Denitrification and a Nitrogen Budget of Created Riparian Wetlands

Thesis

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By

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Abstract

Riparian wetland creation and restoration have been proposed as a means to mediate aquatic nitrate (NO_3^-) pollution from non-point runoff. Excess nitrate concentrations from the US Midwest are known to cause hypoxia in the Gulf of Mexico. Denitrification by anaerobic microbial communities in wetland soils results in the permanent removal of NO_3^- through reduction to NO , N_2O , and N_2 . Denitrification rates were quantified using the in situ acetylene inhibition technique at 12 locations in three wetland/riverine sites at the Olentangy River Wetland Research Park, Columbus, OH for one year. Sites included two created flow-through experimental wetlands and one bottomland forest/river-edge site. Points were spatially distributed at inflows, center, and outflows to include permanently flooded open water, intermittently flooded transitions, and upland. Annual median (mean) denitrification rates were significantly higher ($p < 0.001$) in flooded zones of the wetlands (266 (415) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$) compared to the transition zones (58 (37.5) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$, respectively). Median wetland transition zone denitrification rates did not differ significantly ($\alpha = 0.05$) from the riverside or upland site. Wetland denitrification rates peaked in spring during the period of highest concentration of nitrate-nitrogen caused by nitrogen fertilizer application and runoff (for the months of April-June, median rates ranged from 240 - 1010 $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$ in the permanently flooded zones). A nitrogen mass balance analysis showed that 57% of surface water N was retained by the wetlands, only about 2% of N entering the wetlands was permanently removed through denitrification.

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$$\frac{\Delta N_s}{\Delta t} = \text{accumulation of nitrogen in wetland sediments;}$$

I_N = surface loading of total nitrogen = surface loading of
 total Kjeldahl nitrogen + $\text{NO}_3\text{-N}$ + $\text{NO}_2\text{-N}$; P_N = atmospheric
 deposition of N through precipitation; O_N = outflow of total
 nitrogen; DN = denitrification; S_N = groundwater seepage
 of $\text{NO}_3\text{-N}$32

Chapter 1: Introduction

Nitrogen (N) takes more forms in soil than any other essential nutrient, and N transformations are usually the result of microbial mediated soil oxidation-reduction reactions. In terrestrial ecosystems, N is often a limiting factor for plant growth; however plant available nitrate (NO_3^-) can become a pollutant in aquatic ecosystems. Dinitrogen gas (N_2) is the most abundant form of N, yet is unusable by most organisms. To maintain balance in the global N budget, N_2 fixation must be matched by denitrification, the return of fixed N to N_2 . Currently, the fixation of N_2 by industrial and biological pathways far exceeds denitrification rates, causing a rapid increase in biologically available N forms (Galloway et al., 2003).

Fertilizer inputs are the major source of this increased N availability, and nonpoint runoff from agricultural areas is a major source of N pollution in streams. Excess nitrate loading from agricultural runoff in the Mississippi-Ohio-Missouri (MOM) River basin has been cited as one of the main causes of hypoxia in the Gulf of Mexico (Goolsby and Battaglin, 2001; Dagg and Breed, 2003). Eutrophication causes algal blooms, and dissolved oxygen levels decline as the algae respire and decompose. Biological oxygen demand can then cause hypoxia, which leads to fish kills and biodiversity loss.

Denitrification is the only process that permanently reduces NO_3^- to N_2 . Facultative anaerobic bacteria utilize NO_3^- as a terminal electron acceptor during respiration in the absence of O_2 , making anoxic soils, such as those found in wetlands, important sites for N management. The

creation of riparian wetlands in the MOM basin has thus been suggested as a means to mitigate hypoxia in the Gulf of Mexico (Mitsch et al., 2001, 2005a; Mitsch and Day, 2006).

Many different soil bacteria can carry out denitrification; more than 50 genera with over 125 species have been identified (Zumft, 1992), and denitrifiers constitute up to 20% of total microbial biomass (Tiedje, 1989). Since NO_3^- is a much less efficient electron acceptor than O_2 , soil must be completely depleted of oxygen before NO_3^- will be reduced through respiration. The multi-step pathway is

where the formation of each intermediate is initiated by individual enzymes: nitrate reductase (*nar*), nitrite reductase (*nir*), nitric oxide reductase (*nor*), and nitrous oxide reductase (*nos*). Any one of the intermediates can be lost to the soil at any point during this process. Denitrification can thus contribute nitrite (NO_2^-) in solution, as well as NO and N_2O , an increasingly significant greenhouse gas (IPCC, 2007).

The largest factor controlling denitrification is O_2 depletion, because O_2 yields much more energy than NO_3^- as a terminal electron acceptor. Facultative anaerobic microbes will prefer O_2 and will thus not begin denitrification until O_2 levels are insufficient. Soil carbon (C) is another important controlling factor, because most denitrifiers are heterotrophs that use C as the primary electron donor for respiration. In addition to O_2 and C, NO_3^- concentrations can be a significant factor when NO_3^- is limiting. In the absence of NO_3^- inputs from agricultural runoff during late summer and fall (Mitsch et al., 2005a), nitrifying bacteria that supply NO_3^- are inhibited by low O_2 levels.

Along a transverse gradient in wetlands, different oxidation-reduction conditions occur as a result of hydrologic pulsing. We hypothesized that denitrification rates would be higher in permanently flooded zones compared to intermittently flooded transition zones, due to the availability of oxygen in the transition zones during dry periods (Hernandez and Mitsch, 2007). Along a longitudinal gradient, NO_3^- concentrations are expected to decrease as NO_3^- is transformed or leached to groundwater as water flows through the wetland (Mitsch et al., 2005a). We therefore hypothesized that denitrification rates would be higher at the inflow compared to the outflow. We also hypothesized a seasonal peak in denitrification in spring and early summer, when river NO_3^- concentrations are highest. However, we hypothesized that denitrification rates would be lower in the wetlands when compared to the adjacent river, due to the higher carbon content of the river sediment.

The objectives of this study were to examine seasonal denitrification patterns along transverse and longitudinal gradients in two 1 ha created riparian wetlands in the agricultural Midwest, USA. We also compared these to denitrification rates along a transverse gradient in the adjacent river. Our ultimate goal was to assess controlling factors of denitrification in created riparian wetlands and to determine the overall importance of the denitrification process in wetland NO_3^- retention.

Chapter 2: Materials and Methods

2.1. Study site

This study was conducted at the Wilma H. Schiermeier Olentangy River Wetland Research Park (ORWRP) in Columbus, Ohio, USA. The ORWRP includes several wetlands that differ in area, depth, vegetation, water source, and flooding frequency (Mitsch et al., 2005b, 2008). We investigated denitrification rates in three wetland sites: two flow-through experimental river diversion wetlands and one bottomland forest/river edge site. The paired 1-ha experimental wetlands were created in 1993-1994 on alluvial old field soils (Mitsch et al., 1998) and have since received water pumped from the Olentangy River at an average rate of 20-35 m yr⁻¹ since March 1994. The two wetlands differ only in that wetland 1 was initially planted with native vegetation, while the vegetation of wetland 2 was allowed to naturally colonize (Mitsch et al., 1998). Both wetlands include three deepwater zones (<50 cm depth) at their inflows, centers, and outflows. These open deepwater zones are surrounded by shallower areas (20-30 cm) of emergent vegetation. An equal volume of water enters both wetlands from their north sides and flows southward, returning to the Olentangy River through an outflow swale. The experimental wetlands originally contained primarily Ross (Rs) series soil, a floodplain alluvial soil that ranges from silt loam to silty clay loam to loam (Hernandez and Mitsch, 2007), and have since developed hydric soils as a result of artificial flooding (Mitsch et al., 2005b; Anderson et al., 2005). Soil chemical parameters during the time of this study are shown in Table 1. Several

publications detail the ecology and biogeochemistry of these wetlands (Mitsch et al., 1998, 2005a,b; Nairn and Mitsch, 2000; Harter and Mitsch, 2003; Anderson et al., 2005; Anderson and Mitsch, 2006; Altor and Mitsch, 2006, 2008; Nahlik and Mitsch, 2010; Sha et al., 2011). Previous nitrogen studies at the ORWRP include Spieles and Mitsch (2000), Hernandez and Mitsch (2006, 2007), and Song et al. (2010).

The riverside site is on the bank of the Olentangy River and adjacent to its bottomland hardwood forest. The river experiences frequent flooding during the cold and wet period from November to May and less flooding during the warm and dry months from June to October (Zhang and Mitsch, 2007).

Sampling locations were spatially distributed in the experimental wetlands along two hydrologic gradients: longitudinal (inflow, center, and outflow) and transverse (permanently flooded open water, intermittently flooded vegetated transition zones, and upland). The river edge site included sampling locations in the permanently flooded river and the intermittently flooded edge. Both river sites lack vegetation. Sampling sites included paired open water and transition zones at the river edge, at the center of wetland 1, and at the inflow, center, and outflow of wetland 2. One reference upland sampling site was located between the two experimental wetlands for a total of 12 sampling locations, each with two replicates (Fig. 1).

2.2. In situ denitrification measurements and analysis

Denitrification measurements were taken monthly at each of the 12 sample sites for one year, from November 2008 through October 2009, using the in situ acetylene inhibition method (Knowles, 1990). Application of acetylene to the soil selectively inhibits the nitrous oxide reductase enzyme, thus preventing the reduction of N_2O to N_2 . Denitrification rates can then be

quantified by calculating the accumulation of N_2O end product in the presence of acetylene, which is theoretically equivalent to the production of N_2O plus N_2 in the absence of acetylene.

At each site, two replicate PVC tubes (4 cm diameter x 80 cm height) were inserted 10 cm into the soil, 3 m apart, 24 hours prior to sampling (Hernandez and Mitsch, 2007). Acetylene gas was injected into the soil to a concentration of 10% (v/v) of the tube headspace. Ten minutes after acetylene injection, the PVC tubes were closed with a cap containing a thermometer and gray butyl rubber stopper sampling port. Gas samples were taken initially when the tubes were sealed and then every 10 minutes for 30 additional minutes, collected in 10 ml headspace Wheaton vials sealed with gray butyl stoppers and aluminum seals, and stored at 4°C until analysis. Water temperature, water depth, and soil temperature at 5 and 15 cm depth were also recorded for each site during gas collection.

Gas samples were analyzed at the Wetland Biogeochemistry Laboratory of Louisiana State University with a gas chromatograph (Varian 3800) using an electron capture detector and N_2 carrier gas (50 ml min^{-1}). Temperatures of injector, column, and detector were set at 60°, 60°, and 300°C, respectively. Denitrification rate was calculated using the linear regression of N_2O production versus time at each location using the flux equation for closed chambers (Holland *et al.*, 1999).

2.3. Soil sampling and analysis

Triplicate soil samples were collected at the surface (0 – 15 cm) of each sampling plot in March 2009 and analyzed at the Plant Biochemistry Lab of the Estonian University of Life Sciences according to standard methods (APHA, 1989). Soil C was analyzed with a dry combustion (Dc) method using an automatic analyzer (Vario EL III Operating Instructions). Soil

Kjeldahl N was measured using a Tecator analyser; available (ammonium lactate extractable) soil P was measured by FiaStar5000 Flow Injection Analyser using the Tecator Flame Photometric Method. Soil Ca content was measured with a flow injection analyzer.

2.4. Wetland nitrogen budget

A monthly hydrology budget was determined over the study period using the following equation (in cm day⁻¹):

$$\frac{\Delta d}{\Delta t} = P_n + S_i - ET - S_o - G_o \quad (\text{eq. 1})$$

where

$\frac{\Delta d}{\Delta t}$ = change in water level

P_n = net precipitation

S_i = surface inflows

ET = evapotranspiration

S_o = surface outflows

G_o = groundwater outflows

Instantaneous and cumulative pumping rate volumes were collected twice daily by students and staff at the ORWRP from flow rate monitors for each wetland inflow pipe (Mitsch et al., 2005a,b). Daily precipitation and temperature data from November 1, 2008-October 31, 2009 were obtained from the Columbus weather station (loc: 39.9611, -82.9989) maintained by the Ohio Agricultural Research and Development Center (OARDC, 2009) of The Ohio State University. Evapotranspiration (ET) was determined using the Thornwaite equation (Mitsch and Gosselink, 2007):

$$ET_i = 16(10T_i/I) \quad (\text{eq.2})$$

where

ET_i = potential evapotranspiration (mm mo^{-1}) for month i

T_i = mean monthly temperature ($^{\circ}\text{C}$)

I = monthly local heat index given by $(T_i/5)^{1.5}$ when $T_i > 0$

$a = 0.47 + 0.0179 \times I - 7.71 \times 10^{-5} \times I^2 + 6.75 \times 10^{-7} \times I^3$

For $T_i < 5$, $ET_i = 0$.

Outflow is measured using the wetland water level and the control weir boxes at the southern edge of the wetlands. Water level data were collected twice daily and supplemented with continuous water level data from Ott Thalimedes data loggers installed in each wetland (Mitsch 2005a,b). Surface outflow (Mitsch and Gosselink, 2007) is then calculated as:

$$S_o = xL^y \quad (\text{eq. 3})$$

where

S_o = surface outflow

L = water level above the control weir

x, y = calibration coefficients (0.59, 2.748)

All data were averaged to determine monthly values and converted into cm d^{-1} . Seepage was then estimated as the residual from the wetland water budget equation above.

The annual nitrogen budget (in $\text{g N m}^2 \text{yr}^{-1}$) was determined for the following equation:

$$\frac{\Delta N_s}{\Delta t} = I_N + P_N - O_N - D_N - S_N \quad (\text{eq. 4})$$

where

$\frac{\Delta N_s}{\Delta t}$ = accumulation of nitrogen in wetland sediments

I_N = surface loading of total nitrogen

= surface loading of total Kjeldahl nitrogen + NO₃-N + NO₂-N

P_N = atmospheric deposition of N through precipitation

O_N = outflow of total nitrogen

D_N = denitrification

S_N = groundwater seepage of NO₃-N

Weekly water samples were collected by the ORWRP at the inflows, center, and outflows of the experimental wetlands and from the Olentangy River. Samples were collected in acid-washed bottles, filtered through 0.45 µm filters and analyzed for nitrate + nitrite (NO₃⁻ + NO₂⁻) and total Kjeldahl N (TKN) according to standard methods (U.S. EPA, 1983; APHA, 1989, 1992) using a Lachat QuikChem IV automated system. Surface N loading (I_N) was then calculated by multiplying the averaged monthly total N inflow concentrations by the monthly average water inflow rate. Local annual atmospheric deposition of total N (P_N) was estimated from seasonal values (December 2009-November 2009) obtained from the Delaware monitoring location OH17 (loc: 40.3555, -83.0661) maintained by the National Atmospheric Deposition Program/National Trends Network (NADP/NTN, 2007). Similar to surface loading, the N surface outflux (O_N) from the wetlands was calculated by multiplying the averaged monthly total N outflow concentrations by the monthly average water outflow rate. N seepage (S_N) was estimated as average inflow, middle, and outflow NO₃⁻-N concentrations multiplied by the water seepage rate,

as NO_3^- is the primary soluble form of nitrogen in groundwater seepage. N accumulation rates in the sediment ($\frac{\Delta N_s}{\Delta t}$) were from Anderson and Mitsch (2006).

2.5. Statistical analysis

Statistical analyses were performed using Minitab 15 for Windows. Nonparametric Mann-Whitney tests were used find significant differences ($\alpha=0.05$) in denitrification rates between the two wetlands and riverside; between inflow, center, and outflow in the wetlands; and between open water and transition zones for all three locations. Since the data are not normal, values are represented as medians followed by means in parentheses.

Chapter 3: Results and Discussion

3.1. Temporal denitrification patterns

Water level, soil temperature, nitrate concentration, and denitrification rate are shown in Figure 2 for the two experimental wetlands (Figure 2a) and the riverside (Figure 2b). The experimental wetlands experienced a similar pulsing hydrology that roughly mimicked the river hydrology. Water levels over the study period were 220.9 ± 0.002 m (elevation above MSL) for the planted wetland (W1), 221.0 ± 0.002 m for the naturally colonizing wetland (W2), and 220.7 ± 0.010 m for the Olentangy River. The Olentangy River experienced strong flood pulses in February, March, late April through early May, and again in June. Water level amplitudes were 48 and 57 cm for W1 and W2, respectively, over the study period. A significant flood event in February raised the water levels in the wetlands to 221.2 m, while a drawdown in mid-March lowered the water levels to 220.7 m. The pumping regime for the experimental wetlands generally follows the river hydroperiod; however, the wetland pumps were temporarily turned off during mid-March and mid-May for pump maintenance, causing a drawdown in the wetlands rather than a flood pulse during those months. Pumps were also turned off in mid-August for annual vegetation sampling, causing another drawdown during that time.

Soil temperatures were not significantly different among the three sites. The mean soil temperatures during the growing and non-growing seasons were 19.6 ± 3.1 and 6.4 ± 4.9 °C, respectively. Both wetland and river nitrate levels are highest in the winter and spring when

biological processes are slow. Nitrate-nitrogen peaked in February at 4.43 ± 0.55 and 4.19 ± 0.14 mg $\text{NO}_3\text{-N L}^{-1}$ for the wetland inflow and river, respectively, decreased in April to 2.34 ± 0.66 and 2.32 ± 0.68 mg $\text{NO}_3\text{-N L}^{-1}$, then peaked again in May (3.69 ± 0.29 and 3.59 ± 0.24 mg $\text{NO}_3\text{-N L}^{-1}$). The February peak coincided with the major flood event in both the river and wetlands; this flood may have caused N runoff from fall fertilizer applications on farms in the watershed. Likewise, the second peak may be due to runoff from spring fertilizer applications. During the rest of the year (July-January), NO_3^- concentrations were low ($0.45\text{-}0.97$ mg $\text{NO}_3\text{-N L}^{-1}$).

Seasonal median (mean) denitrification rates among all sites were 112 (278) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$ in spring, 135 (353) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$ in summer, 182 (258) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$ in autumn, and 77.9 (158) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$ in winter. Only autumn and winter differed significantly ($p=0.0277$), and when comparing seasons by the four sites or sites according to season, only the naturally colonizing wetland (W2) autumn rate (188 (293) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$) differed from W2 winter rate (80.2 (180) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$, $p=0.0404$). Peak median (mean) denitrification rates were found in the open water zones of the experimental wetlands in May (1020 (951) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$) and June (938 (1124) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$).

Seasonal patterns of denitrification rates (Figure 2) can be explained by higher soil temperatures in the summer and higher NO_3^- concentrations in the spring due to agricultural fertilizer application runoff. Higher temperatures increase microbial anaerobic respiration, while higher NO_3^- concentrations provide the necessary electron acceptor for denitrification. The open water zones in the wetlands showed a significant correlation between denitrification rates and temperature, and the only seasonal denitrification differences were found between autumn and winter in wetland 2. Significant correlations between temperature and denitrification were found previously for this site (Hernandez and Mitsch, 2007), but the literature remains inconsistent. For riparian wetland soils in Virginia, Pavel et al. (1996) found a positive relationship, which was

also found in constructed wetlands in North Carolina (Poe et al. 2003) and Estonia (Teiter and Mander, 2005). However, Hefting et al. (2003) did not find temperature effects in sites with lower denitrification rates in The Netherlands. Seasonal effects at our Ohio site were only found in this study in open water zones with higher denitrification rates as well.

While NO_3^- concentration alone did not have a significant relationship with denitrification rates, Figure 2 suggests there may be weak interactive effects between NO_3^- and temperature in the open water zones of the wetlands. Hernandez and Mitsch (2007) found the highest rates in late spring when the combination of NO_3^- input and temperature is the highest; White and Reddy (1999) also observed this pattern has also been observed in the Florida Everglades. For the transition sites, which are intermittently inundated, NO_3^- input concentrations may be less important than internal production of NO_3^- via nitrification. Available NO_3^- concentration has been described as a primary factor controlling denitrification in many studies: e.g. Mississippi diversion wetlands in Louisiana (Gardner and White, 2010); riparian mitigation wetlands along the Illinois River in Illinois (Peralta et al., 2010); coastal Louisiana wetlands (Dodla et al., 2008), created, restored, and natural reference wetlands in North Carolina (Bruland et al., 2006); constructed wetlands receiving agricultural runoff in North Carolina (Poe et al., 2003); and natural riparian wetlands in Mont St. Michel Bay, France (Clément et al., 2002).

3.2. Spatial denitrification patterns

Soil organic carbon (TOC) is variably distributed and ranges from $2.09 \pm 0.32\%$ in the center of W1 to $3.32 \pm 0.36\%$ in the riverside (Table 1). The pH of the open water sites (6.75 ± 0.04) is higher than the pH of the transition sites (5.92 ± 0.05) in the experimental wetlands. The open water sites of the two wetlands contain more P ($60.43 \pm 7.01 \text{ mg kg}^{-1}$, $n=36$) compared to

the transition sites ($12.15 \pm 1.93 \text{ mg kg}^{-1}$, $n=18$). There is also a higher concentration of soil NH_4^+ in the open water sites ($55.87 \pm 5.04 \text{ mg kg}^{-1}$) compared to the transition sites ($3.25 \pm 0.71 \text{ mg kg}^{-1}$), though there is little difference in the proportion of total N for the open water and transition ($0.26 \pm 0.02\%$ and $0.24 \pm 0.01\%$, respectively).

Median (mean) denitrification rates for the planted wetland (W1), naturally colonizing wetland (W2), riverside, and upland were 165 (286), 118 (310), 71.2 (49.2), and 46.6 (54.8) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$, respectively. W1 and W2 did not differ significantly from each other, but only W1 differed significantly from the riverside ($p=0.0412$). Both W1 and W2 had significantly higher rates than the upland site ($p=0.0029$ and 0.0089 , respectively), but the riverside did not differ from the upland.

In the experimental wetlands, median denitrification rates along the longitudinal gradient from inflow to outflow were 146 (310) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$ at the inflows, 151 (320) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$ at the centers, and 110 (261) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$ at the outflows. There were no significant differences found among these longitudinal locations.

Along the transverse gradient (Figure 3), denitrification rates were significantly higher in open water than in transition zones in W1 ($p<0.0001$) and W2 ($p<0.0001$). Water depths for the open water sites in the experimental wetlands were $19.87 \pm 8.62 \text{ cm}$, while water levels of the transition zones were near the soil surface ($1.72 \pm 0.23 \text{ cm}$). For W1, respective open water and transition denitrification rates were 316 (390) and 60.0 (56.3) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$, while respective rates for open water and transition zones in W2 were 253 (424) and 56.0 (140) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$.

Riverside open water depths averaged $22.08 \pm 13.02 \text{ cm}$. Transition zone water levels fluctuated more than in the wetlands, but also remained near the surface (1.41 ± 2.97). Riverside open water (51.9 (137) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$) and transition (81.3 (211) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$) rates did not differ significantly from each other nor from upland rates (46.6 (54.8) $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$).

Denitrification rates in the open water zones for both wetlands were higher than those for their transition zones, probably because the transition zones are not continually inundated, and therefore the soil condition may not be continually anoxic. Enzymes responsible for NO_3^- reduction are inhibited by oxygen (Wrage et al., 2001). This same pattern was found at the ORWRP by Hernandez and Mitsch (2007); similar deep water to shallow water reduction gradients were the most significant factor affecting denitrification in several other studies (Seo and DeLaune, 2010; Wigland et al., 2004; Clément et al., 2002; Johnston et al., 2001; Pavel et al., 1996; Koch et al., 1992). While our study sites consist of permanently flooded unvegetated open water zones and intermittently flooded vegetated (herbaceous macrophytes with some overhanging woody vegetation) transition zones, results from Hernandez and Mitsch (2007) suggest that highest denitrification rates are found in the permanently flooded emergent marsh zones. While vegetative community type has been shown not to affect rates (Clément et al., 2002; Song et al., 2011), the presence of vegetation could contribute more organic substrate and an aerobic rhizosphere, the former favorable for denitrification and the latter for nitrification (Reddy et al., 1989). Transpiration also draws down water in the soil, bringing NO_3^- into the anaerobic zones (Martin et al., 2003). However, the high concentrations of NH_4^+ in the open water soils relative to the transition zone soils could still contribute higher concentrations of NO_3^- in the open water through nitrification in the oxidized soil layer.

Our hypothesis that the riverside denitrification rates would be highest, due to organic carbon content, was not supported. Several studies illustrate the significance of organic C content and quality on denitrifier respiration (Bruland et al., 2006; Dodla et al., 2008; Sutton-Grier et al., 2009; Song et al., 2011). For the ORWRP open water zones, denitrification rates were limited by organic carbon and nitrate concentrations (Hernandez and Mitsch, 2007). When water NO_3^- concentrations are high, there is not enough electron availability to increase denitrification rates.

When NO_3^- concentrations are low, then NO_3^- concentrations limit denitrification. It remains unclear why the riverside open water site, with abundant carbon, adequate NO_3^- , and proper anaerobic soil conditions, would have low denitrification rates similar to upland zones. A possible explanation is the absence of vegetation, causing both a lack of aerobic pore spaces for nitrification and an absence of transpiration to pull NO_3^- into anaerobic zones. In addition, Sha et al. (2010) analyzed methane emission rates from these same sample sites over the same study period. They found methanogenesis to be significantly higher in the river site, correlating with organic C content. The river sediments are highly reduced, even though soil microbes would prefer NO_3^- if available. This suggests that either NO_3^- is not getting into the sediment water in the river site or terminal electron acceptors for methanogenesis are available in significantly higher concentrations than NO_3^- . Also, while the river NO_3^- concentration is the same as wetland inflow concentration, the riverside sampling site may be diluted by groundwater seepage, resulting in lower NO_3^- concentrations.

3.3. Nitrogen mass balance in the naturally colonized wetland

During the one year study period, the wetlands on average received 4360 cm of surface water and 107 cm of precipitation. The outflows included 2270 cm from surface outflows, 2150 cm due to groundwater seepage, and an additional 86 cm due to evapotranspiration.

For the naturally colonizing wetland (W2), N loading and surface water outflows were 135.4 and 58.1 g N m⁻² yr⁻¹, respectively (Figure 4). Thus, surface water N was reduced by 57% in the experimental wetlands. Annual losses of N from the wetlands through the denitrification process total 2.7 g N m⁻² yr⁻¹, accounting for only 2% of the inflow N and 3.5% of the difference between inflow and outflow. Calculated groundwater seepage of NO_3^- -N is 35.0 g N m⁻² yr⁻¹, and

wetland soil accumulation rates are estimated to be $16.4 \text{ g N m}^{-2} \text{ yr}^{-1}$ (Anderson and Mitsch, 2006). Additional N inputs from N fixation were not measured, yet at least $23.2 \text{ g N m}^{-2} \text{ yr}^{-1}$, or 17% of the inflow, remain unaccounted for.

N loss through denitrification was low in the experimental wetlands compared to a dairy wastewater wetland ($6.8 \text{ g N m}^{-2} \text{ yr}^{-1}$, Lowrance et al., 1995) and a boreal peat marsh ($11 \text{ g N m}^{-2} \text{ yr}^{-1}$) and fen ($24 \text{ g N m}^{-2} \text{ yr}^{-1}$; Wray and Bailey, 2007). The unaccounted for $23.2 \text{ g N m}^{-2} \text{ yr}^{-1}$ in W2 could be due to error in almost all of the estimated fluxes. The inflow fluxes are largest and could have been overestimated due to monthly averages of both water flow and TN concentration instead of daily or weekly estimates. The outflows could be underestimated if water level readings were missing during short flood pulses. However, groundwater N seepage could be overestimated. We did not directly measure groundwater NO_3^- concentrations, but instead assumed that NO_3^- would not be retained by the soil and would flow with the groundwater seepage in average concentrations.

Another potential route for NO_3^- is dissimilatory nitrate reduction to ammonium (DNRA). While ammonium (NH_4^+) concentrations are minimal and included in surface TKN in this study, NH_4^+ concentrations were not measured in the pore waters. However, Scott et al. (2008) found that the impact of DNRA is minor compared to denitrification in created wetlands in Texas. Any NH_4^+ created in the soil through DNRA could be oxidized by nitrite-nitrogen ($\text{NO}_2\text{-N}$), a denitrification intermediate, through anaerobic ammonium oxidation (anammox). This process also removes N from the system as N_2 gas, though its importance in wetland N budgets is unknown.

Furthermore, the acetylene inhibition method is known to underestimate denitrification rates (Knowles, 1990). The N_2O reductase enzyme may not be sufficiently blocked in low concentrations of NO_3^- , such as those found in the summer and fall during our study. Sulfide can

also interact with C_2H_2 to reduce the N_2O reductase inhibition. Sulfide is present in the riverside site, so this may also help explain the unexpectedly low denitrification rates in those locations. Over time, C_2H_2 may become less effective through repeated exposure, though we tried to reduce this problem by placing the tubes in different locations within the same sampling zone each month. Acetylene inhibition also inhibits nitrification, so the only denitrification rates measured are those using only surface NO_3^- concentrations as available electron acceptors. Nitrification in the oxidized surface layer and rhizospheres could produce much higher NO_3^- for denitrification in lower anaerobic zones, but these higher NO_3^- concentrations are inhibited by acetylene. This could also partially explain why denitrification rates in our vegetated transition zones are very low even when those zones are flooded. Finally, C_2H_2 may not have been evenly distributed in the soil, and C_2H_2 may not diffuse through wet soil fast enough to adequately inhibit N_2O reduction (Ryden et al., 1987). Our sampling time of 40 minutes may have been too short for both C_2H_2 to diffuse through the soil and N_2O to diffuse out of the soil.

3.4. Comparison of denitrification rates with other wetland types.

The variability in denitrification rates for different types of wetlands in the literature is high (Table 2). This is the third independent study of denitrification at the ORWRP. Rates between the three studies are consistent with each other, and they fall within the wide range found in other studies of natural and created wetlands. However, the maximum denitrification values for the ORWRP appear to be consistently lower than most other wetlands. This could be due to several environmental factors, including nitrate concentration and loading, soil chemical properties, and hydrology. The highest values (Teiter and Mander, 2005) are from treatment wetlands. The constructed wetlands in Illinois were receiving nitrate concentrations of 9-20 mg

$\text{L}^{-1} \text{NO}_3\text{-N}$ (Xue et al., 1999). The Olentangy River is more dilute, with our wetlands receiving only $<1\text{-}4 \text{ mg L}^{-1} \text{NO}_3\text{-N}$.

In a comparison of created, restored, and natural wetlands in North Carolina, Bruland et al. (2006) found that soil chemical properties were more homogenous in the created and restored sites. The variability in soil properties of the natural wetlands led to greater numbers of denitrification and NO_3^- hotspots. The created and restored sites had some hotspots, but significantly fewer than the natural sites. In this study, data were highly right skewed, with mean values frequently much higher than medians. While many of the denitrification rates were low, mean rates were skewed by a few very high outlying denitrification values. Perhaps if the soil properties in these wetlands were more heterogeneous, more of these hotspots would be encountered through sampling. Open water denitrification rates during the growing season (May-September) in this study ($435 (590 \pm 105 \mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1})$) were comparable to the open water denitrification rates during the same growing season of 2005 ($584 \pm 101 \mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$; Hernandez and Mitsch, 2007). Hydrology, temperature, soil C, and NO_3^- loading were similar for the two studies, suggesting that these wetlands have not increased in denitrification potential over the last 4-5 years.

Chapter 4: Conclusions

1. Denitrification rates varied seasonally, peaking in late spring in the experimental wetlands. Soil temperatures increase through spring and maximize in the summer, while inflow NO_3^- concentrations are high in winter and peak again in spring. This suggests a pattern of denitrification related to temperature, which increases microbial rates, and NO_3^- availability as an electron acceptor for respiration in the absence of oxygen.
2. Denitrification rates did not differ between the planted and naturally colonizing wetlands, but wetland rates were higher than riverside and upland rates.
3. Denitrification rates in the experimental wetlands did not differ among inflows, middle, and outflows. There are probably insufficient differences in temperature, carbon substrate, and nitrate availability along this gradient.
4. Denitrification rates were significantly higher in permanently flooded open water zones than in transition zones in the experimental wetlands. This may be due to periodic drying of the transition zone, providing oxygen for aerobic microbial respiration.
5. The nitrogen budget for the experimental wetlands suggest that much of the N “retained” by the wetlands may actually be lost to groundwater due to high groundwater seepage flows. The 17% of N loading unaccounted for could be due to imprecision of inflow and outflow fluxes.

6. Denitrification rates from three different studies at this site are consistent, with maximum denitrification rates generally similar to some natural wetlands yet lower than maximum rates at other constructed wetlands receiving high input of nitrogen.
7. Open water denitrification rates during the growing season of this study (2009) are nearly equivalent to those in 2004-2005, suggesting that these 15 year-old wetlands, relatively low in NO_3^- concentrations and soil organic C content, have not increased in denitrifying activity over the past 4-5 years.

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Appendix A:

Tables

Location		pH _{KCl}	N %	P mg kg ⁻¹	K mg kg ⁻¹
<u>Wetland 1</u>					
Open water	Inflow	6.84 ± 0.04 (6)	0.26 ± 0.04 (6)	97.28 ± 14.39 (6)	197.44 ± 23.07 (6)
	Center	6.82 ± 0.02 (6)	0.25 ± 0.05 (6)	59.71 ± 15.86 (6)	176.31 ± 17.46 (6)
	Outflow	6.82 ± 0.04 (6)	0.24 ± 0.04 (6)	25.88 ± 7.29 (6)	191.14 ± 17.62 (6)
Marsh edge	Inflow	6.20 ± 0.03 (3)	0.28 ± 0.00 (3)	27.01 ± 0.87 (3)	172.02 ± 8.41 (3)
	Center	5.85 ± 0.03 (3)	0.21 ± 0.01 (3)	7.09 ± 0.60 (3)	123.86 ± 3.58 (3)
	Outflow	6.05 ± 0.04 (3)	0.28 ± 0.00 (3)	10.24 ± 0.64 (3)	186.76 ± 6.33 (3)
<u>Wetland 2</u>					
Open water	Inflow	6.88 ± 0.07 (6)	0.27 ± 0.05 (6)	85.29 ± 19.69 (6)	183.38 ± 25.34 (6)
	Center	6.84 ± 0.03 (6)	0.26 ± 0.04 (6)	55.59 ± 17.09 (6)	165.70 ± 20.32 (6)
	Outflow	6.30 ± 0.15 (6)	0.29 ± 0.06 (6)	38.84 ± 11.89 (6)	195.62 ± 40.51 (6)
Marsh edge	Inflow	5.87 ± 0.03 (3)	0.20 ± 0.01 (3)	9.61 ± 0.30 (3)	149.53 ± 2.93 (3)
	Center	5.95 ± 0.05 (3)	0.27 ± 0.00 (3)	16.66 ± 0.75 (3)	203.94 ± 7.00 (3)
	Outflow	5.60 ± 0.06 (3)	0.18 ± 0.01 (3)	2.29 ± 0.09 (3)	116.36 ± 2.96 (3)
Wetland average		6.47 ± 0.06 (54)	0.25 ± 0.01 (54)	44.34 ± 5.64 (54)	176.00 ± 7.27 (54)
River edge		6.91 ± 0.05 (12)	0.20 ± 0.01 (12)	45.11 ± 0.93 (12)	66.30 ± 1.23 (12)
Upland		6.24 ± 0.20 (12)	0.23 ± 0.01 (12)	29.13 ± 5.94 (12)	129.01 ± 7.68 (12)
Location		C %	NO3-N mg kg ⁻¹	NH4-N mg kg ⁻¹	Ca mg kg ⁻¹
<u>Wetland 1</u>					
Open water	Inflow	2.46 ± 0.28 (6)	0.34 ± 0.22 (6)	67.42 ± 5.09 (6)	4816.83 ± 49.60 (6)
	Center	2.09 ± 0.23 (6)	0.00 ± 0.00 (6)	90.16 ± 6.95 (6)	3675.83 ± 532.02 (6)
	Outflow	2.33 ± 0.19 (6)	0.37 ± 0.21 (6)	14.54 ± 4.99 (6)	5159.67 ± 196.52 (6)
Marsh edge	Inflow	2.89 ± 0.06 (3)	1.34 ± 0.41 (3)	0.06 ± 0.03 (3)	2553.00 ± 8.50 (3)
	Center	2.30 ± 0.06 (3)	0.12 ± 0.03 (3)	0.08 ± 0.06 (3)	1564.33 ± 16.33 (3)
	Outflow	3.16 ± 0.06 (3)	0.02 ± 0.02 (3)	3.57 ± 0.27 (3)	2560.67 ± 82.48 (3)
<u>Wetland 2</u>					
Open water	Inflow	2.41 ± 0.24 (6)	0.88 ± 0.42 (6)	72.90 ± 3.22 (6)	4569.00 ± 202.53 (6)
	Center	2.21 ± 0.21 (6)	0.47 ± 0.21 (6)	69.02 ± 2.36 (6)	4255.00 ± 304.94 (6)
	Outflow	2.77 ± 0.38 (6)	0.31 ± 0.19 (6)	21.17 ± 3.79 (6)	3691.50 ± 727.97 (6)
Marsh edge	Inflow	2.35 ± 0.04 (3)	0.06 ± 0.04 (3)	5.07 ± 1.40 (3)	2185.33 ± 90.22 (3)
	Center	3.26 ± 0.19 (3)	0.00 ± 0.00 (3)	7.85 ± 0.68 (3)	2534.67 ± 19.70 (3)
	Outflow	2.28 ± 0.08 (3)	0.92 ± 0.39 (3)	2.84 ± 0.65 (3)	1821.33 ± 181.85 (3)
Wetland average		2.49 ± 0.08 (54)	0.41 ± 0.08 (54)	38.33 ± 4.78 (54)	3641.94 ± 186.43 (54)
River edge		3.32 ± 0.36 (12)	0.79 ± 0.23 (12)	1.79 ± 0.93 (12)	3379.58 ± 31.86 (12)
Upland		2.91 ± 0.16 (12)	4.87 ± 1.10 (12)	1.83 ± 0.60 (12)	2356.00 ± 278.68 (12)

Table 1. Soil chemical properties for the ORWRP sampling sites. Values represent means ± standard errors (number of samples).

Wetland type	Location	Denitrification rate (mg N m ⁻² h ⁻¹)	Reference
Natural swamp forest	Minnesota, USA	0.1-0.4	Zak and Grigal (1991)
Created wetlands receiving drainage tile	Illinois, USA	2.1-11.8	Xue et al. (1999)
Natural riparian wetlands in an agricultural watershed	Mont St. Michel Bay, France	6.4-10.9	Clement et al. (2002)
Created wetland in an agricultural watershed	North Carolina, USA	0.7-9.2	Poe et al. (2003)
Treatment wetland receiving municipal wastewater	Tartu, Estonia	0.3-17.0	Teiter and Mander (2005)
Boreal marshes	Alberta, Canada	2.1-4.2	Wray and Bailey (2007)
Boreal fens	Alberta, Canada	6.2-6.8	Wray and Bailey (2007)
Natural riparian habitats in an agricultural watershed	North Carolina, USA	0.2-4.4	Ensign (2008)
Created wetland	Texas, USA	0.8-3.9	Scott et al. (2008)
<u>ORWRP</u> -created riparian wetlands			
2004-2005	Ohio, USA	0.2-1.8	Hernandez and Mitsch (2007)
2008 (pulse)	Ohio, USA	0.1-0.5	Song et al. (2010)
2008-2009	Ohio, USA	0.1-2.5	This study

Table 2. Comparison of denitrification rates measured at various wetlands

Appendix B:

Figures

Figure 1. Wilma H. Schiermeier Olentangy River Wetland Research Park, Columbus, Ohio, USA showing locations of sample sites.

Figure 2. Daily water level, monthly soil temperature, inflow NO_3^- concentration, and denitrification rates for a) the two experimental wetland sites, and b) the riverside site. Bars represent standard errors.

Figure 3. Denitrification rates by site and transverse (deep water open vs. shallow vegetated) gradient. Horizontal lines are medians, diamonds are means, boxes are interquartile ranges, and vertical lines are data ranges within 1.5 box lengths (outliers not visible on graph). Different letters represent significant differences at $\alpha=0.05$.

Figure 4. Nitrogen mass balance for Olentangy River Wetland Research Park experimental wetland 2 (in $\text{g N m}^{-2} \text{y}^{-1}$) for 2008-2009 study period. Soil accumulation was estimated from 1994-2004 by Anderson and Mitsch (2006). $\frac{\Delta N_s}{\Delta t}$ = accumulation of nitrogen in wetland sediments; I_N = surface loading of total nitrogen = surface loading of total Kjeldahl nitrogen + $\text{NO}_3\text{-N}$ + $\text{NO}_2\text{-N}$; P_N = atmospheric deposition of N through precipitation; O_N = outflow of total nitrogen; DN = denitrification; S_N = groundwater seepage of $\text{NO}_3\text{-N}$.

Appendix C:

Raw data and denitrification calculations

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{h}^{-1}$
Nov-08	PW1CO	R1	T0	11/5/2008	351.253	15:47	25	0	401.999	132.027	66.013
		T1			401.615	15:57	25	10	459.637		
		T2			411.482	16:07	25	20	470.929		
		T3			409.289	16:17	23	30	471.583		
Nov-08	PW1CO	R2	T0	11/5/2008	345.786	15:49	27	0	393.105	481.749	240.875
		T1			497.184	15:59	27.5	10	564.282		
		T2			540.161	16:09	26	20	616.133		
		T3			562.233	16:19	25	30	643.460		
Nov-08	PW1CT	R1	T0	11/5/2008	332.671	14:49	25	0	380.732	29.839	14.920
		T1			339.227	14:59	26	10	386.938		
		T2			342.506	15:09	26	20	390.678		
		T3			330.485	15:19	26				
Nov-08	PW1CT	R2	T0	11/5/2008	342.506	14:51	28	0	388.084		
		T1			344.693	15:01	29	10	389.268		
		T2			332.671	15:11	29	20	375.692		
		T3			333.763	15:21	30	30	375.682		
Nov-08	PW2IO	R1	T0	11/6/2008	339.201	16:35	22	0	392.152	372.832	186.416
		T1			379.206	16:45	20	10	441.393		
		T2			460.359	16:55	18	20	539.535		
		T3			480.933	17:05	16.5	30	566.566		
Nov-08	PW2IO	R2	T0	11/6/2008	332.974	16:36	22	0	384.953	568.872	284.436
		T1			407.689	16:46	21	10	472.933		
		T2			483.808	16:56	19	20	565.077		
		T3			570.934	17:06	17.5	30	670.279		
Nov-08	PW2IT	R1	T0	11/6/2008	311.769	16:46	19	0	364.139	93.738	46.869
		T1			328.914	16:56	16	10	388.149		
		T2			319.770	17:06	15	20	378.668		
		T3			352.917	17:16	14	30	419.376		
Nov-08	PW2IT	R2	T0	11/6/2008	295.223	16:47	18.5	0	345.405	59.586	29.793
		T1			289.987	16:57	18	10	339.861		
		T2			295.223	17:07	16	20	348.391		
		T3			317.234	17:17	15	30	375.665		

Table 3. Raw data and denitrification calculations

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Nov-08	PW2CO	R1	T0	11/6/2008	323.199	16:39	23	0	372.390	96.783	48.391
		T1			347.202	16:49	22	10	401.402		
		T2			339.201	16:59	20	20	394.827		
		T3			365.490	17:09	18	30	428.350		
Nov-08	PW2CO	R2	T0	11/6/2008	357.489	16:40	22	0	413.295	683.123	341.562
		T1			466.074	16:50	22	10	538.830		
		T2			556.371	17:00	20	20	647.611		
		T3			645.525	17:10	18	30	756.547		
Nov-08	PW2CT	R1	T0	11/6/2008	350.631	16:50	14	0	416.659		
		T1			344.916	17:00	15	10	408.446		
		T2			416.925	17:10	14	20	495.437		
		T3			333.486	17:20	15.5	30	394.226		
Nov-08	PW2CT	R2	T0	11/6/2008	343.773	16:51	14.5	0	407.800		
		T1			324.342	17:01	16	10	382.754		
		T2			364.347	17:11	15	20	431.456		
		T3			340.344	17:21	14	30	404.435		
Nov-08	PW2OO	R1	T0	11/6/2008	303.605	9:49	17	0	357.047	229.981	114.990
		T1			327.726	9:59	17	10	385.414		
		T2			377.130	10:09	16	20	445.049		
		T3			393.983	10:19	16	30	464.937		
Nov-08	PW2OO	R2	T0	11/6/2008	297.318	9:50	16	0	350.864	375.971	187.986
		T1			328.775	10:00	16	10	387.986		
		T2			384.501	10:10	16	20	453.747		
		T3			454.164	10:20	15	30	537.816		
Nov-08	PW2OT	R1	T0	11/6/2008	309.894	10:53	17.5	0	363.816		
		T1			326.676	11:03	16.5	10	384.843		
		T2			318.283	11:13	16.5	20	374.955		
		T3			316.185	11:22	16	30	373.128		
Nov-08	PW2OT	R2	T0	11/6/2008	327.726	10:55	15			155.101	77.550
		T1			310.942	11:05	15	10	368.214		
		T2			318.283	11:15	15	20	376.907		
		T3			353.986	11:25	14.5	30	419.915		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{h}^{-1}$
Nov-08	PWOU	R1	T0	11/5/2008	354.534	10:57	16.5	0	417.661		
		T1			315.196	11:07	16.5	10	371.318		
		T2			298.826	11:17	16	20	352.643		
		T3			329.393	11:27	15	30	390.064		
Nov-08	PWOU	R2	T0	11/5/2008	335.949	10:59	16			156.742	78.371
		T1			319.563	11:09	16.5	10	376.463		
		T2			326.116	11:19	16	20	384.847		
		T3			363.285	11:29	16	30	428.711		
Nov-08	PRIO	R1	T0	11/4/2008	310.829	15:37	22	0	359.351		
		T1			287.920	15:47	21.5	10	333.430		
		T2			291.191	15:57	21	20	337.791		
		T3			274.839	16:07	20.5	30	319.366		
Nov-08	PRIO	R2	T0	11/4/2008	295.553	15:39	20	0	344.022		
		T1			313.012	15:49	21	10	363.105		
		T2			296.644	15:59	21	20	344.117		
		T3			301.008	16:09	20	30	350.371		
Nov-08	PRIT	R1	T0	11/4/2008	293.372	15:41	18.5	0	343.239	170.856	85.428
		T1			340.320	15:51	19.5	10	396.807		
		T2			310.829	16:01	19.5	20	362.421		
		T3			386.275	16:11	20	30	449.621		
Nov-08	PRIT	R2	T0	11/4/2008	321.747	15:43	23.5			100.010	50.005
		T1			304.281	15:53	23.5	10	350.002		
		T2			313.012	16:03	22	20	361.875		
		T3			331.578	16:13	22	30	383.339		
Dec-08	PW2IO	R1	T0	12/5/2008	292.082	15:26	0	0	364.874		
		T1			281.613	15:36	1	10	350.513		
		T2			282.660	15:46	0	20	353.104		
		T3			286.846	15:56	0	30	358.334		
Dec-08	PW2IO	R2	T0	12/5/2008	297.318	15:28	0	0	371.416		
		T1			0.000	15:38	1		0.000		
		T2			298.366	15:48	0	20	372.724		
		T3			303.605	15:58	0	30	379.269		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Dec-08	PW2IT	R1	T0	12/5/2008	297.318	15:31	-2.5			57.481	28.741
			T1		278.474	15:41	-2.5	10	351.088		
			T2		286.846	15:51	-3	20	362.313		
			T3	12/5/2008	293.129	16:01	-3	30	370.248	33.958	16.979
		R2	T0		309.894	15:33	-2.5	0	390.701		
			T1		314.088	15:43	-2.5	10	395.989		
			T2	12/5/2008	318.283	15:53	-3	20	402.020	54.049	27.024
			T3		255.472	16:03	-3				
		R1	T0		339.201	16:03	-2.5	0	427.650		
			T1	12/5/2008	354.060	16:13	-3	10	447.210	1320.657	
			T2		359.775	16:23	-3	20	454.429		
			T3		359.775	16:33	-3.5	30	455.271		
		R2	T0	12/5/2008	1045.575	16:05	-3	0	1320.657	1051.623	
			T1		834.120	16:15	-2.5	10	1051.623		
			T2		867.267	16:25	-2.5	20	1093.414		
			T3	12/5/2008	557.514	16:35	-2.5	30	702.890	421.769	
		R1	T0		335.772	16:08	-1.5	0	421.769		
			T1		336.915	16:18	-1	10	422.427		
			T2	12/5/2008	348.345	16:28	-1.5	20	437.562	426.862	
			T3		339.201	16:38	-2	30	426.862		
		R2	T0		733.536	16:10	-2	0	923.106		
			T1	12/5/2008	606.663	16:20	-1.5	10	762.040	695.996	
			T2		554.085	16:30	-1.5	20	695.996		
			T3		552.942	16:40	-2	30	695.841		
		R1	T0	12/5/2008	315.136	14:22	1	0	395.848	29.451	14.725
			T1		314.088	14:32	1.5	10	393.806		
			T2		328.775	14:42	1.5	20	412.980		
			T3	12/5/2008	322.479	14:52	1.5	30	405.818	389.981	
		R2	T0		309.894	14:24	0	0	389.981		
			T1		303.605	14:34	1	10	381.363		
			T2	12/5/2008	314.088	14:44	1.5	20	394.531	389.981	
			T3		309.894	14:54	1.5	30	389.981		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Dec-08	PW2OT	R1	T0	12/5/2008	322.479	14:27	1	0	401.378		
			T1		308.845	14:37	2	10	383.011		
			T2		305.701	14:47	2.5	20	378.424		
			T3		281.613	14:57	0	30	351.796		
Dec-08	PW2OT	R2	T0	12/5/2008	304.653	14:29	1	0	379.190	44.686	22.343
			T1		307.797	14:39	2.5	10	381.019		
			T2		319.332	14:49	3	20	394.582		
			T3		320.381	14:59	0.5	30	399.495		
Dec-08	PWOU	R1	T0	12/5/2008	314.104	13:38	-5	0	399.701		
			T1		284.649	13:48	-3.5	10	360.204		
			T2		292.281	13:58	-4	20	370.550		
			T3		325.024	14:08	-4	30	412.060		
Dec-08	PWOU	R2	T0	12/5/2008	297.735	13:30	-5	0	378.871		
			T1		290.100	13:40	-3	10	366.423		
			T2		291.191	13:50	-4	20	369.167		
			T3		325.024	14:00	-4	30	412.060		
Dec-08	PRIO	R1	T0	12/1/2008	308.646	13:39	4	0	380.002		
			T1		268.302	13:49	3.5	10	330.928		
			T2		262.856	13:59	3.5	20	324.210		
			T3		291.191	14:09	3	30	359.809		
Dec-08	PRIO	R2	T0	12/1/2008	287.920	13:41	4	0	354.484		
			T1		286.829	13:51	3.5	10	353.779		
			T2		275.929	14:01	3.5	20	340.335		
			T3		261.767	14:11	3	30	323.452		
Dec-08	PRIT	R1	T0	12/1/2008	280.288	13:35	5	0	345.088	86.361	43.181
			T1		311.921	13:45	5	10	384.728		
			T2		314.104	13:55	4.5	20	387.420		
			T3		317.379	14:05	5	30	392.169		
Dec-08	PRIT	R2	T0	12/1/2008	296.644	13:37	5	0	363.912		
			T1		340.320	13:47	4.5	10	418.244		
			T2		313.012	13:57	4.5	20	384.683		
			T3		306.464	14:07	4.5	30	376.635		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{h}^{-1}$
Jan-09	PW1CO	R1	T0	1/14/2009	363.285	13:47	-2	0	457.170		
			T1		353.440	13:57	-2	10	444.781		
			T2		295.553	14:07	-2	20	371.934		
			T3		322.839	14:17	-2	30	406.272		
Jan-09	PW1CO	R2	T0	1/14/2009	304.281	13:49	-5	0	387.201	155.070	77.535
			T1		332.671	13:59	-6	10	424.912		
			T2		353.440	14:09	-5	20	449.757		
			T3		365.474	14:19	-5	30	465.070		
Jan-09	PW1CT	R1	T0	1/14/2009	355.628	14:03	-3	0	449.190	303.359	151.679
			T1		373.135	14:13	-3	10	471.304		
			T2		414.772	14:23	-3	20	523.895		
			T3		475.177	14:33	-3	30	600.192		
Jan-09	PW1CT	R2	T0	1/14/2009	364.380	14:05	-4	0	461.955		
			T1		343.599	14:15	-5	10	437.235		
			T2		332.671	14:25	-5	20	423.327		
			T3		355.628	14:35	-5	30	452.541		
Jan-09	PW2IO	R1	T0	1/15/2009	304.653	14:07	-8	0	392.061		
			T1		295.223	14:17	-8	10	379.926		
			T2		296.271	14:27	-8	20	381.274		
			T3		294.176	14:37	-8	30	378.578		
Jan-09	PW2IO	R2	T0	1/15/2009	301.509	14:09	-8	0	388.015		
			T1		293.129	14:19	-9	10	378.658		
			T2		292.082	14:29	-10	20	378.739		
			T3		337.174	14:39	-10	30	437.211		
Jan-09	PW2IT	R1	T0	1/15/2009	234.589	14:02	-5	0	298.518	1026.932	513.466
			T1		347.679	14:12	-8	10	447.432		
			T2		475.333	14:22	-9	20	614.027		
			T3		628.561	14:32	-9.5	30	813.504		
Jan-09	PW2IT	R2	T0	1/15/2009	330.875	14:04	-4	0	419.478		
			T1		353.986	14:14	-9.5	10	458.139		
			T2		324.578	14:24	-10	20	420.877		
			T3		330.875	14:34	-10	30	429.042		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Jan-09	PW2CO	R1	T0	1/15/2009	984.996	13:21	-10	0	1277.235		
			T1		466.074	13:31	-7	10	597.542		
			T2		429.498	13:41	-10	20	556.926		
			T3		462.645	13:51	-10	30	599.907		
Jan-09	PW2CO	R2	T0	1/15/2009	318.627	13:23	-10	0	413.161	71.142	35.571
			T1		332.343	13:33	-10	10	430.946		
			T2		338.058	13:43	-10	20	438.357		
			T3		347.202	13:53	-10	30	450.214		
Jan-09	PW2CT	R1	T0	1/15/2009	581.517	13:16	-10	0	754.048	2347.893	1173.947
			T1		1188.450	13:26	-9	10	1535.218		
			T2		1415.907	13:36	-9	20	1829.043		
			T3		1511.919	13:46	-10	30	1960.491		
Jan-09	PW2CT	R2	T0	1/15/2009	514.080	13:18	-10	0	666.603	302.207	151.104
			T1		547.227	13:28	-11	10	712.291		
			T2		589.518	13:38	-11	20	767.338		
			T3		543.798	13:48	-11				
Jan-09	PW2OO	R1	T0	1/15/2009	317.234	14:45	-8	0	408.252	84.500	42.250
			T1		326.676	14:55	-11	10	425.214		
			T2		328.775	15:05	-11	20	427.946		
			T3		347.679	15:15	-12	30	454.285		
Jan-09	PW2OO	R2	T0	1/15/2009	341.376	14:47	-9	0	440.983	65.136	32.568
			T1		335.074	14:57	-11	10	436.145		
			T2		340.325	15:07	-11	20	442.980		
			T3		363.450	15:17	-12	30	474.891		
Jan-09	PW2OT	R1	T0		339.275	14:40	-7	0	434.976	37.707	18.854
			T1		345.578	14:50	-8	10	444.728		
			T2		352.934	15:00	-9	20	455.914		
			T3		348.730	15:10	-10	30	452.195		
Jan-09	PW2OT	R2	T0		334.024	14:42	-8	0	429.859	143.275	71.637
			T1		369.762	14:52	-10	10	479.467		
			T2		380.288	15:02	-10.5	20	494.055		
			T3		387.661	15:12	-11	30	504.594		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Jan-09	PRIO	R1	T0	1/12/2010	321.747	14:21	1.5	0	399.737	22.409	11.205
		T1			328.301	14:30	1	9	408.623		
		T2			330.485	14:41	0.5	20	412.094		
		T3			330.485	14:51	1	30	411.343		
Jan-09	PRIO	R2	T0	1/12/2010	335.949	14:23	1	0	418.143		
		T1			353.440	14:33	0	10	441.524		
		T2			344.693	14:43	0	20	430.597		
		T3			343.599	14:53	1	30	427.665		
Jan-09	PRIT	R1	T0	1/12/2010	342.506	14:25	1	0	426.305		
		T1			307.555	14:35	1	10	382.802		
		T2			294.463	14:45	1	20	366.507		
		T3			314.104	14:55	1	30	390.953		
Jan-09	PRIT	R2	T0	1/12/2010	353.440	14:27	1	0	439.914		
		T1			271.570	14:37	1	10	338.014		
		T2			277.019	14:47	1	20	344.795		
		T3			322.839	14:57	0.5	30	402.560		
Feb-09	PW1CO	R1	T0	2/13/2009	377.514	13:21	10.5	0	454.141	483.871	241.935
		T1			436.718	13:31	11	10	524.437		
		T2			508.196	13:41	12	20	608.132		
		T3			578.802	13:51	11	30	695.059		
Feb-09	PW1CO	R2	T0	2/13/2009	356.721	13:22	12	0	426.870	575.794	287.897
		T1			422.451	13:32	15	10	500.262		
		T2			504.892	13:42	15	20	597.888		
		T3			603.125	13:52	15	30	714.214		
Feb-09	PW1CT	R1	T0	2/13/2009	343.599	13:15	20	0	399.947	44.409	22.205
		T1			342.506	13:25	16	10	404.190		
		T2			353.440	13:35	15	20	418.540		
		T3			354.534	13:45	15	30	419.835		
Feb-09	PW1CT	R2	T0	2/13/2009	367.663	13:26	12.5	0	439.193		
		T1			342.506	13:36	11.5	10	410.579		
		T2			349.066	13:46	11	20	419.179		
		T3			345.786	13:56	11	30	415.240		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Feb-09	PW2IO	R1	T0	2/14/2009	311.991	12:12	4.5	0	383.428	534.666	267.333
		T1			442.533	12:22	4	10	544.842		
		T2			445.704	12:32	4	20	548.746		
		T3			549.641	12:42	3	30	679.163		
Feb-09	PW2IO	R2	T0	2/14/2009	316.185	12:13	4.5	0	388.583	156.521	78.261
		T1			362.398	12:23	4	10	446.180		
		T2			363.450	12:33	4	20	447.475		
		T3			384.501	12:43	3	30	475.108		
Feb-09	PW2IT	R1	T0	2/14/2009	385.554	12:08	4	0	474.690	347.174	173.587
		T1			471.097	12:18	4	10	580.010		
		T2			495.469	12:28	3	20	612.225		
		T3			531.564	12:38	3	30	656.826		
Feb-09	PW2IT	R2	T0	2/14/2009	347.679	12:10	4	0	428.059	299.546	149.773
		T1			410.853	12:20	4.5	10	504.927		
		T2			442.533	12:30	5	20	542.883		
		T3			474.274	12:40	5	30	581.822		
Feb-09	PW2CO	R1	T0	2/14/2009	355.203	12:18	1	0	442.108	740.099	370.049
		T1			419.211	12:26	1	8	521.776		
		T2			514.080	12:36	1	18	639.856		
		T3			632.952	12:46	1	28	787.811		
Feb-09	PW2CO	R2	T0	2/14/2009	391.779	12:18	1	0	487.633	722.137	361.068
		T1			448.929	12:28	1	10	558.765		
		T2			541.512	12:38	1	20	674.000		
		T3			683.244	12:48	1	30	850.408		
Feb-09	PW2CT	R1	T0	2/14/2009	380.349	12:21	4	0	468.282	85.279	42.640
		T1			376.920	12:31	4	10	464.060		
		T2			413.496	12:41	4	20	509.092		
		T3			406.638	12:51	4	30	500.648		
Feb-09	PW2CT	R2	T0	2/14/2009	357.489	12:23	4	0	440.137	164.099	82.050
		T1			384.921	12:33	4	10	473.911		
		T2			413.496	12:43	4.5	20	508.175		
		T3			423.783	12:53	5	30	519.881		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{h}^{-1}$	
Feb-09	PW200	R1	T0	2/14/2009	328.775	12:38	4	0	404.785	171.065	85.532
			T1		371.867	12:48	3.5	10	458.666			
			T2		364.502	12:58	3.5	20	449.582			
			T3		407.689	13:08	3.5	30	502.849			
Feb-09	PW200	R2	T0	2/14/2009	331.925	12:40	4	0	408.662	930.954	465.477
			T1		439.362	12:50	3	10	542.897			
			T2		544.322	13:00	3	20	672.591			
			T3		714.303	13:10	3	30	882.627			
Feb-09	PW20T	R1	T0	2/14/2009	367.658	12:33	4	0	452.656	188.342	94.171
			T1		404.525	12:43	4	10	498.046			
			T2		430.910	12:53	3.5	20	531.490			
			T3		443.590	13:03	4	30	546.143			
Feb-09	PW20T	R2	T0	2/14/2009	344.527	12:35	3	0	425.714
			T1		348.730	12:45	3	10	430.908			
			T2		336.124	12:55	2	20	416.841			
			T3		344.527	13:05	2	30	427.262	119.567	59.784	
Feb-09	PWOU	R1	T0	2/13/2009	358.909	13:40	16	0	423.547
			T1		340.320	13:50	14	10	404.407			
			T2		398.327	14:00	12.5	20	475.823			
			T3		389.561	14:10	12	30	466.168	232.526	116.263	
Feb-09	PWOU	R2	T0	2/13/2009	367.663	13:42	12	0	439.963
			T1		372.041	13:52	12	10	445.202			
			T2		414.772	14:02	11	20	498.083			
			T3		460.885	14:12	12	30	551.517	96.702	48.351	
Feb-09	PRIO	R1	T0	2/12/2009	343.599	11:29	12	0	411.168
			T1		349.066	11:39	14	10	414.800			
			T2		373.135	11:49	14	20	443.401			
			T3		340.320	11:59	14					
Feb-09	PRIO	R2	T0	2/12/2009	367.663	11:38	15	0	435.382
			T1		349.066	11:47	14	9	414.800			
			T2		358.909	11:58	14	20	426.497			
			T3		347.973	12:08	14.5	30	412.782			

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{h}^{-1}$
Mar-09	PW1CO	R1	T0	3/11/2009	396.135	13:39	9	0	479.075	1329.056	664.528
		T1			536.852	13:49	10	10	646.961		
		T2			758.533	13:59	10	20	914.109		
Mar-09	PW1CO	R2	T0	3/11/2009	936.345	14:09	10	30	1128.390	2243.636	1121.818
		T1			424.645	13:41	8	0	515.380		
		T2			656.286	13:51	8	10	796.516		
Mar-09	PW1CT	R1	T0	3/11/2009	917.267	14:01	8	20	1113.262	37.710	18.855
		T1			1364.670	14:11	8	30	1656.263		
		T2			335.949	13:34	10.5	0	404.138		
Mar-09	PW1CT	R2	T0	3/11/2009	346.879	13:44	12	10	415.092	45.387	22.694
		T1			347.973	13:54	13.5	20	414.222		
		T2			356.721	14:04	13	30	425.378		
Mar-09	PW2IO	R1	T0	3/12/2009	335.949	13:36	13.5	0	399.909	211.800	105.900
		T1			340.320	13:46	12	10	407.243		
		T2			345.786	13:56	12	20	413.784		
Mar-09	PW2IO	R2	T0	3/12/2009	353.440	14:06	12	30	422.944	223.648	111.824
		T1			337.174	10:18	2	0	418.143		
		T2			376.077	10:28	3	10	464.699		
Mar-09	PW2IT	R1	T0	3/12/2009	387.661	10:38	2	20	480.753	11.720	5.860
		T1			427.741	10:48	2	30	530.458		
		T2			324.578	10:20	3	0	401.064		
Mar-09	PW2IT	R2	T0	3/12/2009	368.710	10:30	3	10	455.596	66.246	33.123
		T1			392.929	10:40	2	20	487.286		
		T2			415.074	10:50	2	30	514.749		
Mar-09	PW2IT	R1	T0	3/12/2009	339.275	10:13	1.5	0	421.514		
		T1			345.578	10:23	1	10	430.128		
		T2			348.730	10:33	0.5	20	434.844		
Mar-09	PW2IT	R2	T0	3/12/2009	341.376	10:43	0	30	426.453		
		T1			315.136	10:15	3	0	389.398		
		T2			320.381	10:25	1.5	10	398.040		
Mar-09	PW2IT	R1	T0	3/12/2009	323.528	10:35	1.5	20	401.950		
		T1			341.376	10:45	1	30	424.897		
		T2									

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{h}^{-1}$
Mar-09	PW2CO	R1	T0	3/12/2009	388.350	10:29	1	0	483.365	460.288	230.144
		T1			466.074	10:39	0	10	582.228		
		T2			540.369	10:49	0	20	675.039		
		T3			568.944	10:59	1	30	708.143		
Mar-09	PW2CO	R2	T0	3/12/2009	362.061	10:30	0	0	452.293	233.026	116.513
		T1			383.778	10:40	0	10	479.423		
		T2			430.641	10:50	0	20	537.965		
		T3			450.072	11:00	0	30	562.238		
Mar-09	PW2CT	R1	T0	3/12/2009	362.061	10:24	4	0	445.766	186.271	93.135
		T1			378.063	10:34	3	10	467.153		
		T2			435.213	10:44	2	20	539.724		
		T3			424.926	10:54	3	30	525.059		
Mar-09	PW2CT	R2	T0	3/12/2009	367.776	10:36	3	0	454.442		
		T1			362.061	10:46	2	10	449.006		
		T2			410.067	10:56	2	20	508.540		
		T3			388.350	11:06	2	30	481.608		
Mar-09	PW2OO	R1	T0	3/12/2009	345.578	11:40	-1	0	433.289	297.499	148.750
		T1			373.972	11:50	-1	10	468.889		
		T2			405.579	12:00	-1	20	508.519		
		T3			466.862	12:10	-1	30	585.356		
Mar-09	PW2OO	R2	T0	3/12/2009	325.627	11:42	2	0	403.823	307.327	153.663
		T1			384.501	11:52	2	10	476.834		
		T2			408.743	12:02	2	20	506.898		
		T3			455.222	12:12	2	30	564.538		
Mar-09	PW2OT	R1	T0	3/12/2009	305.701	11:35	4	0	376.376	100.553	50.277
		T1			324.578	11:45	2	10	402.521		
		T2			349.781	11:55	2	20	433.777		
		T3			341.376	12:05	3	30	421.820		
Mar-09	PW2OT	R2	T0	3/12/2009	311.991	11:37	2.5	0	386.210	81.050	40.525
		T1			303.605	11:47	1	10	377.885		
		T2			337.174	11:57	0.5	20	420.435		
		T3			335.074	12:07	1	30	417.054		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Mar-09	PWOU	R1	T0	3/9/2010	356.721	12:40	10	0	429.885		
			T1		345.786	12:50	8	10	419.671		
			T2		370.946	13:00	8	20	450.207		
			T3		341.413	13:10	9	30	412.895		
Mar-09	PWOU	R2	T0		355.628	12:42	9	0	430.086		
			T1		350.159	12:52	8	10	424.979		
			T2		355.628	13:02	8	20	431.616		
			T3		353.440	13:12	9	30	427.441		
Mar-09	PRIO	R1	T0	3/9/2010	438.914	13:40	9	0	530.810		
			T1		404.904	13:50	8	10	491.420		
			T2		353.440	14:00	9	20	427.441		
			T3		362.191	14:10	9	30	438.024		
Mar-09	PRIO	R2	T0	3/9/2010	373.135	13:41	11	0	448.083	114.664	57.332
			T1		396.135	13:51	12.5	10	473.205		
			T2		408.193	14:01	11.5	20	489.321		
			T3		422.451	14:11	11.5	30	506.413		
Mar-09	PRIT	R1	T0	3/9/2010	357.815	13:43	12	0	428.179	142.363	71.182
			T1		349.066	13:53	11	10	419.179		
			T2		388.466	14:03	11	20	466.493		
			T3		409.289	14:13	11	30	491.498		
Mar-09	PRIT	R2	T0	3/9/2010	374.230	13:44	12	0	447.821	744.252	372.126
			T1		568.859	13:54	11	10	683.120		
			T2		685.134	14:04	11	20	822.750		
			T3		678.474	14:14	11	30	814.751		
Apr-09	PW1CO	R1	T0	4/12/2009	355.628	14:07	21	0	412.540	1164.224	582.112
			T1		450.995	14:17	18	10	528.561		
			T2		615.296	14:28	18	21	721.119		
			T3		857.891	14:37	18	30	1005.438		
Apr-09	PW1CO	R2	T0	4/12/2009	350.159	14:09	18	0	410.383	267.857	133.928
			T1		388.466	14:19	15	10	460.017		
			T2		419.160	14:29	15	20	496.364		
			T3		461.984	14:39	15	30	547.076		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Apr-09	PW1CT	R1	T0	4/12/2009	353.440	14:12	21	0	410.003		
		T1			334.856	14:22	18	10	392.447		
		T2			362.191	14:32	17.5	20	425.214		
		T3			362.191	14:42	17.5	30	425.214		
Apr-09	PW1CT	R2	T0	4/12/2009	360.003	14:14	25	0	412.013		
		T1			343.599	14:24	21	10	398.587		
		T2			344.693	14:34	20	20	401.219		
		T3			360.003	14:44	19	30	420.475		
Apr-09	PW2IO	R1	T0	4/16/2009	329.825	13:25	21	0	382.609	119.162	59.581
		T1			341.376	13:35	21	10	396.008		
		T2			359.243	13:45	20	20	418.156		
		T3			379.235	13:55	20	30	441.427		
Apr-09	PW2IO	R2	T0	4/16/2009	359.243	13:27	23	0	413.920	480.705	240.352
		T1			380.288	13:37	23	10	438.168		
		T2			419.295	13:47	20	20	488.056		
		T3			568.803	13:57	19	30	664.349		
Apr-09	PW2IT	R1	T0	4/16/2009	332.974	13:30	21	0	386.262	42.627	21.314
		T1			352.934	13:40	22	10	408.029		
		T2			346.629	13:50	22	20	400.739		
		T3			356.088	14:00	21.5	30	412.374		
Apr-09	PW2IT	R2	T0	4/16/2009	355.037	13:32	18	0	416.099		
		T1			357.140	13:42	19	10	417.131		
		T2			358.191	13:53	20	20	416.932		
		T3			341.376	14:02	21	30	396.008		
Apr-09	PW2CO	R1	T0	4/16/2009	362.061	13:38	30	0	407.534	660.511	330.255
		T1			430.641	13:48	22	10	497.866		
		T2			524.367	13:58	22	20	606.223		
		T3			638.667	14:08	22	30	738.366		
Apr-09	PW2CO	R2	T0	4/16/2009	523.224	13:39	30	0	588.938	529.336	264.668
		T1			960.993	13:49	23				
		T2			656.955	13:59	23	20	756.944		
		T3			742.680	14:09	23	30	855.716		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$	
Apr-09	PW2CT	R1	T0	4/16/2009	350.631	13:42	22	0	405.366	115.937	57.968
		T1			357.489	13:52	20	10	416.114			
		T2			365.490	14:02	20	20	425.427			
		T3			400.923	14:12	20	30	466.671			
Apr-09	PW2CT	R2	T0	4/16/2009	359.775	13:43	24	0	413.138	44.682	22.341
		T1			363.204	13:53	22	10	419.902			
		T2			382.635	14:03	22	20	442.366			
		T3			372.348	14:13	22	30	430.473			
Apr-09	PW200	R1	T0	4/16/2009	352.934	14:23	21	0	409.416	304.770	152.385
		T1			376.077	14:33	21	10	436.262			
		T2			449.933	14:43	21	20	521.938			
		T3			474.274	14:53	21	30	550.174			
Apr-09	PW200	R2	T0	4/16/2009	335.074	14:25	22	0	387.381	681.195	340.598
		T1			466.862	14:35	20	10	543.424			
		T2			554.962	14:45	20	20	645.971			
		T3			628.561	14:55	20	30	731.640			
Apr-09	PW20T	R1	T0	4/16/2009	340.325	14:28	23.5	0	391.462
		T1			335.074	14:38	21	10	388.698			
		T2			327.726	14:48	20.5	20	380.821			
		T3			338.225	14:58	21	30	392.352			
Apr-09	PW20T	R2	T0	4/16/2009	346.629	14:30	23	0	399.386
		T1			340.325	14:40	22.5	10	392.786			
		T2			349.781	14:50	22	20	404.384			
		T3			0.000				0.000			
Apr-09	PWOU	R1	T0	4/12/2009	365.474	13:25	27	0	415.487
		T1			401.615	13:35	20	10	467.476			
		T2			350.159	13:45	21	20	406.197			
		T3			369.851	13:55	20	30	430.504			
Apr-09	PWOU	R2	T0	4/12/2009	351.253	13:26	27	0	399.320	160.026	80.013
		T1			361.097	13:36	19	10	421.753			
		T2			373.135	13:46	19	20	435.813			
		T3			412.579	13:56	18	30	483.537			

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$	
Apr-09	PRIO	R1	T0	4/9/2009	341.413	11:00	19	0	398.762
		T1			366.568	11:10	18	10	429.613			
		T2			355.628	11:20	18	20	416.791			
Apr-09	PRIO	T3		4/9/2009	357.815	11:30	18	30	419.355
		R2	T0		331.578	11:01	16	0	391.293	45.827	22.913	
		T1			345.786	11:11	17	10	406.653			
Apr-09	PRIT	T2		4/9/2009	356.721	11:21	18	20	418.073
		T3			352.347	11:31	18	30	412.946			
		R1	T0		339.227	11:03	15	0	401.709	27.621	13.811	
Apr-09	PRIT	T1		4/9/2009	338.134	11:13	16	10	399.030
		T2			347.973	11:23	17	20	409.225			
		T3			352.347	11:33	17.5	30	413.656			
Apr-09	PRIT	R2	T0	4/9/2009	355.628	11:04	14.6	0	421.716	13.801	6.901
		T1			361.097	11:14	18	10	423.201			
		T2			364.380	11:24	18.5	20	426.316			
May-09	PW1CO	T3		5/13/2009	347.973	11:34	19
		R1	T0		361.097	11:14	19	0	421.753	1490.892	745.446	
		T1			467.480	11:24	17	10	549.769			
May-09	PW1CO	T2		5/13/2009	766.332	11:34	17	20	901.227
		T3			963.306	11:44	17	30	1132.873	977.415	488.707	
		R2	T0		332.671	11:16	22	0	384.602			
May-09	PW1CT	T1		5/13/2009	423.548	11:26	20	10	493.006
		T2			578.802	11:36	20	20	673.720			
		T3			745.170	11:46	20	30	867.372			
May-09	PW1CT	R1	T0	5/13/2009	337.041	11:19	16.5	0	397.054	125.620	62.810
		T1			352.347	11:29	17	10	414.369			
		T2			365.474	11:39	17	20	429.807			
May-09	PW1CT	T3		5/13/2009	393.944	11:49	18	30	461.697
		R2	T0		335.949	11:21	18	0	393.728	172.297	86.149	
		T1			378.609	11:31	19	10	442.206			
		T2			386.275	11:41	19	20	451.160			
		T3			358.909	11:51	20					

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
May-09	PW2IO	R1	T0	5/15/2009	373.491	13:27	33.5	0	415.601		
		T1			460.359	13:37	26	10	525.106		
		T2			362.061	13:47	26	20	412.983		
May-09	PW2IO	T3		5/15/2009	359.775	13:57	26	30	410.376		
		R2	T0		373.972	13:27	33.5	0	416.136	433.175	216.587
		T1			392.929	13:37	26	10	448.193		
May-09	PW2IT	T2		5/15/2009	423.518	13:47	26	20	483.083		
		T3			565.608	13:57	26	30	645.159		
		R1	T0		319.770	13:31	30	0	355.823	2925.017	1462.508
May-09	PW2IT	T1		5/15/2009	408.924	13:41	30	10	466.437		
		T2			1166.733	13:51	30	20	1330.829		
		T3			348.345	14:01	29				
May-09	PW2IT	R2	T0	5/15/2009	371.867	13:28	33	0	414.470	251.264	125.632
		T1			429.853	13:38	24	10	493.611		
		T2			375.024	13:48	24	20	430.649		
May-09	PW2CO	T3		5/15/2009	500.772	13:58	24	30	575.048		
		R1	T0		378.063	14:22	32	0	422.757		
		T1			1011.285	14:32	28	10	1145.857		
May-09	PW2CO	T2		5/15/2009	366.633	14:42	28	20	415.421		
		T3			919.845	14:52	19	30	1074.357		
		R2	T0		368.919	14:23	31.5	0	413.209	2963.802	1481.901
May-09	PW2CO	T1		5/15/2009	583.803	14:33	28	10	661.490		
		T2			490.077	14:43	28	20	555.292		
		T3			1849.104	14:53	28	30	2095.165		
May-09	PW2CT	R1	T0	5/15/2009	314.055	14:25	33	0	350.035	226.037	113.018
		T1			335.772	14:35	28	10	380.453		
		T2			360.918	14:45	27	20	410.308		
May-09	PW2CT	T3		5/15/2009	408.924	14:55	26.5	30	465.659		
		R2	T0		332.343	14:26	33	0	370.418	178.964	89.482
		T1			351.774	14:36	29	10	397.266		
May-09	PW2CT	T2		5/15/2009	404.352	14:46	27.5	20	458.921		
		T3			395.208	14:56	27	30	449.290		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
May-09	PW200	R1	T0	5/15/2009	350.832	15:34	34	0	389.752	2975.262	1487.631
		T1			817.773	15:44	31	10	917.455		
		T2			1305.664	15:54	31	20	1464.817		
		T3			1658.108	16:04	31	30	1860.222		
May-09	PW200	R2	T0	5/15/2009	328.775	15:35	31	0	368.851	2571.323	1285.662
		T1			675.665	15:45	29	10	763.042		
		T2			1040.843	15:55	29	20	1175.445		
		T3			1469.819	16:05	29	30	1659.897		
May-09	PW20T	R1	T0	5/15/2009	316.185	15:38	28	0	358.260	232.490	116.245
		T1			325.627	15:48	29	10	367.737		
		T2			414.018	15:58	28.5	20	468.334		
		T3			399.253	16:08	27	30	453.889		
May-09	PW20T	R2	T0	5/15/2009	313.039	15:39	29	0	353.522	171.372	85.686
		T1			362.398	15:49	30	10	407.913		
		T2			362.398	15:59	29.5	20	408.587		
		T3			397.145	16:09	29	30	448.503		
May-09	PWOU	R1	T0	5/15/2009	340.320	15:04	33	0	379.309	29.103	14.552
		T1			334.856	15:14	33	10	373.219		
		T2			341.413	15:24	35	20	378.058		
		T3			354.534	15:34	34	30	393.865		
May-09	PWOU	R2	T0	5/15/2009	341.413	15:05	31	0	383.030		
		T1			339.227	15:15	32	10	379.330		
		T2			320.655	15:25	33	20	357.391		
		T3			335.949	15:35	32	30	375.664		
May-09	PRIO	R1	T0	5/19/2009	387.370	11:06	20.5	0	450.128		
		T1			330.485	11:16	20.5	10	384.027		
		T2			346.879	11:26	21	20	402.392		
		T3			372.041	11:36	21	30	431.580		
May-09	PRIO	R2	T0	5/19/2009	389.561	11:07	21	0	451.905		
		T1			407.096	11:17	21	10	472.246		
		T2			355.628	11:27	21	20	412.540		
		T3			362.191	11:37	21	30	420.154

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$	
May-09	PRIT	R1	T0	5/19/2009	381.894	11:09	23	0	440.019	154.268	77.134
		T1			381.894	11:19	21	10	443.010			
		T2			378.609	11:29	21	20	439.200			
		T3			454.291	11:39	21	30	526.993			
May-09	PRIT	R2	T0	5/19/2009	365.474	11:10	22	0	422.526	393.744	196.872
		T1			387.370	11:20	21	10	449.363			
		T2			477.377	11:30	21	20	553.774			
		T3			374.230	11:40	20.5					
Jun-09	PW1CO	R1	T0	6/11/2009	344.693	14:34	25	0	394.491	744.667	372.333
		T1			427.937	14:44	25	10	489.762			
		T2			577.697	14:54	25	20	661.157			
		T3			651.851	15:04	23	30	751.063			
Jun-09	PW1CO	R2	T0	6/11/2009	320.655	14:35	27	0	364.535	908.705	454.352
		T1			430.132	14:45	25	10	492.274			
		T2			551.194	14:55	24	20	632.949			
		T3			716.244	15:05	24	30	822.479			
Jun-09	PW1CT	R1	T0	6/11/2009	362.191	14:37	25	0	414.518
		T1			343.599	14:47	25	10	393.240			
		T2			382.989	14:57	25	20	438.320			
		T3			372.041	15:07	25	30	425.790			
Jun-09	PW1CT	R2	T0	6/11/2009	347.973	14:38	26	0	396.913
		T1			282.469	14:48	23	10	325.460			
		T2			280.288	14:58	23	20	322.948			
		T3			301.008	15:08	23	30	346.821			
Jun-09	PW2IO	R1	T0	6/12/2009	296.271	12:29	24	0	340.215	1056.468	528.234
		T1			404.525	12:39	21	10	469.263			
		T2			552.833	12:49	21	20	641.306			
		T3			749.800	12:59	21	30	869.794			
Jun-09	PW2IO	R2	T0	6/12/2009	327.726	12:30	26	0	373.819	4903.983	2451.991
		T1			753.030	12:40	25	10	861.822			
		T2			1537.248	12:50	25	20	1759.336			
		T3			2445.743	13:00	25	30	2799.083			

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Jun-09	PW2IT	R1	T0	6/12/2009	334.024	12:33	21	0	387.480		
		T1			313.039	12:43	21	10	363.136		
		T2			323.528	12:53	21	20	375.304		
Jun-09	PW2IT	T3		6/12/2009	328.775	13:03	21	30	381.391		
		R2	T0		281.613	12:34	21	0	326.681		
		T1			321.430	12:44	21	10	372.870		
Jun-09	PW2CO	T2		6/12/2009	310.942	12:54	21	20	360.704		
		T3			302.557	13:04	21	30	350.976		
		R1	T0		359.775	13:24	26	0	410.376	1932.156	966.078
Jun-09	PW2CO	T1		6/12/2009	623.808	13:34	25	10	713.930		
		T2			872.982	13:44	24	20	1002.465		
		T3			1212.453	13:54	25	30	1387.618		
Jun-09	PW2CO	R2	T0	6/12/2009	344.916	13:25	26	0	393.427	4308.179	2154.089
		T1			1019.286	13:35	24	10	1170.469		
		T2			2448.036	13:45	22	20	2830.185		
Jun-09	PW2CT	T3		6/12/2009	1945.116	13:55	24	30	2233.621		
		R1	T0		271.764	13:28	23	0	313.127		
		T1			-21.987	13:38	25	10	-25.163		
Jun-09	PW2CT	T2		6/12/2009	304.911	13:48	24	20	350.136		
		T3			183.753	13:58	24	30	211.008		
		R2	T0		341.487	13:29	25	0	390.822		
Jun-09	PW2CT	T1		6/12/2009	320.913	13:39	26	10	366.048		
		T2			330.057	13:49	25	20	377.741		
		T3			304.911	13:59	25	30	348.962		
Jun-09	PW2OO	R1	T0	6/12/2009	341.376	14:16	27.5	0	387.446	1821.814	910.907
		T1			634.977	14:26:30	26	10.5	724.284		
		T2			767.037	14:36	25.5	20	876.382		
Jun-09	PW2OO	T3		6/12/2009	1177.174	14:46	26	30	1342.738		
		R2	T0		332.974	14:17	25	0	381.080	2311.327	1155.664
		T1			798.325	14:27	26	10	910.605		
Jun-09	PW2OO	T2		6/12/2009	1016.766	14:37	25	20	1163.659		
		T3			1385.881	14:47	26	30	1580.799		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Jun-09	PW2OT	R1	T0	6/12/2009	331.925	14:20	27	0	377.347
		T1			331.925	14:30	27	10	377.347
		T2			378.183	14:40	26	20	431.372
		T3			335.074	14:50	27	30	380.928
Jun-09	PW2OT	R2	T0	6/12/2009	309.894	14:21	23.5	0	356.458
		T1			331.925	14:31	24	10	381.157
		T2			345.578	14:41	23.5	20	397.504
		T3			327.726	14:51	25	30	375.073
Jun-09	PWOU	R1	T0	6/11/2009	315.196	14:04	26	0	359.527	77.860	38.930
		T1			321.747	14:14	26.5	10	366.387		
		T2			354.534	14:24	27	20	403.050		
		T3			344.693	14:34	28	30	390.561		
Jun-09	PWOU	R2	T0	6/11/2009	349.066	14:06	24.5	0	400.167	57.457	28.729
		T1			362.191	14:16	23.5	10	416.614		
		T2			323.931	14:26	24				
		T3			375.325	14:36	24.5	30	430.270		
Jun-09	PRIO	R1	T0	6/9/2009	297.735	10:29	31	0	334.027	368.725	184.363
		T1			294.463	10:39	29	10	332.543		
		T2			334.856	10:49	28.5	20	378.786		
		T3			461.984	10:59	28	30	523.460		
Jun-09	PRIO	R2	T0	6/9/2009	369.851	10:30	29	0	417.681		
		T1			343.599	10:40	27	10	390.619		
		T2			325.024	10:50	26	20	370.737		
		T3			374.230	11:00	26	30	426.864		
Jun-09	PRIT	R1	T0	6/9/2009	354.534	10:32	28	0	401.712		
		T1			413.675	10:43	27	11	470.285		
		T2			369.851	10:52	26	20	421.869		
		T3			373.135	11:02	25	30	427.043		
Jun-09	PRIT	R2	T0	6/9/2009	345.786	10:33	28	0	391.800	280.846	140.423
		T1			402.711	10:44:30	27	10.5	457.820		
		T2			373.135	10:53	26	20	425.615		
		T3			488.379	11:03	26	30	557.067		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Jul-09	PW1CO	R1	T0	7/19/2009	351.253	13:55	29	0	396.677		
			T1		368.757	14:05	25	10	422.032		
			T2		366.568	14:15	25	20	419.527		
			T3		360.003	14:25	26	30	410.636		
Jul-09	PW1CO	R2	T0	7/19/2009	327.208	13:56	26.5	0	372.606	292.120	146.060
			T1		381.894	14:06	26	10	435.606		
			T2		386.275	14:16	26	20	440.603		
			T3		467.480	14:26	26	30	533.229		
Jul-09	PW1CT	R1	T0	7/19/2009	338.134	13:59	25	0	386.985		
			T1		339.227	14:09	25	10	388.236		
			T2		331.578	14:19	25	20	379.481		
			T3		328.301	14:29	25	30	375.731		
Jul-09	PW1CT	R2	T0	7/19/2009	337.041	14:00	23.5	0	387.685	120.078	60.039
			T1		347.973	14:10	24	10	399.585		
			T2		361.097	14:20	24.5	20	413.960		
			T3		392.848	14:30	25	30	449.603		
Jul-09	PW2IO	R1	T0	7/20/2009	716.452	13:06	30	0	806.435		
			T1		341.376	13:16	29	10	385.522		
			T2		430.910	13:26	27.5	20	489.063		
			T3		421.406	13:36	27	30	479.074		
Jul-09	PW2IO	R2	T0	7/20/2009	300.461	13:07	31	0	337.086	869.513	434.757
			T1		356.088	13:17	28	10	403.473		
			T2		501.833	13:27	27	20	570.507		
			T3		672.449	13:37	27	30	764.471		
Jul-09	PW2IT	R1	T0	7/20/2009	308.845	13:10	30	0	347.635	26.623	13.311
			T1		308.845	13:20	27.5	10	350.526		
			T2		345.578	13:30	28				
			T3		318.283	13:40	28	30	360.637		
Jul-09	PW2IT	R2	T0	7/20/2009	370.946	13:11	30	0	417.535		
			T1		349.066	13:21	27.5	10	396.174		
			T2		357.815	13:31	28	20	405.430		
			T3		364.380	13:41	28	30	412.868		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Jul-09	PW2CO	R1	T0	7/20/2009	376.920	13:22	29	0	425.663	217.350	108.675
		T1			423.783	13:32	28	10	480.176		
		T2			472.932	13:42	27	20	537.651		
		T3			463.788	13:52	27	30	527.255		
Jul-09	PW2CO	R2	T0	7/20/2009	258.048	13:23	30	0	290.458	101.559	50.780
		T1			269.478	13:33	29	10	304.327		
		T2			299.196	13:43	27	20	340.140		
		T3			294.624	13:53	27	30	334.942		
Jul-09	PW2CT	R1	T0	7/20/2009	359.775	13:18	27	0	409.009		
		T1			366.633	13:28	28	10	415.421		
		T2			283.194	13:38	26	20	323.024		
		T3			298.053	13:48	25	30	341.113		
Jul-09	PW2CT	R2	T0	7/20/2009	319.770	13:19	28	0	362.322	279.983	139.991
		T1			423.783	13:29	29	10	478.587		
		T2			444.357	13:39	27	20	505.165		
		T3			445.500	13:49	25.5	30	509.008		
Jul-09	PW2OO	R1	T0	7/20/2009	360.003	14:05	28	0	407.909	71.315	35.657
		T1			369.851	14:15	28	10	419.068		
		T2			0.000	14:25	29				
		T3			393.944	14:35	30	30	443.421		
Jul-09	PW2OO	R2	T0	7/20/2009	356.721	14:06	29	0	402.853	238.104	119.052
		T1			373.135	14:16	29	10	421.389		
		T2			433.425	14:26	30	20	487.861		
		T3			456.489	14:36	30.5	30	512.975		
Jul-09	PW2OT	R1	T0	7/20/2009	308.845	14:09	28	0	349.944		
		T1			296.271	14:19	28.5	10	335.139		
		T2			319.332	14:29	30	20	359.438		
		T3			308.845	14:39	30	30	347.635		
Jul-09	PW2OT	R2	T0	7/20/2009	358.909	14:10	28	0	406.669		
		T1			361.097	14:20	30	10	406.449		
		T2			350.159	14:30	31.5	20	392.197		
		T3			347.973	14:40	32	30	389.109		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Jul-09	PWOU	R1	T0	7/19/2009	347.973	14:18	25	0	398.245		
		T1			340.320	14:28	28	10	385.607		
		T2			316.287	14:38	26	20	360.772		
		T3			287.920	14:48	28	30	326.233		
Jul-09	PWOU	R2	T0	7/19/2009	253.057	14:09	26	0	288.648	95.702	47.851
		T1			229.121	14:19	28	10	259.610		
		T2			275.929	14:29	26	20	314.737		
		T3			283.559	14:39	26	30	323.440		
Jul-09	PRIO	R1	T0	7/15/2009	400.519	10:28	28	0	453.816	74.021	37.010
		T1			435.620	10:38	27	10	495.233		
		T2			419.160	10:48	26	20	478.113		
		T3			438.914	10:58	26	30	500.646		
Jul-09	PRIO	R2	T0	7/15/2009	387.370	10:29	27	0	440.380	317.168	158.584
		T1			423.548	10:39	26	10	483.118		
		T2			454.291	10:49	25	20	519.923		
		T3			528.031	10:59	25	30	604.316		
Jul-09	PRIT	R1	T0	7/15/2009	403.807	10:31	29	0	456.028	441.301	220.650
		T1			430.132	10:41	28	10	487.370		
		T2			466.381	10:51	27	20	530.203		
		T3			604.231	11:01	27	30	686.917		
Jul-09	PRIT	R2	T0	7/15/2009	331.578	10:32	28	0	375.701	471.633	235.817
		T1			341.413	10:42	27.5	10	387.489		
		T2			464.182	10:52	27	20	527.703		
		T3			518.111	11:02	26	30	590.981		
Aug-09	PW1CO	R1	T0	8/17/2009	317.379	18:23	32	0	354.899	261.490	130.745
		T1			369.851	18:33	32	10	413.574		
		T2			414.772	18:43	31	20	465.330		
		T3			429.035	18:53	30	30	482.919		
Aug-09	PW1CO	R2	T0	8/17/2009	337.041	18:24	29	0	380.628	330.492	165.246
		T1			414.772	18:34	29	10	468.411		
		T2			478.477	18:44	28	20	542.148		
		T3			476.277	18:54	28	30	539.655

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Aug-09	PW1CT	R1	T0	8/17/2009	335.949	18:20	28.5			135.456	67.728
			T1		311.921	18:30	28.5	10	352.842		
		T2			332.671	18:40	28	20	376.939		
Aug-09	PW1CT	T3		8/17/2009	351.253	18:50	28	30	397.994		
		R2	T0		339.227	18:21	30	0	381.832		
			T1		341.413	18:31	29.5	10	384.928		
Aug-09	PW2IO	T2		8/18/2009	331.578	18:41	29	20	374.458	587.233	293.616
		T3			340.320	18:51	29.5	30	383.696		
		R1	T0		370.946	13:55	35	0	410.760		
Aug-09	PW2IO	T1		8/18/2009	539.058	14:05	31.5	10	603.774	166.847	83.424
		T2			593.171	14:15	33	20	661.128		
		T3			644.092	14:25	33	30	717.882		
Aug-09	PW2IO	R2	T0	8/18/2009	350.159	13:56	33	0	390.276		
		T1			416.966	14:06	29	10	470.888		
		T2			415.869	14:16	30.5	20	467.329		
Aug-09	PW2IT	T3		8/18/2009	430.132	14:26	30	30	484.155		
		R1	T0		326.116	13:59	28	0	369.512		
		T1			360.003	14:09	29	10	406.559		
Aug-09	PW2IT	T2		8/18/2009	344.693	14:19	29	20	389.268		
		T3			342.506	14:29	29	30	386.799		
		R2	T0		363.285	14:00	27	0	412.999		
Aug-09	PW2CO	T1		8/18/2009	370.946	14:10	28	10	420.308	1219.889	609.945
		T2			369.851	14:20	28	20	419.068		
		T3			357.815	14:30	28	30	405.430		
Aug-09	PW2CO	R1	T0	8/18/2009	310.626	14:50	32.5	0	346.779		
		T1			555.228	15:00	31.5	10	621.885		
		T2			716.391	15:10:15	32	20.25	801.081		
Aug-09	PW2CO	T3		8/18/2009	862.695	15:20	31.5	30	966.264		
		R2	T0		652.383	14:51	30.8	0	732.386		
		T1			431.784	15:01	29.5	10	486.817		
Aug-09	PW2CO	T2		8/18/2009	418.068	15:11	30	20	470.575		
		T3			415.782	15:21	29.5	30	468.775

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{h}^{-1}$
Aug-09	PW2CT	R1	T0	8/18/2009	358.632	14:54	30.1	0	403.608	174.692	87.346
			T1		374.634	15:04	31	10	420.300		
			T2		411.210	15:14	31	20	461.334		
			T3	8/18/2009	434.070	15:24	31	30	486.981		8.905
		R2	T0		330.057	14:55	29	0	372.740	17.810	
			T1		322.056	15:05	29				
			T2	8/18/2009	334.629	15:15	28.8	20	378.154		16.587
			T3		338.058	15:25	29	30	381.776		
		R1	T0		364.380	11:26	26	0	415.628	33.175	
			T1	8/18/2009	386.275	11:36	26	20	428.112		109.451
			T2		375.325	11:46	26	30	431.859		
			T3		378.609	11:56	26	0	386.938	218.902	
		R2	T0	8/18/2009	339.227	11:27	26	10	431.859		53.940
			T1		378.609	11:37	26	20	478.113		
			T2		419.160	11:47	26	30	493.132	107.880	
			T3	8/18/2009	432.327	11:57	26	0	331.860		38.088
		R1	T0		293.372	11:23	28.5	10	354.665		
			T1		313.012	11:33	28	20	391.800		
			T2	8/18/2009	345.786	11:43	28	30	379.415		76.176
			T3		334.856	11:53	28	0	410.388		
		R2	T0		362.191	11:24	28	10	422.788		
			T1	8/18/2009	373.135	11:34	28	20	414.108		38.088
			T2		365.474	11:44	28	30	412.868		
			T3		364.380	11:54	28	0	270.138		
		R1	T0	8/17/2009	244.350	13:23	35.5	10	298.061		38.088
			T1		270.481	13:33	36.5	20	311.271		
			T2		245.438	13:43	37.2	30	356.227		
			T3	8/17/2009	282.469	13:53	36.5	0	292.531		261.649
		R2	T0		320.655	13:24	34	10	261.649		
			T1		265.034	13:34	36	20	275.707		
			T2	8/17/2009	237.822	13:44	37	30			275.707
			T3		249.791	13:54	36				

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Aug-09	PRIO	R1	T0	8/14/2009	339.227	9:48	28	0	384.368	65.482	32.741
			T1		372.041	9:58	30				
			T2		362.191	10:08:30	30	20.5	407.681		
			T3		370.946	10:18	30.5	30	416.847		
Aug-09	PRIO	R2	T0	8/14/2009	343.599	9:49	30	0	386.754	97.877	48.939
			T1		391.752	9:59	31				
			T2		379.704	10:09	32	20	424.592		
			T3		388.466	10:19	32	30	434.389		
Aug-09	PRIT	R1	T0	8/14/2009	329.393	9:51	30	0	370.763	945.299	472.649
			T1		384.085	10:01	31	10	430.902		
			T2		519.213	10:11	31.5	20	581.546		
			T3		756.306	10:21	32	30	845.714		
Aug-09	PRIT	R2	T0	8/14/2009	340.320	9:52	29.5	0	383.696	2838.159	1419.079
			T1		796.439	10:02	31	10	893.520		
			T2		1219.882	10:12	32	20	1364.094		
			T3		1637.246	10:22	32.5	30.5	1827.802		
Sep-09	PW1CO	R1	T0	9/11/2009	333.763	11:41	25.5	0	381.343	689.439	344.719
			T1		465.281	11:51	25.5	10	531.610		
			T2		553.402	12:01	25.5	20	632.292		
			T3		638.551	12:11	25	30	730.804		
Sep-09	PW1CO	R2	T0	9/11/2009	342.506	11:42	28	0	388.084	413.571	206.786
			T1		420.257	11:52	26	10	479.364		
			T2		478.477	12:02:10	25.5	20.2	546.686		
			T3		521.417	12:12	25.5	30	595.748		
Sep-09	PW1CT	R1	T0	9/11/2009	341.413	11:45	21	0	396.051		
			T1		327.208	11:55	21	10	379.573		
			T2		332.671	12:05	21.5	20	385.254		
			T3		350.159	12:15	22	30	404.821		
Sep-09	PW1CT	R2	T0	9/11/2009	349.066	11:46	19	0	407.701		
			T1		353.440	11:56	20	10	411.401		
			T2		361.097	12:06	20.5	20	419.598		
			T3		353.440	12:16	22	30	408.614

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{h}^{-1}$
Sep-09	PW2IO	R1	T0	9/12/2009	315.196	10:28	26	0	359.527	1082.729	541.365
		T1			433.425	10:38	21	10	502.788		
		T2			664.049	10:48	23	20	765.118		
		T3			760.761	10:58	24	30	873.600		
Sep-09	PW2IO	R2	T0	9/12/2009	335.949	10:29	24.5	0	385.129	414.375	207.188
		T1			485.078	10:39	20	10	564.626		
		T2			463.083	10:49	21	20	537.192		
		T3			540.161	10:59	22	30	624.483		
Sep-09	PW2IT	R1	T0	9/12/2009	229.121	10:32	20.8	0	265.969	285.825	142.912
		T1			284.649	10:42:20	22	10.3	329.084		
		T2			331.578	10:52	22	20	383.339		
		T3			351.253	11:02	22	30	406.085		
Sep-09	PW2IT	R2	T0	9/12/2009	307.555	10:33	20	0	357.991	93.917	46.959
		T1			294.463	10:43	21	10	341.587		
		T2			352.347	10:53	21	20	408.734		
		T3			334.856	11:03	21.5	30	387.785		
Sep-09	PW2CO	R1	T0	9/12/2009	636.381	11:22	26.5	0	724.674	1396.765	698.382
		T1			493.506	11:32	23	10	568.618		
		T2			2419.461	11:42	23	20	2787.704		
		T3			662.670	11:52	24	30	760.959		
Sep-09	PW2CO	R2	T0	9/12/2009	350.631	11:23	27.5	0	397.950	870.021	435.011
		T1			512.937	11:33	23	10	591.006		
		T2			630.666	11:43	24	20	724.208		
		T3			731.250	11:53	25	30	836.895		
Sep-09	PW2CT	R1	T0	9/12/2009	363.204	11:25	27	0	412.907		
		T1			383.778	11:36	27	11	436.296		
		T2			371.205	11:46	28.2	21	420.322		
		T3			386.064	11:56	29	31	435.990		
Sep-09	PW2CT	R2	T0	9/12/2009	351.774	11:26	25	0	402.595		
		T1			367.776	11:37	24	11	422.326		
		T2			371.205	11:47	24.5	21	425.547		
		T3			365.490	11:57	25	31	418.293		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Sep-09	PW200	R1	T0	9/12/2009	362.191	12:25	29	0	409.030	356.020	178.010
		T1			456.489	12:35	26	10	520.692		
		T2			464.182	12:45	27	20	527.703		
		T3			422.451	12:55	26				
Sep-09	PW200	R2	T0	9/12/2009	305.372	12:26	30	0	343.726		
		T1			368.757	12:36	24	10	423.452		
		T2			332.671	12:46	24	20	382.013		
		T3			293.372	12:56	24	30	336.886		
Sep-09	PW20T	R1	T0	9/12/2009	323.931	12:29	31.5	0	362.820		
		T1			309.738	12:39	29.5	10	349.215		
		T2			338.134	12:49	29	20	381.862		
		T3			317.379	12:59	29.2	30	358.186		
Sep-09	PW20T	R2	T0	9/12/2009	353.440	12:30	30	0	397.831		
		T1			365.474	12:40	31	10	410.023		
		T2			370.946	12:50	30.5	20	416.847		
		T3			349.066	13:00	31	30	391.615		
Sep-09	PWOU	R1	T0	9/11/2009	301.008	13:34	30	0	338.813		
		T1			258.500	13:44	33	10	288.115		
		T2			245.438	13:54	33.2	20	273.378		
		T3			269.392	14:04	33	30	300.254		
Sep-09	PWOU	R2	T0	9/11/2009	297.735	13:31	29	0	336.238		
		T1			317.379	13:41	33.5	10	353.163		
		T2			297.735	13:51	33.8	20	330.980		
		T3			293.372	14:01	33.2	30	326.769		
Sep-09	PRIO	R1	T0	9/9/2009	358.909	10:13	27	0	408.024	999.471	499.736
		T1			466.381	10:23	26	10	531.975		
		T2			635.228	10:33	27	20	722.156		
		T3			794.207	10:43	28	30	899.893		
Sep-09	PRIO	R2	T0	9/9/2009	378.609	10:14	25	0	433.307	1075.285	537.642
		T1			543.471	10:24	26	10	619.907		
		T2			725.140	10:34	25	20	829.902		
		T3			842.233	10:44	26	30	960.689		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Sep-09	PRIT	R1	T0	9/9/2009	347.973	10:15	26	0	396.913	522.676	261.338
		T1			424.645	10:25	28	10	481.153		
		T2			513.704	10:35	28	20	582.063		
		T3			578.802	10:45	29	30	653.653		
Sep-09	PRIT	R2	T0	9/9/2009	367.663	10:16	26	0	419.373	59.615	29.808
		T1			393.944	10:26	27	10	447.853		
		T2			401.615	10:36	28	20	455.058		
		T3			397.231	10:46	28	30	450.091		
Oct-09	PW1CO	R1	T0	10/26/2009	345.786	15:44	23.5	0	397.743	1720.079	860.039
		T1			500.487	15:54	24	10	574.721		
		T2			836.643	16:04	24	20	960.737		
		T3			1064.692	16:14	23.5	30	1224.671		
Oct-09	PW1CO	R2	T0	10/26/2009	360.003	15:46	21.5	0	416.907	925.626	462.813
		T1			500.487	15:56:15	21.5	10.25	579.597		
		T2			630.797	16:06	21.5	20	730.504		
		T3			760.761	16:16	22	30	879.519		
Oct-09	PW1CT	R1	T0	10/26/2009	338.134	15:49	23.5	0	388.942		
		T1			337.041	15:59	25	10	385.734		
		T2			357.815	16:09	24.5	20	410.197		
		T3			346.879	16:19	24	30	398.329		
Oct-09	PW1CT	R2	T0	10/26/2009	358.909	15:51	23.5	0	412.838		
		T1			350.159	16:01	26	10	399.408		
		T2			353.440	16:11	26	20	403.150		
		T3			351.253	16:21	25.5	30	401.326		
Oct-09	PW2IO	R1	T0	10/27/2009	396.135	10:57	14.5	0	469.914	1292.662	646.331
		T1			444.405	11:07	14	10	528.092		
		T2			519.213	11:17	13.5	20	618.064		
		T3			974.549	11:27	14	30	1158.069		
Oct-09	PW2IO	R2	T0	10/27/2009	390.657	10:58	12.5	0	466.660	1902.528	951.264
		T1			466.381	11:08	12	10	558.093		
		T2			623.045	11:18	12	20	745.566		
		T3			1221.019	11:28	12	30	1461.129		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Oct-09	PW2IT	R1	T0	10/27/2009	404.904	11:01	12.5	0	483.679	97.104	48.552
		T1			410.386	11:11	12	10	491.087		
		T2			425.742	11:21	12.2	20	509.107		
Oct-09	PW2IT	T3		10/27/2009	445.503	11:31	12.8	30	531.619		
		R2	T0		396.135	11:02	14	0	470.733		
		T1			396.135	11:12	14.5	10	469.914		
Oct-09	PW2CO	T2		10/27/2009	406.000	11:22	14.8	20	481.115		
		T3			392.848	11:32	15	30	465.206		
		R1	T0		304.911	11:50	16	0	359.824	672.825	336.413
Oct-09	PW2CO	T1		10/27/2009	386.064	12:00	15	10	457.173		
		T2			455.787	12:10	15	20	539.738		
		T3			595.233	12:20	14.5	30	706.094		
Oct-09	PW2CO	R2	T0	10/27/2009	341.487	11:51	15	0	404.385	1638.004	819.002
		T1			539.226	12:01	12	10	645.264		
		T2			819.261	12:11	12	20	980.367		
Oct-09	PW2CT	T3		10/27/2009	1003.284	12:21	11.5	30	1202.687		
		R1	T0		354.060	11:54	13	0	422.205	46.024	23.012
		T1			351.774	12:04	13.5	10	418.747		
Oct-09	PW2CT	T2		10/27/2009	366.633	12:14	13.5	20	436.435		
		T3			371.205	12:24	13.5	30	441.877		
		R2	T0		343.773	11:55	15	0	407.092	41.329	20.664
Oct-09	PW200	T1		10/27/2009	359.775	12:05	16	10	424.568		
		T2			354.060	12:15	15.5	20	418.548		
		T3			365.490	12:25	15.5	30	432.060		
Oct-09	PW200	R1	T0	10/27/2009	395.039	12:46	15.2	0	467.477	749.913	374.956
		T1			479.577	12:56	14	10	569.888		
		T2			587.643	13:06	14	20	698.304		
Oct-09	PW200	T3		10/27/2009	708.463	13:16	14.2	30	841.289		
		R2	T0		353.440	12:47	17	0	415.655	1057.694	528.847
		T1			444.405	12:57	16	10	524.439		
Oct-09	PW200	T2		10/27/2009	664.049	13:07	16	20	783.640		
		T3			777.478	13:17	16.2	30	916.863		

Table 3. continued

Month	Site	Rep	T	Date	N2O ppbv	Time actual	Temp C	Time min	N2O-Cm $\mu\text{g N}_2\text{O-N m}^{-3}$	Rate $\mu\text{g N}_2\text{O-N m}^{-3} \text{ h}^{-1}$	Flux $\mu\text{g N}_2\text{O-N m}^{-2} \text{ h}^{-1}$
Oct-09	PW2OT	R1	T0	10/27/2009	385.180	12:50	15	0	456.126
		T1			368.757	13:00	15	10	436.678		
		T2			381.894	13:10	15.5	20	451.452		
Oct-09	PW2OT	R2	T0	10/27/2009	380.799	13:20	16	30	449.379
		T1			389.561	12:51	16	0	459.719		
		T2			386.275	13:01	16.5	10	455.054		
Oct-09	PWOU	T3		10/26/2009	391.752	13:11	17.5	20	459.919		
		T1			369.851	13:21:10	17.5	30.2	434.207		
		R1	T0		294.463	17:14	17	0	346.296	90.730	45.365
Oct-09	PWOU	T1		10/26/2009	315.196	17:24	17.2	10	370.423		
		T2			323.931	17:34	17	20	380.952		
		T3			333.763	17:44	16.5	30	393.192		
Oct-09	PWOU	R2	T0	10/26/2009	326.116	17:15	18	0	382.204
		T1			310.829	17:25	18	10	364.288		
		T2			316.287	17:35	18	20	370.685		
Oct-09	PRIO	T3		10/22/2009	318.471	17:45	17.5	30	373.886		
		R1	T0		306.464	14:25	23.5	0	352.512	103.821	51.910
		T1			335.949	14:35	23.2	10	386.819		
Oct-09	PRIO	T2		10/22/2009	339.227	14:45	23.5	20	390.199		
		T3			355.628	14:55	23.5	30	409.064		
		R2	T0		296.644	14:26	23	0	341.794	182.704	91.352
Oct-09	PRIT	T1		10/22/2009	356.721	14:36	22.8	10	411.292
		T2			349.066	14:46	23	20	402.194		
		T3			387.370	14:56	23	30	446.328		
Oct-09	PRIT	R1	T0	10/22/2009	338.134	14:28	21.5	0	391.582	78.841	39.420
		T1			345.786	14:38	21.8	10	400.036		
		T2			349.066	14:48	22	20	403.557		
Oct-09	PRIT	T3		10/22/2009	375.325	14:58	21.8	30	434.209
		R2	T0		323.931	14:29	20	0	377.053	126.032	63.016
		T1			341.413	14:39	20	10	397.402		
Oct-09	PRIT	T2		10/22/2009	379.704	14:49	20.2	20	441.671		
		T3			372.041	14:59	20.5	30	432.315

Table 3. continued