								
Oreodytes rivalis	1								
Oreodytes sanmarkii				1		1			
Limnius volckmari	3	7	9	18	22	20	19	18	27
Oulimnius sp.			1				79	25	
Oulimnius tuberculatus	9	10		4	56	40			23
Sialis fuliginosa								1	
Rhyacophila sp.						3			
Rhyacophila dorsalis				1		2	1		
Rhyacophila obliterata									1
POLYCENTROPODIDAE									1
Plectrocnemia conspersa	11	1	1	1	2	3	4	4	5
Polycentropus flavomaculatus	1			3			6	4	15
Hydroptila sp.									1
Oxyethira sp.									2
LIMNEPHILIDAE undet.	6	3	6	5	8	6	4	8	3
Ecclisopteryx guttulata			1						
Halesus sp.									6
Halesus radiatus								2	
Halesus digitatus						2			
Chaetopteryx villosa									2

TAXON	1996	1997	1998	1999	2000	2001	2002	2003	2004
DIPTERA			1	1				6	
TIPULIDAE							1	3	6
Dicranota sp.	7		5	9		5	3	8	
CHIRONOMIDAE	14	7	10	18	6	186	8	18	81
SIMULIIDAE		12	1	76	1	2	7	1	7
EMPIDIDAE								2	2
Leuctra sp.						6	3	1	13

Appendix 12 Control Burn macroinvertebrate summary statistics

Year	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total Count	768	231	256	178	307	257	314	409	428	241	508
Total no. of taxa	24	22	27	19	21	23	18	26	19	21	23
RICHNESS (rareftn 100)	17	17	18	15	12	17	13	15	14	17	17
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
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
EVENNESS (E5)	0.71	0.73	0.68	0.68	0.69	0.76	0.67	0.61	0.68	0.63	0.60
BMWP	110	99	125	88	88	118	93	108	88	104	116
ASPT	6.4	6.6	6.6	6.3	6.3	6.6	6.1	6.7	6.8	6.5	6.4

Appendix 13 Experimental Burn macroinvertebrate summary statistics

Year	1993	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total Count	477	231	247	110	96	142	162	227	134	114	313
Total no. of taxa	25	20	20	18	20	22	19	22	18	14	18
RICHNESS (rareftn 100)	18	14	14	16	19	19	16	13	16	13	13
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
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
EVENNESS (E5)	0.57	0.64	0.54	0.87	0.69	0.61	0.69	0.67	0.71	0.76	0.70
BMWP	108	83	82	67	94	84	93	80	79	52	88
ASPT	6.4	5.5	5.9	6.1	6.3	6.5	7.0	5.7	6.6	5.2	5.9

Appendix 14 Allt Riabhach na Bioraich Burn macroinvertebrate summary statistics

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total Count	109	128	171	268	315	437	234	286	316
Total no. of taxa	17	13	16	22	13	20	18	20	21
RICHNESS (rareftn 100)	17	12	13	16	10	13	15	16	17
HILL'S N1	12.6	7.6	8.8	10.3	6.6	6.7	9.1	9.9	11.9
HILL'S N2	11.9	5.5	6.8	7.5	5.1	4.2	6.0	6.7	8.7
EVENNESS (E5)	0.94	0.67	0.74	0.69	0.73	0.57	0.62	0.64	0.70
BMWP	89	78	83	105	75	95	80	85	121
ASPT	6.9	7.1	6.4	6.6	6.1	6.3	6.7	6.1	6.7

Appendix 15 Control Burn aquatic macrophyte percentage cover

	1992	1993	1994	1995	1996	1997	1998	1999	2001	2002	2003	2004
Batrachospermum sp.	+	0.7	+		+				+	+		
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
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
Racomitrium aciculare	0.3	+	2.1	0.4	+	+		0.7	0.1	0.6	1.1	+
Juncus bulbosus var *fluitans*	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
Filamentous green algae	+	10.7	+	0.1	+	+	+	1.3	+	0.8	0.3	+

Sampling stretch 50m long.

Appendix 16 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.

Appendix 17 Allt Riabhach na Bioraich Burn aquatic macrophyte percentage cover

	1996	1997	1998	1999	2001	2002	2003	2004
Batrachospermum sp.		1.6	0.3	0.3	0.4	+		
Marsupella emarginata var *aquatica*	+							
Scapania undulata	0.4	0.2	0.7	0.5	0.9	1.0	0.4	0.3
Racomitrium aciculare			0.2	0.2	0.2	0.2	0.2	
TOTAL COVER (excluding filamentous green algae)	0.4	1.8	1.2	1.0	1.5	1.2	0.6	0.3
Filamentous green algae	0.4		+	+	+	0.2	3.9	

Sampling stretch 50m long.

Appendix 18 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
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	31.2	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
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

Appendix 19 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

* Only control burn sampled in 1992