Adrianna C. Foster, Ph.D.

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https://adrifoster.github.io/

Research Interests

High-resolution modeling of forest ecosystems; remote sensing of vegetation characteristics, vegetation stress, and disturbances; and disturbance-vegetation-climate interactions.

Professional Experience

2021 – present **Project Scientist I,** National Center for Atmospheric Research, Terrestrial Sciences Section, Boulder, CO
Development and application of FATES-CTSM regionally and globally.

2018 – 2021 **Postdoctoral Researcher,** School of Informatics, Computing, and Cyber Systems, Northern Arizona University, Flagstaff, AZ
High resolution modeling of forest ecosystem dynamics of the Alaskan and Canadian boreal zone.

2016 – 2018 **Postdoctoral Fellow** NASA Postdoctoral Program, Goddard Space Flight Center, Greenbelt, MD.
Forest dynamics of the Alaskan boreal zone in response to shifting climate and disturbance regimes. Work utilized both individual tree-based modeling and analysis of high-resolution remote sensing data.

Education

2012 – 2016 **Ph.D., University of Virginia** Environmental Sciences
Dissertation title: *Understanding the combined effects of spruce beetle outbreaks and climate change on Rocky Mountains vegetation through ecological modeling*

2008 – 2012 **B.A., University of Virginia** Environmental Sciences
Distinguished Majors Program: *High Distinction*
Thesis title: *Ecology of Symmetrischema sp. (Lepidoptera: Gelechiidae) on Physalis spp.*

Publications

In Prep and In Review

1. Burrell, A., Cooperdock, S., Potter, S., Berner, L., Hember, R., Macander, M., Walker, X., Massey, R., **Foster**, **A. C.**, Mack, M., Goetz, S., & Rogers, B. (In Review). The predictability of near-term forest biomass change in boreal North America. *Ecological Applications*.

2. Hansen, W., **Foster**, **A. C.**, Gaglioti, B., Seidl, R., & Rammer, W. (In review). The Permafrost and Organic LayEr module for Forest Models (POLE-FM) 1.0. *EGUsphere*.
https://doi.org/10.5194/egusphere-2022-1062

3. Wang, S., **Foster**, **A. C.**, Lenz, E., Kessler, J., Stroeve, J., Anderson, L., Turetsky, M., Betts, R., Zou, S., Liu, W., Boos, W., & Hausfather, Z. (In Review). Mechanisms and impacts of climate tipping elements. *Reviews in Geophysics*.

In Press and Published

1. Massey, R., Berner, L., **Foster**, **A. C.**, Goetz, S., & Vepakomma, U. (In Press). Remote sensing tools for monitoring forests and tracking their dynamics. In M. Girona, H. Morin, S. Gauthier, & Y. Bergeron (Eds.), *Boreal Forests in the Face of Climate Change - Sustainable Management*. Springer-Nature Switzerland AG.

2. **Foster**, **A. C.**, Shuman, J., Rogers, B., Walker, X., Mack, M., Bourgeau-Chavez, L., Veraverbeke, S., & Goetz, S. (2022). Bottom-up drivers of future fire regimes in western boreal north america. *Environmental Research Letters*, *17*(2), 025006. https://doi.org/10.1088/1748-9326/ac4c1e

3. **Foster**, **A. C.**, Wang, J., Frost, G., Davidson, S., Hoy, E., Turner, K., Sonentag, O., Epstein, H., Berner, L., Armstrong, A., Kang, M., Rogers, B., Campbell, E., Miner, K., Orndahl, K., Bourgeau-Chavez, L., Lutz, D., French, N., Chen, D., … Goetz, S. (2022). Disturbances in North American boreal forest and tundra: Impacts, interactions, and responses. *Environmental Research Reviews*, *17*(11), 113001. https://doi.org/10.1088/1748-9326/ac98d7

4. Boyd, M., Berner, L., **Foster**, **A. C.**, Goetz, S., Rogers, B., Walker, X., & Mack, M. (2021). Historic declines in productivity portend trembling aspen death during a contemporary leaf miner outbreak in Alaska. *Ecosphere*, *12*(6), e03569. https://doi.org/10.1002/ecs2.3569

5. Cessna, J., Alonzo, M., **Foster**, **A. C.**, & Cook, B. (2021). Mapping boreal forest spruce beetle health status at the individual crown scale using fused spectral and structural data. *Forests*, *12*(9), 1145. https://doi.org/10.3390/f12091145

6. Raiho, A., Nicklen, E., **Foster**, **A. C.**, Roland, C. A., & Hooten, M. (2021). Bridging implementation gaps to connect large ecological datasets and complex models. *Ecology and Evolution*, *11*(24), 18271–18287. https://doi.org/10.1002/ece3.8420

7. Shugart, H., **Foster**, **A. C.**, Wang, B., Drukenbrod, D., Ma, J., Lerdau, M., Saatchi, S., Yang, X., & Yan, X. (2020). Gap models across micro- to mega-scales of time and space: Examples of Tansley's ecosystem concept. *Forest Ecosystems*, *7*(14). https://doi.org/10.1186/s40663-020-00225-4

8. **Foster**, **A. C.**, Armstrong, A., Shuman, J., Shugart, H., Rogers, B., Mack, M., Goetz, S., & Ranson, K. (2019). Importance of tree- and species-level interactions with wildfire, climate, and soils in interior Alaska: Implications for forest change under a warming climate. *Ecological Modelling*, *409*(1), 39–47. https://doi.org/10.1016/j.ecolmodel.2019.108765

9. Hess, K., Cullen, C., Cobian-Iniguez, J., Rumthun, J., Lenske, V., Magness, D. R., Bolton, J., **Foster**, **A. C.**, & Spruce, J. (2019). Satellite-based assessment of grassland conversion and related fire disturbance in the Kenai Peninsula, Alaska. *Remote Sensing*, *11*(3), 283. https://doi.org/10.3390/rs11030283

10. **Foster**, **A. C.**, Shuman, J., Shugart, H., & Negron, J. (2018). Modeling the interactive effects of spruce beetle infestation and climate on subalpine vegetation. *Ecosphere*, *9*(10), e02457. https://doi.org/10.1002/ecs2.2437

11. **Foster**, **A. C.**, Shuman, J., Shugart, H., Dwire, K., Fornwalt, P., Sibold, J., & Negron, J. (2017). Validation and application of a forest gap model to the southern Rocky Mountains. *Ecological Modelling*, *351*, 109–128. https://doi.org/10.1016/j.ecolmodel.2017.02.019

12. Shuman, J., **Foster**, **A. C.**, Shugart, H., Hoffman-Hall, A., Krylov, A., Loboda, T., Ershov, D., & Sochilova, E. (2017). Model-based evidence for cyclic phenomena in a high-elevation, two-species forest. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/aa5eed

13. **Foster**, **A. C.**, Walter, J., Shugart, H., Sibold, J., & Negron, J. (2016). Fire disturbance and climate change: Implications for Russian forests. *Forest Ecology and Management*, *384*, 347–357. https://doi.org/10.1016/j.foreco.2016.11.004

14. Yu, K., & **Foster**, **A. C.** (2015). Model-based predictions for hydraulic redistribution in tree-grass, CAM-grass, and tree-CAM associations: The implications of Crassulacean Acid Metabolism (CAM). *Oecologia*, *180*(4), 1113–1125. https://doi.org/10.1007/s00442-015-3518-9

Conference and Workshop Presentations

1. **Foster**, **A. C.** (2022a). CLM-FATES PPE: First steps in the calibration cascade. 2022 CESM Workshop. June 13. Boulder, C.O. Talk.

2. **Foster**, **A. C.** (2022b). FATES capabilities at NEON sites: Initialization, calibration, and parameter uncertainty. NCAR Land Model Working Group Meeting. February 1. Boulder, C.O. Talk.

3. **Foster**, **A. C.** (2021b). Multi-scale modeling of boreal forest ecosystems. NCAR-NEON Workshop. November 9. Boulder, C.O. Talk.

4. **Foster**, **A. C.**, Macander, M., Mack, M., Rogers, B., York, A., Lutz, D., & Goetz, S. (2021). Development of a forest modeling and management tool for testing climate and fire mitigation strategies. IBFRA 2021 Virtual Conference. August 16 - 20. Talk.

5. **Foster**, **A. C.**, & Shuman, J. (2021). Fine-scale vegetation-climate-disturbance interactions in the boreal forest: Can we use an individual-tree model to improve coarser scale models? CESM Land Model and Biogeochemistry Working Group Meeting. February 23-25. Talk.

6. Bonan, G., Shuman, J., & **Foster**, **A. C.** (2020). Moving beyond the incorrect but useful paradigm: Re-envisioning forests in earth system models. Abstract B041-04. AGU Fall 2020 Virtual Meeting. December 1-17. Talk.

7. Burrell, A., Cooperdock, S., Goetz, S., Mack, M., Hember, R., Berner, L., Massey, R., Potter, S., **Foster**, **A. C.**, Walker, X., & Rogers, B. (2020). Predicting biomass change at boreal North American forest inventory sites using long-term satellite vegetation indices and environmental drivers. NASA ABoVE 6th Science Team Virtual Meeting 2020. IPoster.

8. Burrell, A., Goetz, S., Cooperdock, S., Massey, R., Walker, X., Mack, M., Hember, R., Berner, L., **Foster**, **A. C.**, Potter, S., & Rogers, B. (2020). The predictability of near-term changes in forest biomass: A case study in boreal North America. Abstract B102-12. AGU Fall 2020 Virtual Meeting. December 1-17. eLightning Talk.

9. Cessna, J., Alonzo, M., **Foster**, **A. C.**, & Cook, B. (2020). Classification of boreal spruce tree status using UAV multispectral and G-LiHT hyperspectral imagery. Abstract B064-0004. AGU Fall 2020 Virtual Meeting. December 1-17. IPoster.

10. **Foster**, **A. C.**, Shuman, J., Berner, L., Rogers, B., Mack, M., & Goetz, S. (2020). Simulation of boreal treeline migration in a warming world. Abstract B100-01. AGU Fall 2020 Virtual Meeting. December 1-17. Talk.

11. **Foster**, **A. C.**, Shuman, J., Rogers, B., Walker, X., Mack, M., & Goetz, S. (2020). Wildfire interactions with climate and vegetation change in the North American boreal forest: Implications for shifting fire regimes under higher temperatures and an altered deciduous fraction. NASA ABoVE 6th Science Team Virtual Meeting 2020. IPoster.

12. Goetz, S., **Foster**, **A. C.**, Macander, M., Mack, M., Rogers, B., & York, A. (2020). Resiliency and vulnerability of boreal forest habitat across DoD lands of interior Alaska. SERDP ESTCP Virtual Symposium. November 30 - December 4. Poster.

13. Lutz, D., Palace, M., Yang, X., Sullivan, F., **Foster**, **A. C.**, Lerdau, M., & Shugart, H. (2020). Boreal forest model validation with discrete LiDAR and spectral-induced fluorescence remotely sensed data. NASA ABoVE 6th Science Team Virtual Meeting 2020. IPoster.

14. Shuman, J., **Foster**, **A. C.**, & Bourgeau-Chavez, L. (2020). Capturing fire-vegetation interactions with the dynamic size-structured vegetation model FATES-SPITFIRE in the Canadian boreal ecosystem. NASA ABoVE 6th Science Team Virtual Meeting. June 1-4. IPoster.

15. **Foster**, **A. C.**, Goetz, S., Rogers, B., Mack, M., Macander, M., Nelson, P., Shuman, J., & Shugart, H. (2019). Individual tree-based modeling within the ABoVE domain: Importance of fine-scale interactions with wildfire, climate, and soils and implications for future forest change. NASA ABoVE 5th Science Team Meeting. May 20-23. La Jolla, CA. Poster.

16. **Foster**, **A. C.**, Shuman, J., Rogers, B., Walker, X., Mack, M., & Goetz, S. (2019). Wildfire interactions with climate and vegetation change in the North American boreal forest: Implications for shifting fire

regimes under higher temperatures and an altered deciduous fraction. Abstract B24F-04. AGU Fall 2019 Meeting. December 9-13. San Francisco, CA. eLightning Poster.

17 Goetz, S., **Foster**, **A. C.**, Macander, M., Mack, M., Nelson, P., & Rogers, B. (2019). Mapping and modeling attributes of an arctic – boreal biome shift: Phase-1 accomplishments and Phase-2 plans within the ABoVE domain. NASA ABoVE 5th Science Team Meeting. May 20-23. La Jolla, CA. Poster.

18 Lutz, D., Lerdau, M., Palace, M., Yang, X., Shugart, H., & **Foster**, **A. C.** (2019). Dynamic modeling of forest ecosystem processes and services in North American boreal forests within the ABoVE study region. NASA ABoVE 5th Science Team Meeting. May 20-23. La Jolla, CA. Poster.

19 Lutz, D., Yang, X., Lerdau, M., Palace, M., **Foster**, **A. C.**, & Shugart, H. (2019). Pixel to process to price: A framework for remote sensing ecological model fusion analyses for ecosystem service evaluation. Abstract B23K-2451. AGU Fall 2019 Meeting. December 9-13. San Francisco, CA. Talk.

20 Armstrong, A., **Foster**, **A. C.**, Rogers, B., Hogg, T., Michaelian, M., Shuman, J., Shugart, H., & Goetz, S. (2018). Toward understanding dynamics in shifting biomes: An individual based modeling approach to characterizing drought and mortality in Central Western Canada. NASA ABoVE 4th Science Team Meeting. January 23-26. Seattle, WA. Poster.

21 **Foster**, **A. C.**, Armstrong, A., Shuman, J., Ranson, J., Shugart, H., Rogers, B., & Goetz, S. (2018). Combining high-resolution LiDAR and forest modeling to improve predictions of forest state across interior Alaska. Abstract 330. ForestSAT 2018 Meeting. October 1-5. College Park, MD. Talk.

22 **Foster**, **A. C.**, Armstrong, A., Shuman, J., Ranson, K., Shugart, H., Rogers, B., & Goetz, S. (2018). Multi-scale modeling of boreal forest vegetation growth under the influence of permafrost and wildfire interactions. NASA ABoVE 4th Science Team Meeting. January 23-26. Seattle, WA. Poster.

23 **Foster**, **A. C.**, Goetz, S., Rogers, B., Mack, M., Shuman, J., & Shugart, H. (2018). Increasing fire frequency in boreal alaska and its impact on forest composition, structure, and dynamics. Abstract GC44C-07B. AGU Fall 2018 Meeting. December 10-14. Washington, DC. Talk.

24 Armstrong, A., Rogers, B., **Foster**, **A. C.**, Hogg, T., Michaelian, M., Shuman, J., Shugart, H., & Goetz, S. (2017). Toward understanding dynamics in shifting biomes: An individual based modeling approach to characterizing drought mortality in Central Western Canada. Abstract B13J-03. AGU Fall 2017 Meeting. December 11-15. New Orleans, LA. Talk.

25 **Foster**, **A. C.**, Armstrong, A., Shuman, J., Ranson, J., Shugart, H., Rogers, B., & Goetz, S. (2017). Multi-scale modeling of boreal forest vegetation growth under the influence of permafrost and wildfire interactions. Abstract B12C-05. AGU Fall 2017 Meeting. December 11-15. New Orleans, LA. Talk.

26 Shugart, H., Wang, B., Armstrong, A., & **Foster**, **A. C.** (2017). Gap models as tools for sustainable development under environmental changes in northern Eurasia. Abstract GC32C-02. AGU Fall 2017 Meeting. December 11-15. New Orleans, LA. Talk.

27 **Foster**, **A. C.** (2016). Understanding spruce beetle outbreak dynamics: Hyperspectral detection of early stage spruce beetle infestation in Engelmann spruce. Virginia Space Grant 2016 Conference. April 11. NASA Langley, VA. Talk.

28 **Foster**, **A. C.**, Shuman, J., Shugart, H., Dwire, K., Fornwalt, P., Sibold, J., & Negron, J. (2016). Model-based evidence for persistent species zonation shifts in the southern Rocky Mountains under a warming climate. Abstract B53A-0522. AGU Fall 2016 Meeting. December 12-16. San Francisco, CA. Poster.

29 **Foster**, **A. C.**, Shuman, J., Shugart, H., & Negron, J. (2016). The interaction between climate change, bark beetles, and fire, and its effect on subalpine vegetation. IUFRO Unit 8.01.06 Boreal and Alpine Forest Ecosystems: Climate-Induced Range Shifts in Boreal Forest Pests, Ecological, Economic, and Social Consequences. July 11-15. Sept Iles, Quebec, Canada. Talk.

30. **Foster**, **A. C.**, Shuman, J., Shugart, H., & Negron, J. (2015). The response of subalpine vegetation to climate change and bark beetle infestation: A multi-scale interaction. Abstract GC21A-1082. AGU Fall 2015 Meeting. December 14-18. San Francisco, CA. Poster.

31. Shuman, J., **Foster**, **A. C.**, Hoffman-Hall, A., Loboda, T., & Shugart, H. (2015). Doubling the Russian fire frequency: Implications for forest biomass and composition. Abstract GC33F-05. AGU Fall 2015 Meeting. December 14-18. San Francisco, CA. Talk.

32. **Foster**, **A. C.**, Shuman, J., & Shugart, H. (2014). The response of vegetation zonation in Rocky Mountain ecotones to climate change. Abstract GC23E-0685. AGU Fall 2014 Meeting. December 15-19. San Francisco, CA. Poster.

Departmental Talks

1. **Foster**, **A. C.** (2022c). Forest ecosystem modeling: From theory and development to calibration and testing. NEON Science Monthly Seminar. February 8. Boulder, C.O.

2. **Foster**, **A. C.** (2021a). Disturbances within the North American boreal and arctic domains.. NCAR Climate and Global Dynamics Seminar. October 26. Boulder, CO.

3. **Foster**, **A. C.** (2019). Modeling vegetation response to disturbances and climate in forested landscapes. National Center for Atmospheric Research. August 22. Boulder, CO.

4. **Foster**, **A. C.** (2018a). Individual-based modeling of forest ecosystems. NASA Goddard Space Flight Center SED Director's Seminar. January 5. Greenbelt, MD.

5. **Foster**, **A. C.** (2018b). Modeling vegetation response to disturbances and climate in forested landscapes. Lawrence-Berkeley National Lab Seminar. April 17. Berkeley, CA.

6. **Foster**, **A. C.** (2017). Modeling vegetation response to bark beetles and climate in forested landscapes. NASA Biospheric Sciences Lab Brown Bag Seminar. February 1. Greenbelt, MD.

Grants

2022 – 2025

- **NASA Terrestrial Ecology, Arctic Boreal Vulnerability Experiment**, *Mapping and modeling attributes of an arctic – boreal biome shift: Phase-3 applications within the ABoVE domain* Co-Investigator (unfunded). (full award: $1,248,063 PI Goetz)
- **NASA Terrestrial Ecology, Arctic Boreal Vulnerability Experiment**, *Integrating remote sensing and modeling to better understand the vulnerability of boreal-taiga ecosystems to wildfire* Co-Investigator. (full award: $853,319 PI Bourgeau-Chavez)

2019 – 2022

- **NASA Terrestrial Ecology, Arctic Boreal Vulnerability Experiment**, *Mapping and modeling attributes of an arctic-boreal biome shift: Phase-2 applications within the ABoVE domain.* Co-Investigator. $65,477 (full award: $889,987 PI Goetz)
- **NASA Terrestrial Ecology, Arctic Boreal Vulnerability Experiment**, *Dynamic modeling of ecosystem processes and services in North American boreal forests within the ABoVE study region* Unfunded Collaborator (full award: $680,138 PI Lutz)
- **NASA Terrestrial Ecology, Arctic Boreal Vulnerability Experiment**, *Understanding the interactions between wildfire disturbance, landscape hydrology and post-fire recovery in boreal-taiga ecosystems.* Unfunded Collaborator (full award: $798,098 PI Bourgeau-Chavez)

2015 – 2018

- **NASA Terrestrial Ecology, Arctic Boreal Vulnerability Experiment**, *Mapping and modeling attributes of an arctic-boreal biome shift: Resource management implications.* Unfunded Collaborator (full award: $941,930 PI Goetz)

Grants (continued)

2016 – 2018 **NASA Postdoctoral Program**, *Multi-scale modeling of the interaction of climate change and disturbance effects on vegetation growth in the boreal forests of interior Alaska*. $61,000/year, Postdoctoral Fellow.

2014 – 2016 **Virginia Space Grant Consortium**, *Understanding spruce beetle outbreak dynamics and their response to climate change*. $11,000, Graduate Student Fellow.

Professional Service

Member — American Geophysical Union

Reviewer — *Agricultural Forest Meteorology* • *Biogeosciences* • *Ecology* • *Ecosystems* • *Environmental Research Letters* • *Forests* • *Forest Ecology and Management* • *Forest Ecosystems* • *Geoscientific Model Development* • *Global Change Biology* • *Journal of Biogeography* • *PLOS ONE* • *Weather and Forecasting*

Guest Editor — *Forests* Special Issue: "Simulation Modeling of Forest Ecosystems"
Environmental Research Letters Focus Issue: "Focus on Coupled Climate Change, Human and Fire Impacts on Terrestrial Ecosystems"

Proposal Panelist — NASA FINESST

Conference Sessions — Co-Chair AGU Session: "Forest Disturbances and Resulting Changes in Structure, Composition, and Biogeochemistry I, II, and III" Sessions B51D and B52B Oral and B55A Poster. AGU Fall 2021 Meeting. December 13-17. New Orleans, LA.
Co-Chair IBFRA Sessions: "Sessions 9a and 9b: Observed and predicted changes in boreal forest productivity and demographics" International Boreal Forest Research Association 2021 Virtual Meeting. August 16-20.
Co-Chair AGU Session: "Forest Disturbance in the Context of Shifting Climate: Understanding Disturbances and their Interactions as Agents of Forest Change I and II" Sessions B059 Oral Panel and B064 Poster. AGU Fall 2020 Virtual Meeting. December 1-17.
Co-Chair AGU Session: "Forest Disturbance in the Context of Shifting Climate: Understanding Disturbances and their Interactions as Agents of Forest Change I and II" Sessions B52C Oral and B53H Poster. AGU Fall 2019 Meeting. December 9-13. San Francisco, CA.
Co-Chair AGU Session: "Monitoring Forest Structure, Productivity, and Change at the Intersection of Forest Modeling, Remote Sensing, and Field Measurements I and II." Sessions B31B Oral and B33N Poster. AGU Fall 2018 Meeting. December 10-14. Washington, DC.
Co-Chair AGU Session: "Drivers and Consequences of Changing Forest Productivity Using Individual-Based Models, Remote Sensing, and Field Measurements I and II." Sessions B32B Oral and B33B Poster. AGU Fall 2017 Meeting. December 11-15. New Orleans, LA.

Liaison and Judge — AGU Outstanding Student Presentation Awards (2017-2020)

Teaching and Mentoring

Science Advisor - NASA DEVELOP Program

Summer 2018 — Project title: *Evaluating Grassland Conversion and the Related Likelihood of Fire Disturbance to Enhance Fire Monitoring and Management in the Kenai Peninsula, Alaska*.

Spring 2018 — Project title: *Mapping Tree-line Rise and Wetland Conversion in Order to Supplement Resource Management Actions in a Changing Alaskan Climate.*

Teaching Assistant - Environmental Sciences, University of Virginia

Fall 2014 and 2015 — Management of Forest Ecosystems Lab
20 upper-level majors/graduates

Spring 2015 and 2016 — Forest Sampling Lab
15 upper-level majors/graduates

Guest Lecturer

Spring 2020 — Graduate Ecological Modeling; Northern Arizona University

Mentoring

Graduate Mentoring — Shelby Sundquist (2021-present)

Undergraduate Mentoring — Megan McDaniels (Spring 2016); Laura Edelman (Spring 2014)

Awards and Achievements

2014 — **Graduate Student Ecology Award**, For high achievement in Graduate Ecology at the University of Virginia; out of 60 students.

2012 — **Mahlon G. Kelly Prize**, For high achievement in Undergraduate Ecology at the University of Virginia; out of 100 students.

Skills

Programming — Fortran, Python, and R

Data Analysis — Utilization of high performance clusters for large data analysis and modeling
Handling and manipulation of large ecological and environmental datasets
Analysis of remote sensing data and imagery in R and GEE

Science Communication — Utilization of 3-D modeling and animation software for data visualization