**Electronic Supplemental Material for**

**Exploring the oxygen sensitivity of wetland soil carbon mineralization**

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**Table S1**- Data on the CO2 and CH4 respiration rates (+/-standard error) CO2 andCO2+CH4 Oxic:Anoxicratios used for the systematic review

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Paper | Wetland type | N | Mean CO2 Oxic respiration | Mean CO2 anoxic respiration | Mean CH4 respiration | CO2 Oxic:Anoxic ratios | CO2 + CH4 Oxic:Anoxic ratios |
| Scanlon et al 2000 | Bog | 4 | 0.185 ± 0.01 (mg g-1 dry peat d-1) | 0.03 ± 0.004 (mg g-1 dry peat d-1) | na | 6.17 ± 0.89 | na |
| Scanlon et al 2000 | Fen | 4 | 0.23 ± 0.02 (mg g-1 dry peat d-1) | 0.02 ± 0.004 (mg g-1 dry peat d-1) | na | 11.50 ± 2.51 | na |
| Bridgham et al 1992 | Pocosin | 3 | 0.445 ± 0.07 (umol CO2 cm-3 d-1) | 0.271 ± 0.03 (umol CO2 cm-3 d-1) | na | 1.64 ± 0.31 | na |
| Bridgham et al 1992 | Pocosin | 3 | 0.712 ± 0.14 (umol CO2 cm-3 d-1) | 0.268 ± 0.03 (umol CO2 cm-3 d-1) | na | 2.66 ± 0.62 | na |
| Bridgham et al 1992 | Swamp | 3 | 1.227 ± 0.23 (umol CO2 cm-3 d-1) | 0.457 ± 0.03 (umol CO2 cm-3 d-1) | na | 2.68 ± 0.53 | na |
| Moore and Dalva 1997 | Bog | 4 | 0.97 ± 0.09 (mg g-1 day-1) | 1.148 ± 0.06 (mg g-1 day-1) | na | 0.84 ± 0.09 | na |
| Moore and Dalva 1997 | Bog | 6 | 0.95 ± 0.15 (mg g-1 day-1) | 1.24 ± 0.11 (mg g-1 day-1) | na | 0.77 ± 0.14 | na |
| Moore and Dalva 1997 | Swamp | 7 | 0.23 ± 0.03 (mg g-1 day-1) | 0.10 ± 0.01 (mg g-1 day-1) | na | 2.30 ± 0.38 | na |
| Moore and Dalva 1997 | Bog | 11 | 0.79 ± 0.21 (mg g-1 day-1) | 0.21 ± 0.05 (mg g-1 day-1) | na | 3.76 ± 1.34 | na |
| Moore and Dalva 1997 | Bog | 6 | 1.68 ± 0.67 (mg g-1 day-1) | 0.51 ± 0.10 (mg g-1 day-1) | na | 3.29 ± 1.46 | na |
| Bridgham et al 1998 | Bog | Na | 176.58 ± 10.9 (mg/g total CO2) | 22.96 ± 1.5 (mg/g total CO2) | 0.1 ± 0.04 (mg/g total CH4) | 7.69 ± 0.69 | 7.66 ± 0.70 |
| Bridgham et al 1998 | Fen | Na | 140.06 ± 23.31 (mg/g total CO2) | 23.34 ± 1.5 (mg/g total CO2) | 0.5 ± 0.36 (mg/g total CH4) | 6.0 ± 1.07 | 5.88 ± 1.08 |
| Bridgham et al 1998 | Fen | Na | 133.66 ± 26.69 (mg/g total CO2) | 27.86 ± 1.13 (mg/g total CO2) | 2.89 ± 0.02 (mg/g total CH4) | 4.8 ± 0.98 | 4.35 ± 0.88 |
| Bridgham et al 1998 | Swamp | Na | 138.55 ± 15.04 (mg/g total CO2) | 23.72 ± 1.5 (mg/g total CO2) | 1.07 ± 0.21 (mg/g total CH4) | 5.84 ± 0.73 | 5.59 ± 0.72 |
| Bridgham et al 1998 | Swamp | Na | 129.14 ± 0 (mg/g total CO2) | 28.61 ± 1.13 (mg/g total CO2) | 1.24 ± 0.51 (mg/g total CH4) | 4.51 ± 0.18 | 4.33 ± 0.24 |
| Bridgham et al 1998 | Meadow | Na | 178.09 ± 0.75 (mg/g total CO2) | 35.39 ± 0.38 (mg/g total CO2) | 4.22 ± 1.06 (mg/g total CH4) | 5.03 ± 0.06 | 4.50 ± 0.16 |
| Magnusson 1993 | Fen | 3 | 13.76 ± 6.18 (µg CO2 g-1 dry soil h-1) | 1.17 ± 0.43 (µg CO2 g-1 dry soil h-1) | 18.33 ± 9.70 (ng CH4 g-1 dry soil h-1) | 11.76 ± 2.51 | 11.58 ± 6.74 |
| Magnusson 1993 | Fen | 3 | 11.69 ± 4.70 (µg CO2 g-1 dry soil h-1) | 1.41 ± 0.33 (µg CO2 g-1 dry soil h-1) | 43.33 ± 9.35 (ng CH4 g-1 dry soil h-1) | 8.29 ± 3.86 | 8.04 ± 3.74 |
| Magnusson 1993 | Fen | 3 | 12.33 ± 1.71 (µg CO2 g-1 dry soil h-1) | 1.9 ± 0.27 (µg CO2 g-1 dry soil h-1) | 133.36 ± 77.94 (ng CH4 g-1 dry soil h-1) | 6.49 ± 1.29 | 6.06 ± 1.34 |
| Magnusson 1993 | Fen | 3 | 9.64 ± 2.93 (µg CO2 g-1 dry soil h-1) | 1.70 ± 0.39 (µg CO2 g-1 dry soil h-1) | 27.33 ± 14.25 (ng CH4 g-1 dry soil h-1) | 5.67 ± 2.16 | 5.58 ± 2.14 |
| Magnusson 1993 | Fen | 3 | 10.61 ± 4.74 (µg CO2 g-1 dry soil h-1) | 1.10 ± 0.39 (µg CO2 g-1 dry soil h-1) | 30 ± na (ng CH4 g-1 dry soil h-1) | 9.65 ± 5.5 | 9.56 ± .49 |
| Szafranek-Nakonieczna 2014 | Moor | 6 | 0.33 ± 0.05 (g CO2 kg-1 dw d-1) | 0.09 ± 0.02 (g CO2 kg-1 DW d-1) | na | 3.67 ± 0.99 | Na |
| Szafranek-Nakonieczna 2014 | Moor | 6 | 0.30 ± 0.04 (g CO2 kg-1 dw d-1) | 0.09 ± 0.02 (g CO2 kg-1 DW d-1) | na | 3.33 ± 0.86 | Na |
| Szafranek-Nakonieczna 2014 | Moor | 6 | 0.22 ± 0.04 (g CO2 kg-1 dw d-1) | 0.14 ± 0.02 (g CO2 kg-1 DW d-1) | na | 1.57 ± 0.36 | Na |
| Broun etal 2014 | Bog | 5 | 0.88 ± 0.07 (µmol g-1 dw h-1) | 0.11 ± 0.02 (µmol g-1 DW h-1) | 0.13 ± 0.06 (µmol g-1 dw h-1) | 8.0 ± 1.59 | 3.74 ± 1.31 |
| Waddington et al 2001 | Bog | 4 | 7.21 ± 2.52 (µmol g-1 d-1) | 2.63 ± 0.33 (µmol g-1 d-1) | na | 2.74 ± 1.02 | Na |
| Waddington et al 2001 | Bog | 5 | 1.84 ± 0.86 (µmol g-1 d-1) | 0.79 ± 0.07 (µmol g-1 d-1) | na | 2.33 ± 1.11 | Na |
| Waddington et al 2001 | Bog | 5 | 1.12 ± 0.11 (µmol g-1 d-1) | 0.79 ± 0.34 (µmol g-1 d-1) | na | 1.42 ± 0.63 | Na |
| Sjögersten et al 2018 | Tropical Wetland | 6 | 114.23 ± 21.66 (CO2 µg g-1 hr-1) | 3.44 ± 1.4 (CO2 µg g-1 hr-1) | 961.95 ± 37.03 (CH4 ng g-1 hr-1) | 33.21 ± 7.39 | 26.55 ± 5.71 |
| Sjögersten et al 2018 | Tropical Wetland | 9 | 40.37 ± 4.19 (CO2 µg g-1 hr-1) | 2.09 ± 0 (CO2 µg g-1 hr-1) | 212.12 ± 5.59 (CH4 ng g-1 hr-1) | 19.32 ± 2.0 | 17.54 ± 1.82 |
| Sjögersten et al 2018 | Tropical Wetland | 3 | 41.66 ± 5.59 (CO2 µg g-1 hr-1) | 1.39 ± 0 (CO2 µg g-1 hr-1) | 178.45 ± 12.8 (CH4 ng g-1 hr-1) | 29.97 ± 4.02 | 26.56 ± 3.57 |
| Sjögersten et al 2018 | Tropical Wetland | 3 | 48.1 ± 18.17 (CO2 µg g-1 hr-1) | 2.09 ± 0 (CO2 µg g-1 hr-1) | 60.61 ± 4.89 (CH4 ng g-1 hr-1) | 23.01 ± 8.69 | 22.37 ± 8.45 |
| Inglett et al 2012 | Tropical Wetland | 3 | 132 ± 14 (µg C g-1 dw d-1) | 14.2 ± 3.6 (µg C g-1 dw d-1) | 4 ± 1.4 (µg C g-1 dw d-1) | 9.30 ± 2.55 | 7.25 ± 2.14 |
| Inglett et al 2012 | Tropical Wetland | 3 | 182 ± 28 (µg C g-1 dw d-1) | 26.3 ± 2.7 (µg C g-1 dw d-1) | 14.7 ± 2.6 (µg C g-1 dw d-1) | 6.92 ± 1.28 | 4.44 ± 0.89 |
| Inglett et al 2012 | Tropical Wetland | 3 | 171 ± 6 (µg C g-1 dw d-1) | 20.4 ± 4.2 (µg C g-1 dw d-1) | 5.9 ± 2.7 (µg C g-1 dw d-1) | 8.38 ± 1.75 | 6.5 ± 1.72 |
| Inglett et al 2012 | Tropical Wetland | 3 | 167 ± 26 (µg C g-1 dw d-1) | 20.6 ± 2.1 (µg C g-1 dw d-1) | 9 ± 1.6 (µg C g-1 dw d-1) | 8.11 ± 1.26 | 5.64 ± 0.94 |
| Inglett et al 2012 | Tropical Wetland | 3 | 109 ± 5 (µg C g-1 dw d-1) | 20.2 ± 2.7 (µg C g-1 dw d-1) | 6.7 ± 1.6 (µg C g-1 dw d-1) | 5.40 ± 0.76 | 4.05 ± 0.67 |
| Glatzel et al 2004 | Bog | 3 | 0.12 ± 0.01 (mg CO2 g dw d-1) | 0.05 ± 0.01 (mg CO2 g dw d-1) | 0.07 ± 0.03 (µg CH4 g-1 dw d-1) | 2.40 ± 0.52 | 2.4 ± 0.52 |
| Glatzel et al 2004 | Bog | 3 | 0.14 ± 0 (mg CO2 g dw d-1) | 0.04 ± 0 (mg CO2 g dw d-1) | 0.05 ± 0.05 (µg CH4 g-1 dw d-1) | 3.50 ± 0.00 | 3.5 ± 0.0 |
| Duval 2018 | Fen | 3 | 61.49 ± 9.32 (µg C g-1 dw d-1) | 17.31 ± 2.44 (µg C g-1 dw d-1) | 0.57 ± 0 (µg C g-1 dw d-1) | 3.55 ± 0.74 | 3.44 ± 0.70 |
| Duval 2018 | Fen | 3 | 121.12 ± 14.91 (µg C g-1 dw d-1) | 28.29 ± 1.70 (µg C g-1 dw d-1) | 0.76 ± 0 (µg C g-1 dw d-1) | 4.28 ± 0.59 | 4.17 ± 0.57 |
| Duval 2018 | Fen | 3 | 134 ± 24.22 (µg C g-1 dw d-1) | 20.24 ± 2.20 (µg C g-1 dw d-1) | 0.19 ± 0 (µg C g-1 dw d-1) | 6.62 ± 1.40 | 6.56 ± 1.38 |
| Duval 2018 | Fen | 3 | 139.75 ± 20.5 (µg C g-1 dw d-1) | 26.34 ± 3.41 (µg C g-1 dw d-1) | 9.49 ± 1.33 (µg C g-1 dw d-1) | 5.31 ± 1.04 | 3.90 ± 0.77 |
| Duval 2018 | Fen | 3 | 206.83 ± 20.5 (µg C g-1 dw d-1) | 21.95 ± 1.22 (µg C g-1 dw d-1) | 13.29 ± 2.85 (µg C g-1 dw d-1) | 9.42 ± 1.07 | 5.87 ± 0.89 |
| Duval 2018 | Fen | 3 | 143.48 ± 26.09 (µg C g-1 dw d-1) | 13.90 ± 0.98 (µg C g-1 dw d-1) | 1.71 ± 0.19 (µg C g-1 dw d-1) | 10.32 ± 2.01 | 9.19 ± 1.81 |
| Turetsky et al 2005 | Fen | 25 | 55.7 ± 2.3 (µmol CO2 g-1 dw d-1) | 40.6 ± 1.3 (µmol CO2 g-1 dw d-1) | na | 1.37 ± 0.07 | na |

**Supplemental Methods**

**A systematic review of O:A ratios**

Using research papers collated through Web of Science, we performed a systematic review on wetland soil incubation data to summarize what is known about how soil oxygenation influences wetland C mineralization. Our Web of Science search criteria consisted of the search topics ‘decomposition’, ‘wetland’ and ‘carbon dioxide’ (CO2). Our search span encompassed all years and we used the following search indices; SCI-EXPANDED, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC. The results of this search resulted in 172 publications. The search was then repeated to include specific search terms for intertidal wetland incubation studies. Specifically, we used the search terms ‘decomposition’, ‘saltmarsh’, ‘mangrove’, ‘intertidal’ and ‘carbon dioxide’. These search terms failed to produce any additional CO2 incubation studies performed on soils from intertidal habitats. Publication results identified through these searches were then sorted to identify research investigating CO2 respiration within wetland soils using both oxic and anoxic incubation conditions. We then also included publications that were identified in the reference sections from the publication search results. It is important to note that all of the studies used in our systematic review were performed in freshwater wetlands rather than coastal wetlands, and only included research using both oxic and anoxic incubation studies. Respiration rates and standard errors for oxic and anoxic incubations were extracted for the systematic review using the available published data or by using the data harvesting WebPlotDigitizer software (Rohatgi 2015). Oxic to anoxic CO2 respiration ratios (heretofore termed “O:A ratios”) for each study were calculated by dividing the rate of oxic respiration by the rate of anoxic respiration (Table S1). In addition to CO2 respiration, we included methane (CH4) respiration where available due to its importance in blue carbon estimates. O:A ratios were log transformed prior to analysis and were analyzed using analysis of variance (ANOVA) models which assessed the effect of wetland type on CO2 respiration ratios. We used two-way analysis of variance (ANOVA) models to assess variations in rates of respiration between wetland types and between individual studies. Further post-hoc analysis was performed with Tukey HSD for wetland types. All errors within the systematic review were propagated using the below formula:

$$\frac{δQ}{Q}= \sqrt{\left(\frac{δx}{x}\right)^{2}+…+\left(\frac{δy}{y}\right)^{2}+…+\left(\frac{δz}{z}\right)^{2} }$$

Where $\frac{δQ}{Q}$ is the propagated error,$x$, $y$ and $z$ are Oxic to anoxic ratios and $δx$, $δy$ and $δz$ are standard errors. All statistical analysis was carried out using the R statistical package (R Foundation for Statistical Computing).

**Flow-through mesocosms**

A peristaltic pump circulated ~5 mL min-1 of porewater from a filtered intake at the bottom of mesocosm and redistributed it at the soil surface (Fig.2). Into the stream of recirculating porewater, we bubbled with either ultra-high purity N2 for anoxic treatment or an N2/O2 80/20 mixture for oxic treatment. The use of N2 for anoxic mesocosms accounts for the effects of purging soil porewater gas by bubbling in exogenous gases. Control and treated mesocosms were the same except for the N2 vs. N2/O2 treatments (n=5).

With these flow-through mesocosms, we took great care to limit the accidental introduction of oxygen into the anoxic treatment. Leakage from the atmosphere or impurity of the treatment gas can introduce small concentrations of oxygen to the porewater. Our system continuously circulated porewater, so even though [O2] may be below detection the total mass of O2 introduced is magnified by the flow rate and may be considerable. Thus, we passed the ultra-high purity N2 gas through an oxygen trap to remove trace amounts of O2. We measured [CO2] in headspace samples on a Li-7000 (Licor, Lincoln, NE) configured for small-volume injection. We estimate a mean ratio as the mean of the O:A ratio for each soil pair at each sampling time (N=50). We report the error as the standard deviation across all of these ratios. Because the measurements through time are not independent, we also report the average temporal error (across 12 sampling dates) and error across mesocosms (n=5) separately.

**Supplementary Figure.**

**Figure S1.** Profile of [O2] in a small, intact soil core incubated with oxic headspace. Headspace [O2] only affects the surface cm of the soil, thereby causing underestimation of the effects of O2 on decomposition (Langley, unpublished).

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**Table S2.** Respiration from mesocosm study for anoxic (a) and oxic (o) treatments for each soil pair.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Soil pair | O2 | 6/10/16 | 6/13/16 | 6/15/16 | 6/17/16 | 6/20/16 | 6/22/16 | 6/28/16 | 6/30/16 | 7/6/16 | 7/13/16 | 7/18/16 | 7/20/16 |
| 1 | a | 0.32 | 0.76 |  | 1.15 |  | 0.53 | 1.34 | 0.79 | 0.25 | 0.37 | 0.80 | 0.45 |
| 1 | o | 1.83 | 2.64 | 2.01 | 2.55 | 2.23 | 1.73 | 1.75 | 2.31 | 1.94 | 1.99 | 1.54 | 1.80 |
| 2 | a | 0.17 | 0.29 | 0.41 | 0.53 | 0.37 | 1.02 | 0.17 | 0.43 | 0.23 | 0.73 | 1.00 |  |
| 2 | o | 1.18 | 1.77 | 1.86 | 3.41 | 1.91 | 2.11 | 2.31 | 3.05 | 2.78 | 4.14 | 2.93 | 3.16 |
| 3 | a | 1.40 | 0.86 | 0.56 | 0.73 | 0.48 | 0.80 | 0.74 |  | 1.17 | 1.78 | 0.84 | 0.67 |
| 3 | o | 0.99 | 2.86 | 3.04 | 3.10 | 3.13 |  |  | 2.11 | 1.45 | 1.32 | 1.01 | 1.47 |
| 4 | a | 0.52 | 1.23 | 0.42 | 0.32 | 0.15 | 0.45 | 0.29 | 0.71 | 0.51 | 0.72 | 0.13 |  |
| 4 | o | 1.31 | 2.39 | 1.67 |  | 1.74 | 2.38 | 1.25 | 1.72 | 1.47 | 1.56 | 1.41 | 1.93 |
| 5 | a | 0.25 | 0.56 | 0.35 | 0.56 | 0.30 |  | 1.14 | 0.45 |  | 0.48 | 0.49 | 0.29 |
| 5 | o | 0.41 | 0.92 | 0.93 | 1.32 | 0.89 | 1.00 | 0.99 | 1.24 | 0.94 | 1.88 | 0.63 | 0.68 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| All rates are μgC·gC-1hr1 |  |  |  |  |  |  |  |  |  |  |  |  |
| Blanks cells represent mesocosms that did not yield linear slopes of CO2 accumulation. |  |  |  |  |  |  |  |

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