

# Paul J. Hanson

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## Research Expertise

Influence of climatic change on eco-physiological processes and ecosystems  
Process-level physiological modeling  
Deposition of trace gases to landscape surfaces  
Physiology of woody plants  
Air pollution stress physiology

## Education

Ph.D.	University of Minnesota	Tree Physiology	1986
M.S.	University of Minnesota	Plant Physiology	1983
B.A.	St. Cloud State University	Biology (summa cum laude)	1981

## Professional Experience

2012–present Corporate Fellow, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee

2006–2020 Group Leader, Ecosystem Sciences Group, Environmental Sciences Division, Oak Ridge National Laboratory

2005–2012 Distinguished R&D Staff Member, Environmental Sciences Division, Oak Ridge National Laboratory.

2004–2009 Chief Scientist, Program for Ecosystem Research, U.S. Department of Energy

2001–2004 Senior R&D Staff Member, Environmental Sciences Division, Oak Ridge National Laboratory

1996–2001 Research Staff Member II, Environmental Sciences Division, Oak Ridge National Laboratory

1994–1998 Adjunct Associate Professor, Department of Ecology, University of Tennessee, Knoxville

1992–1995 Research Staff Member I, Environmental Sciences Division, Oak Ridge National Laboratory

1989–1992 Research Associate, Physiological Ecology Group, Environmental Sciences Division, Oak Ridge National Laboratory

1988–1989 Scientist, Automated Sciences Group, Oak Ridge, Tennessee

1986–1988 Postdoctoral Research Associate, Environmental Sciences Division, Oak Ridge National Laboratory

### Professional Activities

- 2005–present Subject Editor, *Global Change Biology*
- 2018–present Member, U.S. Department of Energy’s (DOE) Environmental Systems Science Data Infrastructure for a Virtual Ecosystem (ESS–DIVE) Archive Partnership Board (APB)
- 2009–2014 Member, North American Carbon Program, Carbon Cycle Science Steering Group (Two 3-year terms)
- 2013–2014 U.S. Global Changes Research Program Invited Reviewer, Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), Working Group I and Synthesis reports
- 2007–2012 Member, National Aeronautics and Space Administration’s Oak Ridge National Laboratory Distributed Active Archive Center (DAAC) User Working Group
- 2007–2011 Member of U.S. Environmental Protection Agency’s (EPA) Clean Air Science Advisory Committee (CASAC) NO<sub>x</sub> & SO<sub>x</sub> Secondary Review Panel
- 2009 Invited Congressional Testimony, 9 June 2009, Energy and Environment Subcommittee of the House Science and Technology Committee
- 2005–2008 Member of EPA’s Clean Air Science Advisory Committee (CASAC) Ozone Review Panel
- 2002–2004 Member, National Institute for Global Environmental Change (NIGEC) National Technical Advisory Committee (NTAC)
- 2003 Panel member, U.S. Department of Agriculture’s (USDA) Cooperative State Research, Education, and Extension Service (CSREES) Competitive Grants Program
- 1994–2004 Editorial Review Board, *Tree Physiology* (not 1999)
- 1995–2000 Associate Editor, *Journal of Environmental Quality* (two 3-year terms)
- 1998 Ad hoc member of an EPA Technical Qualifications Board
- 1996–1998 Advisory Board Southeast Regional Center of the National Institute for Global Environmental Change
- 1994–1995 Panel Member, DOE’s Southeast Regional Center – National Institute for Global Environmental Change
- 1994–1996 Contributing Author, EPA, contributing to the revised Air Quality Criteria Document for Particulate Matter
- 1992, 1994 Panel Member, USDA's National Research Initiative Competitive Grants Program
- 1992 Grand Awards Judge, 43rd International Science and Engineering Fair.
- 1988–1990 Contributing Author, EPA, Air Quality Criteria Document for Oxides of Nitrogen

### Awards and Honors

- 2020 Fellow, American Geophysical Union (AGU), awarded December 2020.
- 2020 Winner of the 2020 Nobel “Peat” Prize – International presented by MAC Ecohydrology, McMaster University for the article Hanson et al. 2020 *AGU Advances*: <https://doi.org/10.1029/2020AV000163>

- 2015 Significant Event Award for SPRUCE (Spruce and Peatland Responses Under Changing Environments), Oak Ridge National Laboratory
- 2008 Fellow, American Association for the Advancement of Science (AAAS), Section on Biological Sciences, elected November 2008
- 2004 Award for excellence in presentation of a paper, Soil Science Society of America, Division S-7, Annual meeting, October 31 – November 4, 2004, Seattle, Washington
- 2003 Award of Merit for a Book, Society for Technical Communication
- 2002 Award for excellence in presentation of a paper, Soil Science Society of America, Division S-7, Annual meeting, November 10–14, 2002, Indianapolis, Indiana
- 1995 Distinguished Scientific Achievement Award, Environmental Sciences Division Oak Ridge National Laboratory
- 1994 Award of Merit in Scholarly Articles, Society for Technical Communication
- 1988 Sigma Xi, elected to full membership
- 1986–1988 Postdoctoral Fellowship, Oak Ridge Associated Universities
- 1985 Graduate School Fellowship, University of Minnesota
- 1980 Phi Kappa Phi

#### Active Society Memberships

American Association for the Advancement of Science (AAAS) – Fellow  
 American Geophysical Union (AGU) – Fellow  
 Ecological Society of America (ESA) – Member  
 European Geophysical Union (EGU) – Life Member  
 Soil Science Society of America (SSSA) – Member

#### Students/Teachers Advised

Keith Rott 1987, Kelly Maas 1989, D. Susanne Ramer 1990, Cindy S. Fuhrer 1990, Stephanie Bohlman 1991–1992, Todd Tabberer 1993–94, Kristin Harter 1994–1995, James ‘Ben’ Stringfellow 1995, James Arnett 1995–1997, Tracy Misek 1996–1997, Jennifer Croker 1995–1997, M. Lala S. Chambers 1994–1997, T. Brendon Johnson 1996–1997, Morgan Castner 1997–1998, Mark Scannell 1999, Karen Voiles 1999, Philip Allen 2000–2001, Bridgette M. Boudreaux 2001 & 2005, Jason C. Fults 2001, Craig Wayson 2003–2005, Rebekah Wagner 2006–2007, Mats Fröberg 2006–2008, Jake Graham 2017-2020.

#### Faculty Sabbaticals Hosted

Yuling Fu, Chinese Academy of Sciences, 2009–2010; H.-J. Segschneider, Institut für Radioagronomie, Jülich, FRG, 1991; W. Hoffman, Denison University, Danville, Ohio, 1991–1992

#### Funded Proposals (2001– present)

Hanson, PJ et al. 2019. Third triennial *Science Plan and Progress Report for the Terrestrial Ecosystem Science Scientific Focus Area (TES SFA)*. U.S. Department

- of Energy, 2019 to 2022, Funded at \$8.3M per year. Extended to include FY2022 and FY2023.
- Hanson, PJ et al. 2015. Second triennial *Science Plan for the Oak Ridge National Laboratory Terrestrial Ecosystem Science Scientific Focus Area*. U.S. Department of Energy, 2016 to 2018, Funded at \$8.255M per year
- Hanson, PJ et al. 2012. *Extended Science Plan for the Oak Ridge National Laboratory Terrestrial Ecosystem Science Scientific Focus Area*. U.S. Department of Energy, 2013 to 2015, Funded at \$8M per year
- Hanson, PJ et al. *Science Plan for the Terrestrial Ecosystem Science Scientific Focus Area*. U.S. Department of Energy, 2010 to 2012, Funded at \$7 to 8M per year
- Hanson, PJ et al. *Science Plan for the Climate Change Response Science Focus Area*. U.S. Department of Energy, 2010 to 2013, Funded at \$5M per year
- Hanson, PJ et al. *Task 3 Component of the Science Plan for the Climate Change Forcing Science Focus*, U.S. Department of Energy, 2010 to 2013, ~\$400K per year
- Hanson PJ *Climate Change Response Science Focus Area*. 2007–2009, ~\$2.5M per year
- Hanson PJ *Program for Ecosystem Research Chief Scientist*. 2004–2009, ~\$200,000 per year
- Gu L, Hanson PJ, Pallardy SG, Wullschleger SD, Edwards NT. *Regulation of carbon sequestration and water use in an Ozark Forest: Proposing a new strategically located Ameriflux tower site in Missouri*. U.S. Department of Energy, 2003–2005, ~\$1.397M over three years.
- Hanson PJ, Tschaplinski TJ, Wullschleger SD, Augé RM. *Identifying Critical Thresholds for Plant/Ecosystem Response to Moisture Stress*. U.S. Department of Energy, 2002–2004, ~\$900,000 over three years.
- Hanson PJ, Trumbore SE, Gaudinski J, Southon J, Torn M, Jastrow J. *Enriched Background Isotope Study (EBIS)*, U.S. Department of Energy, 2002–2004, ~\$2.7M over three years.
- Hanson PJ. *Mechanisms of forest ecosystem adjustments to altered precipitation-the Walker Branch Throughfall Displacement Experiment (TDE)*. Renewal proposal 2002–2006, \$2.2M over five years.
- Hanson PJ and others. *Mechanisms of Forest Ecosystem Adjustment to Altered Precipitation - The Walker Branch Throughfall Displacement Experiment (TDE)*. Renewal proposal 1999–2001, \$2.6M over three years.

Publication Record

ORCID ID: <http://orcid.org/0000-0001-7293-3561>

**Web of Science ResearcherID:**

**D-8069-2011** [<https://publons.com/researcher/2792226/paul-j-hanson/>]

**Web of Science metrics (All Data Bases, November 2020)**

h-index = 61 with >14,000 citations for 167 indexed publications

**Scopus metrics, November 2020**

h-index = 60 with >13,800 citations for 162 indexed publications

## Google Scholar metrics, November 2020

h-index 71; i10-index 163; with >21,600 citations for over 300 items

## Published works and data sets (1 book; 216 articles; 34 data sets)

38 Publications with more than 100 citations as of November 2020

### Book:

**Hanson PJ**, Wullschleger SD, Editors (2003) *North American Temperate Deciduous Forest Responses to Changing Precipitation Regimes*. Springer, New York, 421 p.

### Articles, Book Chapters, and Key Reports:

1. Salmon VG, Brice DJ, Bridgham S, Childs J, Graham J, Griffiths NA, Hofmockel K, Iversen CM, Jicha TM, Kolka RK, Kostka J, Malhotra A, Norby RJ, Phillips JR, Ricciuto DR, Schadt CW, Sebestyen SD, Shi X, Walker AP, Warren JM, Weston DJ, Yang X, **Hanson PJ** (2021?) Nitrogen and phosphorus cycling in an ombrotrophic peatland: A benchmark for assessing change. *Plant and Soil* ([submitted](#)).
2. Horst AM, Santos-Medellín C, Sorensen JW, Zinke LA, Wilson RM, Johnston ER, Trubl GG, Pett-Ridge J, Blazewicz SJ, **Hanson PJ**, Chanton JP, Schadt CW, Kostka JE, Emerson JB (2021?) Minnesota peat viromes reveal terrestrial and aquatic niche partitioning for local and global viral populations. *Microbiome* ([submitted](#)).
3. Wilson RM, Tfaily MM, Zalman CM, Kolton MM, Johnston E, Petro C, **Hanson PJ**, Heyman HM, Kyle J, Hoyt DW, Eder EK, Purvine SO, Kolka RK, Sebestyen SD, Griffiths NA, Schadt CW, Keller JK, Bridgham SD, Chanton JP, Kostka JE (2020) Soil metabolome response to whole ecosystem warming at the Spruce and Peatland Responses Under Changing Environments experiment. *Proceedings of the National Academy of Sciences* ([resubmitted with revisions](#)).
4. Yuan F, Wang Y, Ricciuto DM, Shi X, Yuan F, **Hanson PJ**, Thornton PE, Xu X (2020) An Integrative Model for Soil Biogeochemistry and Methane Processes: II. Warming and Elevated CO<sub>2</sub> Effects on Peatland CH<sub>4</sub> Emission. *Journal of Geophysical Research - Biogeosciences* ([Revisions made and returned](#)).
5. Shi X, Ricciuto DM, Thornton PE, Xu X, Yuan F, Norby RJ, Walker AP, Warren J, Mao J, **Hanson PJ**, Meng L, Weston D, Griffiths NA (2020) Modeling the hydrology and physiology of *Sphagnum* moss in a northern temperate bog. *Biogeosciences* ([in press](#)) doi:10.5194/bg-2020-90
6. Defrenne CE, Childs J, Fernandez CW, Taggart M, Nettles WR, Allen MF, **Hanson PJ**, Iversen CM (2020) High-resolution minirhizotrons advance our understanding of roots-fungal dynamics in an experimentally-warmed peatland. *Plants, People, Planet* ([in press](#)), <https://doi.org/10.1002/ppp3.10172>.
7. Ricciuto DM, Xu X, Shi X, Wang Y, Song X, Schadt CW, Griffiths NA, Mao J, Warren JM, Thornton PE, Chanton J, Keller JK, Bridgham S, Gutknecht J, Sebestyen SD, Finzi A, Kolka RK, and **Hanson PJ** (2019) An interactive model for soil biogeochemistry and methane processes: I. model structure and

- sensitivity analyses. *Journal of Geophysical Research -Biogeosciences* (in press).
8. McPartland MY, Montgomery RA, **Hanson PJ**, Phillips JR, Kolka RK, Palik B (2020) Vascular plant species response to warming and elevated carbon dioxide in a boreal peatland. *Environmental Research Letters* 15:124066, <https://doi.org/10.1088/1748-9326/abc4fb>
  9. Poyatos R, Granda V, Flo V, Mencuccini M, Steppe K, Martínez-Vilalta J, SAPFLUXNET contributors [**Hanson PJ**, Norby RJ Wullschleger SD] (2020) Global transpiration data from sap flow measurements: the SAPFLUXNET database. *Earth System Science Data* doi:10.5194/essd-2020-227.
  10. Malhotra A, Brice D, Childs J, Graham JD, Hobbie EA, Vander Stel H, Feron SC, **Hanson PJ**, Iversen CM (2020) Peatland warming strongly increases fine-root growth. *Proceedings of the National Academy of Sciences* 117:17627-17634, doi:10.1073/pnas.2003361117
  11. **Hanson PJ**, Griffiths NA, Iversen CM, Norby RJ, Sebestyen SD, Phillips JR, Chanton JP, Kolka RK, Malhotra A, Oleheiser KC, Warren JM, Shi X, Yang X, Mao J, Ricciuto DM (2020) Rapid net carbon loss from a whole-ecosystem warmed peatland. *AGU Advances* 1, e2020AV000163. *AGU Advances* 1, e2020AV000163 doi:10.1029/2020AV000163
  12. Hopple AM, Wilson, RM, Kolton, M, Zalman, CA, Chanton JP, Kostka J, **Hanson PJ**, Keller JK, Bridgham SD (2020) Massive peatland carbon banks vulnerable to rising temperatures. *Nature Communication* 11:2373. doi:10.1038/s41467-020-16311-8
  13. Graham JD, Glenn NF, Spaete LP, **Hanson PJ** (2020) Characterizing peatland microtopography using gradient and microform-based approaches. *Ecosystems* 23:1464-1480. doi:10.1007/s10021-020-00481-z
  14. Paschalis A, Fatichi S, Zscheischler J, Ciais P, Bahn M, Boysen L, Chang J, De Kauwe M, Estiarte M, Goll D, **Hanson PJ**, Harper AB, Hou E, Kigel J, Knapp AK, Larsen KS, Li W, Lierert S, Luo Y, Meir P, Ogaya R, Parolari AJ, Peng C, Peñuelas J, Pongratz J, Rambal S, Schmidt IK, Shi H, Sternberg M, Tian H, Tschumi E, Ukkola A, Vicca S, Viovy N, Wang Y-P, Wang Z, Wu D, Zhu Q (2020) Rainfall-manipulation experiments as simulated by terrestrial biosphere models: where do we stand? *Global Change Biology* 26:3336-3355. doi:10.1111/gcb.15024.
  15. Kluber LA, Johnston ER, Allen SA, Hendershot JN, **Hanson PJ**, Schadt CW (2020) Constraints on microbial communities, decomposition and methane production in deep peat deposits. *PLOS ONE* 15(2):e0223744. doi:10.1371/journal.pone.0223744.
  16. **Hanson PJ**, Walker AP (2020) Invited Commentary: “Advancing global change biology through experimental manipulations: Where have we been and where might we go?” *Global Change Biology* 26:287-299. doi:10.1111/gcb.14894.
  17. Norby RJ, Childs J, **Hanson PJ**, Warren JM (2019) Rapid loss of an ecosystem engineer: Sphagnum decline in an experimentally warmed bog. *Ecology and Evolution* 9:12571-12585. doi:10.1002/ece3.5722.

18. Ward EJ, Warren JM, McLennan DA, Dusenge ME, Way DA, Wullschleger SD, **Hanson PJ** (2019) Photosynthetic and respiratory responses of two bog shrub species to whole ecosystem warming and elevated CO<sub>2</sub> at the boreal-temperate ecotone. *Frontiers in Forests and Global Change* 2:article 54, doi:10.3389/ffgc.2019.00054.
19. Carrell AA, Kolton M, Glass JB, Pelletier DA, Warren MJ, Kostka JE, Iversen CM, **Hanson PJ**, Weston DJ (2019) Experimental warming alters the composition, diversity and N<sub>2</sub> fixation activity of the peat moss (*Sphagnum fallax*) microbiomes. *Global Change Biology* 25:2993-3004. doi:10.1111/gcb.14715.
20. Jensen AM, Warren JM, King AW, Ricciuto DM, **Hanson PJ**, Wullschleger SD (2019) Simulated projections of boreal forest peatland ecosystem productivity are sensitive to observed seasonality in leaf physiology. *Tree Physiology* 39:556-572. doi:10.1093/treephys/tpy140.
21. Liang J, Wang G, Ricciuto DM, Gu L, **Hanson PJ**, Wood JD, Mayes MA (2019) Evaluating the E3SM Land Model at a temperate forest site using flux and soil water measurements. *Geoscientific Model Development* 12:1601-1612. doi:[10.5194/gmd-12-1601-2019](https://doi.org/10.5194/gmd-12-1601-2019).
22. Huang Y, Stacy M, Jiang J, Sundi N, Ma S, Saruta V, Jung CG, Shi Z, Xia J, **Hanson PJ**, Ricciuto D, Luo Y (2019) Realized ecological forecast through an interactive ecological platform for assimilating data (EcoPAD, v 1.0) into models. *Geoscientific Model Development* 12:1119–1137, doi:[10.5194/gmd-12-1119-2019](https://doi.org/10.5194/gmd-12-1119-2019).
23. Asbjornsen H, Campbell JL, Jennings KA, Vadeboncoeur MA, McIntire C, Templer PH, Phillips RP, Bauerle TL, Dietze MC, Frey SD, Groffman PM, Guerrieri R, **Hanson PJ**, Kelsey EP, Knapp AK, McDowell NG, Meir P, Novick KA, Ollinger SV, Pockman WT, Schaberg G, Wullschleger SD, Smith MD, Rustad L (2018) Guidelines and considerations for designing precipitation manipulation experiments in forest ecosystems. *Methods in Ecology and Evolution* 9:2310-2325, doi:10.1111/2041-210X.13094.
24. Krassovski MB, Lyon GE, Riggs JS, **Hanson PJ** (2018) Near real time environmental monitoring and large volume data collection over slow communication links. *Geoscientific Instrumentation, Methods and Data Systems* 7:289-295, doi:10.5194/gi-7-289-2018.
25. Richardson AD, Hufkens K, Milliman T, Aubrecht DM, Furze ME, Seyednasrollah B, Krassovski MB, Latimer JM, Nettles WR, Heiderman RR, Warren JM, **Hanson PJ** (2018) Ecosystem warming extends vegetation activity but heightens cold temperature vulnerability. *Nature* 560:368-371, doi:10.1038/s41586-018-0399-1.
26. Steinweg JM, Kostka JE, **Hanson PJ**, Schadt CW (2018) Temperature sensitivity of extracellular enzymes differs with peat depth but not with season in an ombrotrophic bog. *Soil Biology and Biochemistry* 125:244-250, doi:10.1016/j.soilbio.2018.07.001.
27. McFarlane KJ, **Hanson PJ**, Iversen CM, Phillips JR, Brice DJ (2018) Local spatial heterogeneity of Holocene carbon accumulation throughout the peat

- profile of an ombrotrophic Northern Minnesota bog. *Radiocarbon* 60:941-962, doi:10.1017/RDC.2018.37.
28. Jiang J, Huang Y, Ma S, Stacy M, Shi Z, Ricciuto DM, **Hanson PJ**, Luo Y (2018) Forecasting responses of a northern peatland carbon cycle to elevated CO<sub>2</sub> and a gradient of experimental warming. *Journal of Geophysical Research – Biogeosciences* 123: 1057-1071, doi:10.1002/2017JG004040.
  29. Smith RJ, Nelson PR, Jovan S, **Hanson PJ**, McCune B (2018) Novel climates reverse carbon uptake of atmospherically-dependent epiphytes: climatic constraints on the iconic boreal forest lichen *Evernia mesomorpha*. *American Journal of Botany* 105:266-274, doi:10.1002/ajb2.1022.
  30. Tfaily MM, Wilson RM, Cooper WT, Kostka JE, **Hanson P**, Chanton JP (2018) Vertical stratification of peat pore water dissolved organic matter composition in a peat bog in Northern Minnesota. *Journal of Geophysical Research – Biogeosciences* 123:479-494, doi:10.1002/2017JG004007.
  31. Iversen CM, Childs C, Norby RJ, Ontl TA, Kolka RK, Brice DJ, McFarlane KJ, **Hanson PJ** (2018) Fine-root growth in a forested bog is seasonally dynamic, but shallowly distributed in a nutrient-poor peat. *Plant and Soil* 424:123-143, doi:10.1007/s11104-017-3231-z.
  32. Griffiths NA, **Hanson PJ**, Ricciuto DM, Iversen CM, Jensen AM, Malhotra A, McFarlane KJ, Norby RJ, Sargsyan K, Sebestyen SD, Shi X, Walker AP, Ward EJ, Warren JM, Weston DJ (2017) Temporal and spatial variation in peatland carbon cycling and implications for interpreting responses of an ecosystem-scale warming experiment. *Soil Science Society of America Journal* 81:1668-1688, doi:10.2136/sssaj2016.12.0422.
  33. Barba J, Cueva A, Bahn M, Barron-Gafford GA, Bond-Lamberty B, **Hanson PJ**, Jaimes A, Kulmala L, Pumpanen J, Scott RL, Wohlfahrt G, Vargas R (2018) Comparing ecosystem and soil respiration: a review of tower-based and soil measurements challenges. *Agricultural and Forest Meteorology* 249:434-443, doi:10.1016/j.agrformet.2017.10.028.
  34. Ma S, Jiang J, Huang Y, Shi Z, Wilson RM, Ricciuto D, **Hanson PJ**, Luo Y (2017) Data-constrained projections of methane fluxes in a northern Minnesota peatland in response to elevated CO<sub>2</sub> and warming. *Journal of Geophysical Research – Biogeosciences* 122: 2841-2861, doi:10.1002/2017JG003932.
  35. Huang Y, Jiang J, Ma S, Ricciuto DM, **Hanson PJ**, Luo Y (2017) Soil thermal dynamics, snow cover and frozen depth under five temperature treatments in an ombrotrophic bog: constrained forecast with data assimilation. *Journal of Geophysical Research – Biogeosciences* 122:2046-2063, doi:10.1002/2016JG003725.
  36. Wilson RM, Tfaily MM, Rich VI, Keller JK, Bridgham SD, Medvedeff C, Meredith L, **Hanson PJ**, Hines M, Pfeifer-Meister L, Saleska SR, Crill P, Cooper WT, Chanton JP, Kostka JE (2017) Hydrogenation of organic matter as a terminal electron sink sustains high CO<sub>2</sub>:CH<sub>4</sub> production ratios during anaerobic decomposition. *Organic Geochemistry* 112:22-32, doi:10.1016/j.orggeochem.2017.06.011.
  37. Porras RC, Hicks Pries CE, McFarlane KJ, **Hanson PJ**, Torn MS (2017) Association with pedogenic iron and aluminum: effects on soil organic carbon



- storage and stability in four temperate forest soils. *Biogeochemistry* 133:333-345, doi:10.1007/s10533-017-0337-6.
38. Walker AP, Carter KR, Gu L, **Hanson PJ**, Malhotra A, Norby RJ, Sebestyen SD, Wullschleger SD, Weston DJ (2017) Biophysical drivers of seasonal variability in *Sphagnum* gross primary production in a northern temperate bog. *Journal of Geophysical Research - Biogeosciences* 122:1078-1097, doi:10.1002/2016JG003711.
  39. Hobbie EA, Chen J, **Hanson PJ**, Iversen CM, McFarlane KJ, Thorp NR, Hofmockel KS (2017) Long-term carbon and nitrogen dynamics at spruce revealed through stable isotopes in peat profiles. *Biogeosciences* 14:2481-2494, doi:10.5194/bg-14-2481-2017.
  40. **Hanson PJ**, Riggs JS, Nettles WR, Phillips JR, Krassovski MB, Hook LA, Gu L, Richardson AD, Aubrecht DM, Ricciuto DM, Warren JM, Barbier C (2017) Attaining whole-ecosystem warming using air and deep soil heating methods with an elevated CO<sub>2</sub> atmosphere. *Biogeosciences* 14:861–883, doi:10.5194/bg-14-861-2017.
  41. Wilson RM, Hoppole AH, Tfaily MM, Sebestyen S, Schadt CW, Pfeifer-Meister L, Medvedeff C, McFarlane K, Kostka JE, Kolton M, Kolka R, Kluber L, Keller J, Guilderson T, Griffiths N, Chanton JP, Bridgham S, **Hanson PJ** (2016) Stability of peatland carbon to rising temperatures. *Nature Communications* 7:13723, doi:10.1038/NCOMMS13723.
  42. Phillips RP, Ibanez I, D'Orangeville L, **Hanson PJ**, Ryan MG, McDowell N (2016) A belowground perspective on the drought sensitivity of forests: towards improved understanding and simulation. *Forest Ecology & Management* 380:309-320, doi:10.1016/j.foreco.2016.08.043.
  43. **Hanson PJ**, Gill AL, Xu X, Phillips JR, Weston DJ, Kolka RK, Riggs JS, Hook LA (2016) Intermediate-scale community-level flux of CO<sub>2</sub> and CH<sub>4</sub> in a Minnesota peatland: Putting the SPRUCE project in a global context. *Biogeochemistry* 129:255-272, doi:10.1007/s10533-016-0230-8.
  44. Xu X, Yuan F, **Hanson PJ**, Wullschleger SD, Thornton PE, Riley WJ, Song X, Graham DE, Song C, Tian H (2016) Reviews and syntheses: four decades of modeling methane cycling in terrestrial ecosystems. *Biogeosciences* 13:3735-3755, doi:10.5194/bg-13-3735-2016.
  45. Estiarte M, Vicca S, Peñuelas J, Bahn M, Beier C, Emmett BA, Fay PA, **Hanson PJ**, Hasibeder R, Kigel J, Kröel-Dulay G, Larsen KS, Lellei-Kovács E, Limousin JM, Ogaya R, Ourcival JM, Reinsch S, Sala OE, Schmidt IK, Sternberg M, Tielbörger K, Tietema A, Janssens IA (2016) Few multi-year precipitation-reduction experiments find a shift in the productivity-precipitation relationship. *Global Change Biology* 22:2570–2581, doi:10.1111/gcb.13269.
  46. Wenk ES, Callahan MA Jr., **Hanson PJ** (2016) Soil macro-invertebrate communities across a productivity gradient in deciduous forests of eastern North America. *Northeastern Naturalist* 23:25-44.
  47. McDowell N, **Hanson PJ**, Ibanez I, Phillips RP, Ryan MG (2016) Physiological Responses of Forests to Drought. [In: Vose JM, Clark JS, Luce CH, Patel-Weynand T (Eds.)], *Effects of drought on forests and rangelands in the United States: a comprehensive science synthesis*. Gen. Tech. Rep. WO-93b.

- Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. pp. 49-58.
48. Krassovski MB, Riggs JS, Hook LA, Nettles WR, Boden TA, **Hanson PJ** (2015) A comprehensive data acquisition and management system for an ecosystem-scale peatland warming and elevated CO<sub>2</sub> experiment. *Geoscientific Instrumentation Methods and Data Systems* 4:203–213, doi:10.5194/gi-4-203-2015, Data at doi: 10.3334/CDIAC/spruce.013.
  49. Shi X, Thornton PE, Ricciuto DM, **Hanson PJ**, Mao J, Sebestyen SD, Griffiths NA, Bisht G (2015) Representing northern peatland microtopography and hydrology within the Community Land Model. *Biogeosciences* 12:6463-6477, doi:10.5194/bg-12-6463-2015.
  50. D’Odorico P, Gonsamob A, Gough CM, Bohrer G, Morison J, Wilkinsone M, **Hanson PJ**, Gianelle D, Fuentes JD, Buchmann N (2015) The match and mismatch between photosynthesis and land surface phenology of deciduous forests. *Agricultural and Forest Meteorology* 214:25-38, doi:10.1016/j.agrformet.2015.07.005.
  51. Torn MS, Chabbi A, Crill P, **Hanson PJ**, Janssens IA, Luo Y, Hicks Pries C, Rumpel C, Schmidt MWI, Six J, Schrumpf M, Zhu B (2015) A call for international soil experiment networks for studying, predicting, and managing global change impacts. *Soil* 1:575-582.
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#### Abstracts and Presentations (2015–present)

Hanson PJ and SPRUCE Project Participants (2020) Ombrotrophic Peatland Responses to Warming and Elevated CO<sub>2</sub>: Implications for Ecosystem Carbon Exchange, Productivity and Greenhouse Gas Production After 3-Years of Manipulation. Invited Talk. Northern Arizona University, 31 January 2020.

- Hanson PJ, Norby RJ, Phillips JR, Warren JM, Griffiths NA, Iversen CM, Shi X, Ricciuto DM (2019) Ombrotrophic Peatland Responses to Warming and Elevated CO<sub>2</sub>: Implications for Ecosystem Carbon Exchange, Productivity and Greenhouse Gas Production after 3-Years of Manipulation. AGU Fall Meeting, Abstract Number: B31C-03, Oral talk, Session: B31C, 9–13 December 2019.
- Hanson PJ, Phillips JR, Norby RJ, Warren JM, Griffiths NA, Ricciuto DM (2019) Peatland Responses to Warming and Elevated CO<sub>2</sub>: CO<sub>2</sub> and CH<sub>4</sub> Flux Responses, the status of Vegetation Net Primary Production and Implications for Ecosystem Carbon Exchange After 3-Years of Manipulation. EGU Annual Meeting, EGU2019-11610 | Orals | Session BG2.15, 8–12 April 2019.
- Hanson PJ (2018) Peatland ecosystem responses to warming and the implications for ecosystem carbon gain or loss: A SPRUCE project overview. , Boise State University, 22 October 2018. (Invited Presentation)
- Hanson PJ, Phillips JR, Nettles WR, Heiderman R (2017) Recent carbon cycle dynamics in an ombrotrophic peatland: implications from warming and eCO<sub>2</sub> treatments and the role of vegetation layers in the flux of CO<sub>2</sub> and CH<sub>4</sub>, B42C-01. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Dusenge ME, Stinzianol JR, Warren JM, Ward EJ, Wullschleger SD, Hanson PJ, Way DA (2017) Thermal acclimation of photosynthesis and respiration differ across conifer species in a mature boreal peatland, B14A-04. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Graham J, Glenn NF, Spaete L, Hanson PJ (2017) Ecosystem structure and function in the SPRUCE chambers at fine resolution, B31D-2011. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Hopple A, Brunik K, Keller J, Pfeifer-Meister L, Woerndle G, Zalman C, Hanson P, Bridgham S (2017) How does whole ecosystem warming of a peatland affect methane production and consumption? B42C-02. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Krassovski M, Hanson PJ, Riggs JS, Nettles IV WR (2017) Near real time/low latency data collection for climate warming manipulations and an elevated CO<sub>2</sub> SPRUCE experiment, IN31C-0087. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Liang J, Ricciuto DM, Wang G, Gu L, Hanson PJ, Mayes MA (2017) A mechanistic diagnosis of the simulation of soil CO<sub>2</sub> efflux of the ACME Land Model, B41F-2034. AGU Fall Meeting, New Orleans, LA, 11-15 December 2017.
- Luo Y, Huang Y, Jiang J, Shuang M, Saruta V, Liang G, Hanson PJ, Ricciuto DM, Milcu A, Roy J (2017) Integration of research infrastructures and ecosystem models toward development of predictive ecology, B31H-03. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017. (Invited)
- Shi X, Ricciuto DM, Thornton PE, Hanson PJ, Xu X, Mao J, Warren J, Yuan F, Norby RJ, Sebastyen S, Griffiths N, Weston DJ, Walker A (2017) Representing Northern Peatland Hydrology and Biogeochemistry with ALM. B43G-2216. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Shuang MA, Huang Y, Jiang J, Ricciuto DM, Hanson PJ, Luo Y (2017) Acclimation of methane production weakens ecosystem response to climate warming in a

- northern peatland. B42C-04. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Shuang MA, Huang Y, Stacy M, Jiang J, Sundi M, Ricciuto DM, Hanson PJ, Luo Y, Saruta V (2017) EcoPAD - An interactive platform for near real-time ecological forecasting by assimilating data into model, B43I-01. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017. (Invited)
- Steinweg JM, Kostka JE, Hanson PJ, Schadt CW (2017) Temperature sensitivity differences with depth and season between carbon, nitrogen, and phosphorus cycling enzyme activities in an ombrotrophic peatland system, B51D-1829. AGU Fall Meeting, New Orleans, LA, 11–15 December.
- Phillips JR, Hanson PJ, Warren J, Ward E, Brice D, Graham J (2017) Peatland Woody Plant Growth Responses to Warming and Elevated CO<sub>2</sub> in a Southern-boreal Raised Bog Ecosystem, B43G-2217. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Ward EJ, Dusenge ME, Warren J, Murphy BK, Way D, King AW, McLennan D, Montgomery R, Stefanski A, Reich PB, Aguilar MC, Wullschleger S, Villanueva RB, Hanson PJ (2017) Ecophysiology at SPRUCE: Impacts of whole ecosystem warming and elevated CO<sub>2</sub> on leaf-level photosynthesis and respiration of two ericaceous shrubs in a boreal peatland, B32B-04. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Warren J, Ward EJ, Wullschleger SD, Hanson PJ (2017) Increased transpiration and plant water stress in a black spruce bog exposed to whole ecosystem warming, B11K-04. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Wilson R, Tfaily M, Chanton J, Rich VI, Saleska SR, Holmes B, Langford L, Hanson PJ, Bridgham SD, Hoppole A, Keller J, Cory A, Kostka JE (2017) Controls on methanogenesis in organic-rich anaerobic environments, B42C-08. AGU Fall Meeting, New Orleans, LA, 11–15 December 2017.
- Hanson PJ, Phillips JR, Graham J, Norby RJ, Warren JM, Wullschleger SD, Griffiths NA, Spaete L, Glenn N (2017) Peatland Responses to Warming and Elevated CO<sub>2</sub>: Early CO<sub>2</sub> and CH<sub>4</sub> Flux Responses and the Status of Vegetation Net Primary Production, ESA Annual Meeting, Portland, Oregon, 5–10 August 2017.
- Ward EJ, Dusenge ME, Warren JM, Way DA, Wullschleger SD, Hanson PJ (2017) Ecophysiology at SPRUCE: Impacts of whole ecosystem warming and elevated CO<sub>2</sub> in a boreal peatland forest. ESA Annual Meeting, Portland, Oregon, 5–10 August 2017.
- Hanson PJ, Griffiths N, Sebestyen S, Ricciuto D (2017) Whole-ecosystem-warming and elevated-CO<sub>2</sub> Results through 1.5 years of manipulation. Invited Presentation #1185 in the session on Climate Change Effects on Northern Peatlands: Results of Manipulative Experiments I, Society of Wetland Scientists 2017 Annual Meeting, San Juan, Puerto Rico, 5–8 April 2017.
- Hoppole A, Brunik K, Pfeifer-Meister L, Keller J, Woerndle G, Medvedeff C, Hanson P, Bridgham S (2017) How does whole-ecosystem warming of a peatland affect methane production? Invited Presentation #1556 in the session on Climate Change Effects on Northern Peatlands: Results of Manipulative Experiments I, Society of Wetland Scientists 2017 Annual Meeting, San Juan, Puerto Rico, 5–8 April 2017.

- Rush J, Medvedeff C, Hanna E, Woerndle G, Bridgham S, Hanson P, Keller J (2017) Effects of Temperature on Humic Substance Reduction in a Northern Minnesota Peatland. Invited Presentation #1463 in the session on Climate Change Effects on Northern Peatlands: Results of Manipulative Experiments I, Society of Wetland Scientists 2017 Annual Meeting, San Juan, Puerto Rico, 5–8 April 2017.
- Shi X, Ricciuto D, Hanson P, Thornton P, Xu X, Mao J (2017) Representing northern peatland hydrology and biogeochemistry with ALM land surface model. Invited Presentation #1177 in the session on Climate Change Effects on Northern Peatlands: Results of Manipulative Experiments II, Society of Wetland Scientists 2017 Annual Meeting, San Juan, Puerto Rico, 5–8 April 2017.
- Hanson PJ, McFarlane KJ, Griffiths NA, Ricciuto DM, Iversen CM, Kolka RK (2017) Peatland Carbon Cycle Responses to Warming and Elevated CO<sub>2</sub>: Early responses from the SPRUCE in situ manipulations. 2017 Joint NACP and AmeriFlux Principal Investigators Meeting, Bethesda, Maryland, 27–30 March 2017.
- Hanson PJ (2017) U.S. Eastern Forest Ecosystems and Drought Chronic and Acute Manipulation Insights (C-Nutrient Cycle Interactions). USDA Forest Service National Drought Meeting, San Antonio, Texas, 21–23 March 2017 (invited talk).
- Hanson PJ, Ricciuto DM, McFarlane KJ, Chanton P, Griffiths NA, Kolka RK, and additional Project Participants (2016) Peatland carbon impacts from warming and elevated CO<sub>2</sub>: initial responses from the SPRUCE in situ manipulations. Conference Abstract, 2016 The 10th INTECOL International Wetlands Conference, 19–24 September 2016, Changshu, China, p. 185.
- Hopple A, Keller JA, Medvedeff CA, Hanson P, Pfeifer-Meister L, Bridgham SD (2016) How does deep warming of a peatland affects methane production? Conference Abstract, 2016 The 10th INTECOL International Wetlands Conference, 19–24 September 2016, Changshu, China, p. 190.
- Kluber LA, Hendershot JN, Allen S, Yip DZ, Yang Z, Hanson PJ, Schadt CW (2016) Microbial community responses and limitations to deep peat heating at the SPRUCE experiment in Northern Minnesota. COS 90-7, ESA Annual Meeting, Fort Lauderdale, Florida, 7–12 August 2016.
- Hanson PJ, Riggs JS, Nettles WR, Phillips JR, Krassovski M, Hook LA (2016) Field performance of the SPRUCE whole-ecosystem warming facility for tall stature peatland vegetation. PS 18-46, ESA Annual Meeting, Fort Lauderdale, Florida 7–12 August 2016.
- Kolka RK, Hanson PJ (2016) Spruce and Peatland Responses Under Climatic and Environmental Change (SPRUCE) Experiment. 15<sup>th</sup> International Peat Congress. Kuching, Malaysia, 15–19 August 2016.
- Chanton J, Wilson R, Tfaily MM, Sebestyen SD, Medvedeff C, McFarlane KJ, Kolka RK, Kostka JE, Keller J, Hanson PJ, Guilderson TP, de La Cruz F, Cooper WT, Bridgham SD, Barlaz M (2015) The Stability of Peatland Carbon Stores to Global Change: Evidence for Enhanced Methane and Carbon Dioxide Production. B44B-01: AGU Fall Meeting, San Francisco, California, 14–18 December 2015.
- Guilderson TP, McFarlane KJ, McNicol G, Hanson PJ, Chanton J, Wilson R, Bosworth R, Singleton MJ (2015) Sources of Below-Ground Respired Carbon in a Northern Minnesota Ombrotrophic Spruce Bog and the Influence of Heating

- Manipulations. B41C-0460: AGU Fall Meeting, San Francisco, California, 14–18 December 2015.
- Iversen CM, Norby RJ, Childs J, McCormack ML, Walker AP, Hanson PJ, Warren J, Sloan VL, Sullivan PF, Wullschleger S, Powell AS (2015) Linking Belowground Plant Traits With Ecosystem Processes: A Multi-Biome Perspective. B51K-03: AGU Fall Meeting, San Francisco, California, 14–18 December 2015.
- Matthews E, Varner RK, Peng C, Hanson PJ - Conveners (2015) Natural Wetlands and Open Waters in the Global Methane Cycle: Modeling, Observations, and Challenges I. B41C: AGU Fall Meeting, San Francisco, California, 14–18 December 2015.
- McFarlane KJ, Iversen CM, Phillips JR, Brice DJ, Hanson PJ (2015) Holocene Carbon Accumulation Rates in the SPRUCE Bog Prior to Warming and Elevated CO<sub>2</sub> Treatment. B11H-0540: AGU Fall Meeting, San Francisco, California, 14–18 December 2015.
- Shi X, Ricciuto DM, Xu X, Thornton PE, Hanson PJ, Mao J, Sebestyen S, Griffiths N (2015) Representing Northern Peatland Hydrology and Biogeochemistry within the Community Land Model. B41C-0431: AGU Fall Meeting, San Francisco, California, 14–18 December 2015.
- Xu X, Yuan F, Hanson PJ, Wullschleger SD, Thornton PE, Tian H, Riley WJ, Song X, Graham DE, Song C (2015) Four decades of modeling methane cycling in terrestrial ecosystems: Where we are heading? B41C-0429: AGU Fall Meeting, San Francisco, California, 14–18 December 2015.
- Hanson PJ, Norby RJ, King AW, Glenn Wilson G (2015) Robert J. (Bob) Luxmoore – Soil physicist, plant physiologist, forester, pioneer elevated CO<sub>2</sub> researcher, modeler, activist, mentor and colleague. *Soil Science Society of American Annual Meeting*, Minneapolis, Minnesota, 17 November 2015, Session 181 Talk #1. (invited talk)
- Keller JK, Bridgman SD, Chanton J, Hanson PJ, Hopple A, Kostka JE, Medvedeff CA, Pfeifer-Meister L, Wilson R, McFarlane K, Guilderson TP, McNicol G (2015) Initial responses of methane cycling to deep peat heating in a bog ecosystem. Session 107 Talk #6, *Soil Science Society of American Annual Meeting*, Minneapolis, Minnesota, 17 November 2015.
- Estiarte M, Vicca S, Peñuelas J, Bahn M, Beier C, Emmett BA, Fay PA, Hanson PJ, Hasibeder R, Kigel J, Kröel-Dulay G, Larsen KL, Lellei-Kovács E, Limousin JM, Ogaya R, Ourcival JM, Sala OE, Smith AR, Schmidt IK, Sternberg M, Tielbörger K, Tietema A, Janssens I (2015) ANPP-precipitation relationships in multi-year drought experiments in natural ecosystems. OOS 58-8, Ecological Society of America Annual Meeting, August 9–14, 2015.
- Hanson PJ (2015) Chronic and acute precipitation manipulations in eastern deciduous forests: build wide, measure deep and be patient. OOS 58-7 Ecological Society of America Annual Meeting, August 9–14, 2015.



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