CHRISTOPHER R. HAKKENBERG

Postdoctoral Scholar, GEODE lab
School of Informatics, Computing, and Cyber Systems
Northern Arizona University

www.chrishakkenberg.wixsite.com/home
chris.hakkenberg@nau.edu

RESEARCH INTERESTS

Ecology: community ecology, macroecology, biogeography, forest structure and dynamics
Remote sensing: LiDAR, image spectroscopy, broad-band optical time series
GIScience: geospatial analysis, ecoinformatics, data visualization
Statistics: multivariate, spatial, hierarchical, nonparametric, prediction and inference
Applications: biodiversity conservation, human-environment, land cover change, urbanization

EDUCATION

2017	PhD	Ecology	**University of North Carolina**, Chapel Hill, NC
2007	MA	Regional Studies East Asia	**Harvard University**, Cambridge, MA
2004	BA	Chinese Studies	**Reed College**, Portland, OR

APPOINTMENTS

	Northern Arizona University, Flagstaff, AZ
2019 –	Postdoctoral Scholar, GEODE lab (PI: Scott Goetz) School of Informatics, Computing, and Cyber Systems
	Rice University, Houston, TX
2017 –	Kinder Scholar, Kinder Institute for Urban Research
2017 – 2019	Postdoctoral Research Fellow, Rice Academy of Fellows Department of Statistics
	National Aeronautics and Space Administration (NASA)
2014 – 2017	Fellow, Earth and Space Science Program
	University of North Carolina, Chapel Hill, NC
2014	Instructor, Department of Geography
2011 – 2014	Teaching Assistant, Ecology / Geography
2010 – 2011	**Yale University**, New Haven, CT University Fellow, Forestry and Environmental Science
	Solarbuzz LLC, San Francisco, CA
2007 – 2010	Consultant
	The Nature Conservancy (TNC), Kunming, China
2007	Communications Assistant
	Harvard University, Cambridge, MA
2005 – 2007	Research Assistant, East Asian Languages and Civilizations
2006	Secretary, Harvard Beijing Academy
	World Wildlife Fund (WWF), Kunming, China
2005	Research Intern

PUBLICATIONS

In Print *(* denotes equal contribution)*

Cawse-Nicholson, K. et al. (2021). *The world of surface imaging algorithms: NASA's Surface Biology and Geology Designated Observables*. **Remote Sensing of Environment**. 257, 112349.

Fagua, J.C., Jantz, P., Burns, P., Massey, R., Buitrago, J.Y., Saatchi, S., Hakkenberg, C.R., and S.J. Goetz. (2021). *Mapping tree diversity in the tropical forest region of Chocó-Colombia*. **Environmental Research Letters.**

Hakkenberg, C.R., R.K. Peet, T.R. Wentworth, T.R. Zhu and M.P. Schafale. (2020). *Tree canopy cover constrains the fertility–diversity relationship in plant communities of the southeastern USA*. **Ecology**. 101 (10), e03119.

Smiley, K.T. and C.R. Hakkenberg*. (2020). *Race and affluence shape spatio-temporal urbanization trends in Greater Houston, 1997 to 2016*. **Land Use Policy**. 99, 105093.

Hakkenberg, C.R., M.P. Dannenberg, C. Song, and G. Vinci. (2020). *Automated continuous fields prediction from Landsat time series: application to fractional impervious cover*. **IEEE Geoscience and Remote Sensing Letters**. 17 (1) 132-136.

Hakkenberg, C.R., M.P. Dannenberg, C. Song and K.B. Ensor. (2019). *Characterizing multi-decadal, annual land cover change dynamics in Houston, TX based on automated classification of Landsat imagery*. **International Journal of Remote Sensing**. 40 (2) 693-718.

Hakkenberg, C.R., K. Zhu, R.K. Peet and C. Song. (2018). *Mapping multi-scale vascular plant richness in a forest landscape with integrated LiDAR and hyperspectral remote-sensing*. **Ecology**. 99(2), 474-487.

Dannenberg, M.P, C. Song, and C.R. Hakkenberg. (2018). *A long-term, consistent land cover database for the southeastern United States using Automatic Adaptive Signature Generalization (AASG)*. **Photogrammetric Engineering & Remote Sensing**. 84 (9): 559–568.

Hakkenberg, C.R., R.K. Peet, D.L. Urban, and C. Song. (2018). *Modeling plant composition as community continua in a forest landscape with LiDAR and hyperspectral remote sensing*. **Ecological Applications**. 28(1), 177-190.

Dannenberg, M.P., C.R Hakkenberg, C. Song. (2016). *Consistent classification of Landsat time series with an improved automatic adaptive signature generalization algorithm*. **Remote Sensing**. 8(8), 691.

Hakkenberg, C.R., C. Song, R.K. Peet, and P.S. White. (2016). *Forest Structure as a Predictor of Tree Species Diversity in the North Carolina Piedmont*. **Journal of Vegetation Science**. 27(6), 1151-1163.

Hakkenberg, C.R. (2008). *Biodiversity and Sacred Sites: Vernacular Conservation Practices in Northwest Yunnan, China*. **Worldviews: Environment, Culture, and Religion**. Vol. 12, No. 1.

Book Chapters

Hakkenberg, C.R., D.D. Tarasi, S.C. Cushman, and R.K. Peet. (2021). *Community - Continuum in Biogeography*. In: **International Encyclopedia of Geography: People, the Earth, Environment, and Technology**. Wiley-AAG, Oxford, UK.

Zhang, Q., Hakkenberg, C.R. and C. Song. (2018). *Evaluating the Effectiveness of Forest Conservation Policies with Multi-temporal Remotely Sensed Imagery*. In: **Comprehensive Remote Sensing (Volume 9): Remote Sensing Applications for Societal Benefits**. Elsevier. 39-58.

Hakkenberg, C.R., D.D. Tarasi, and R.K. Peet. (2017). *Community/Continuum in Biogeography*. In: **International Encyclopedia of Geography: People, the Earth, Environment, and Technology**. Wiley-AAG, Oxford, UK. 882-885.

Song, C., J. Chen, T. Hwang, A. Gonsamo, H. Croft, Q. Zhang, M.P. Dannenberg, Y. Zhang, C.R. Hakkenberg and J. Li. (2015). *Ecological Characterization of Vegetation Using Multi-Sensor Remote Sensing in the Solar Reflective Spectrum*. In: **Remote Sensing Handbook Vol. 2: Land Resources Monitoring, Modeling, and Mapping with Remote Sensing**. Taylor and Francis. 533-575.

Other Publications and Data Products

Hakkenberg, C. R. (2019). *Houston Subannual Percent Impervious (SPI) Land Cover Dataset: 1997-2018*. [Data set]. Rice University-Kinder Institute: UDP. doi.org/10.25612/837.d8nxbzwj01ad

Hakkenberg, C.R. (2018). *Greater Houston Land Cover Change Dataset: 1997-2017 (Version 2)* [Data set]. Rice University-Kinder Institute: Urban Data Platform. doi.org/10.25612/837.al72581lw7md

Hakkenberg, C.R. (2017). *Mapping Plant Diversity and Composition Across North Carolina Piedmont Forest Landscapes Using Lidar-Hyperspectral Remote Sensing*. Ph.D. Dissertation, Curriculum for Environment and Ecology, University of North Carolina at Chapel Hill.

Dannenberg, M.P., Hakkenberg, C.R. and C. Song. (2016). *Automatic Adaptive Signature Generalization (AASG) in R*. DOI: 10.17632/s7c3vfr84w.1

Hakkenberg, C.R. (2008). *Greener Forests: Vernacular Conservation Practices and Biodiversity in Southwest China*. VDM Press.

Hakkenberg, C.R. (2008*). Re-articulating Literary Dissent: An Analysis of Wang Shuo's Playing for Thrills*, VDM Press.

Hakkenberg, C.R. (2007). 文化对话: Cultural Dialogues in *汉语世界 - The World of Chinese*. Vol. 1.

Tu, W. (2006). 笔论中国 [Writings on China] in S. Feng and Y. Feng, 用中文谈中国 [China Issues in Chinese Prose]. Trans. C.R. Hakkenberg. Beijing, PRC: BLCU Press.

Feng, S. and Y. Feng (2006). 序言 [Preface] in 文以载道: 汉语综合教程（五年级） [Writing and Truth: A Comprehensive Course in Mandarin (Level 5)]. Trans. C.R. Hakkenberg. Beijing, PRC: Higher Education Press.

Wu, Y. (2004). 扶贫开发与环境协调指导手册 [Harmonizing the Development of Poverty Alleviation and the Environment: A Guide Book]. Trans. C.R. Hakkenberg. Kunming, PRC: WWF and Yunnan Government Poverty Alleviation Office.

GRANTS, FELLOWSHIPS & AWARDS

External Grants

Pending

Timely prediction of wildfire burn severity in Californian forests with spaceborne observations of 3D vegetation structure. PI: M. Clark. Co-I: C.R. Hakkenberg *(Pending)*. **CAL FIRE: California Climate Investments Forest Health Program.** $443,737. 6/2021-5/2024.

Surface temperature extremes and their impacts on productivity and disturbance across northern conifer forests assessed with satellite remote sensing, in situ observations, and ecological modeling (Pending). PI: L. Berner; Co-I: C.R. Hakkenberg. **NASA: The Science of TERRA, AQUA, SUOMI NPP, and JPSS Series Satellites.** $825,000. 8/2021 – 7/2024.

Selected

Understanding the Impact of Land Cover/Land Use Change on Plant Diversity: Scaling from Plots to Landscapes Using Multi-Sensor Remote Sensing. PI: C. Song, Graduate Student: C.R. Hakkenberg. **NASA Earth and Space Science Fellowship**. $90,000, 08/01/2014 - 07/31/2017.

Filling in the Gaps: Restoring Forest Ecosystems in SW China. PI: Christopher Hakkenberg. **NSF East Asia and Pacific Summer Institute**. $12,500 (+ stipend and research funds), 06/01/2012 - 08/05/2012.

The Lost Voices: The Impact of the Development and Preservation Policies upon the Local People of Wudang Shan. PI: Christopher Hakkenberg. **Luce Foundation Grant for Undergraduate Research in Chinese Studies**. $3000. 05/15/2004 - 08/15/2004

Internal Grants

The Cost of Mangrove Encroachment on Tidal Salt Marsh Habitat: Quantifying the Ecological and Economic Impacts. PI: A.M.S. Correa, Co-PIs: S.P. Egan, C.R. Hakkenberg, P.R. Hartley. Creative Ventures Fund: **InterDisciplinary Excellence Awards (IDEA)**, $75,000. 5/10/2018 - 5/9/2020.

Greater Houston Land Cover Change Dataset: 1997-2017. PI: C.R. Hakkenberg. Co-PI: K.B. Ensor. Kinder Institute for Urban Research **Urban Data Platform (UDP)**, $15,000. 3/1/2017 - 7/30/2017.

Urbanization and Biodiversity in the 21st Century American South: Tracking Regional Change from Space. PI: C.R. Hakkenberg. **Center for the Study of the American South**, $3000. 6/1/2015 - 8/30/2015.

Spatio-temporal dynamics of land cover change in the Piedmont, NC. PI: C.R. Hakkenberg. **Kevin Satisky and Judith Thorn Summer Research Fellowship**. $4000. 6/1/2013 - 8/30/2013.

Spatio-temporal Dynamics of Forest Recovery: Ecological Outcomes of Human-Environment Interactions in China's Rural Reforestation Programs. PI: C.R. Hakkenberg. **Carolina Asia Center Pre-dissertation Asia Travel Award**, $2000. 2013. (*declined*)

Fellowships and Scholarships

2017-2019	Rice Academy Fellowship, Rice University
2010-2011	University Fellowship, Yale University
2005-2007	Graduate School Fellowship, Harvard University
2003	Starr Foundation Chinese Scholarship
2002	Starr Foundation Chinese Scholarship

1999 Donald Flanders Scholarship

Awards

2012 NASA-MSU Professional Enhancement Award
2012 UNC Innovative Use of GIS Competition
2004 Commendation for Excellence for Academic Performance, Reed College

SELECTED SCHOLARLY PRESENTATIONS

Invited Lectures

2019 "Subannual mapping of impervious surface in the Houston metropolitan area," *SICCS Ecoinformatics Seminar Series*, Northern Arizona University, Flagstaff, AZ.

"Automated characterization of subannual urbanization dynamics in Houston using satellite remote-sensing" *Machine Learning Seminar Series,* Rice University, Houston, TX.

"From forests to cities: spatio-temporal dynamics of complex socio-ecological systems" *Geography Seminar*. University of Tennessee, Department of Geography, Knoxville, TN.

2018 "Monitoring Two Decades of Urbanization in Houston from Space" *Rice Data Science Conference*, Houston, TX.

2017 "Spatio-temporal dynamics of land cover change in the greater Houston area: 1997-2016" *NASA Data Science Day 2*.0. Johnson Space Center*,* Houston, TX.

"Modeling landscape turnover in vascular plant composition in heterogeneous forests." *Department of Forestry Spring Seminar Series*, University of Kentucky, Lexington, KY.

"Mapping landscape plant diversity and composition using LiDAR-hyperspectral remote sensing." *Vanzant Lecture Series*. Rice University, BioSciences. Houston, TX.

"Land cover change in Houston." *NASA Lecture Series on Sustainability,* NASA Johnson Space Center, Houston, TX.

2015 "Monitoring Biodiversity with Remote Sensing: Opportunities and Challenges." *US-China Biodiversity Workshop*. Raleigh, NC.

2014 "Tracking Forest Dynamics from Space: Remote Sensing and the History of Vegetation Mapping." *New Hope Audubon Society Invited Lecture*. Chapel Hill, NC.

Presentations

2020 "Scale Dependence in the Relationship between Forest Structural Diversity and Vascular Plant Diversity across Ecoclimatic Gradients" *American Geophysical Union (AGU) Fall Meeting*. San Francisco, CA.

"Bioclimatic constraints on the relationship between forest structure and biodiversity across all NEON sites." *Ecological Society of America (ESA) Annual Meeting*. Salt Lake City, UT.

2019 "Characterizing high-order spatio-temporal urbanization dynamics from remotely-sensed time series" *American Geophysical Union (AGU) Fall Meeting*. San Francisco, CA.

"Automated prediction of subannual continuous fields impervious fractional cover dynamics" *Association of American Geographers (AAG) Annual Meeting*, Washington DC.

"Characterizing urbanization in Houston with satellite remote sensing," *Urban Affairs Association (UAA) Conference.* University of California, Los Angeles (UCLA).

2018 "Discrete and continuous approaches to characterizing subannual urbanization dynamics from multi-scene, multi-decadal Landsat imagery" *American Geophysical Union (AGU) Fall Meeting*. Washington, DC.

"Leveraging remote sensing time series to characterize annual land-cover dynamics in greater Houston over two decades." *Association of American Geographers (AAG) Annual Meeting*, New Orleans, LA.

2017 "Spatio-temporal dynamics of land cover change in the Greater Houston Area: 1997-2017." *Smalley-Curl Institute Lecture Series*. Houston, TX.

"Houston land cover dynamics: 1997-2016." *Texas A&M Center for Texas Beaches and Shores and Kinder Institute Joint Workshop*, Galveston, TX.

"Mapping multi-scale vascular plant species richness in a Carolina Piedmont landscape using LiDAR-hyperspectral remote sensing." *Ecological Society of America (ESA) Annual Meeting*. Portland, OR.

"Mapping landscape turnover in plant diversity and composition with G-LiHT." *NASA Biodiversity and Ecological Forecasting Team Meeting*, Washington DC.

"Multi-decadal spatio-temporal land-cover dynamics in the greater Houston area: Landsat time series generation using Automatic Adaptive Signature Generalization." *The Kinder Institute Urban Data Platform Launch*. Houston, TX.

"Mapping plant diversity and composition in Duke Forest." *NASA Biodiversity and Ecological Forecasting Team Meeting*, Washington DC. (poster)

2016 "Remotely-sensed predictive models of forest composition: community-unit classification versus continuous gradient modeling." *American Geophysical Union (AGU) Fall Meeting*. San Francisco, CA.

"Evaluating forest structure and foliar reflectance for modeling forest community properties in the NC Piedmont." *US – International Association of Landscape Ecology (US-IALE) Annual Conference*. Asheville, NC. (poster)

"Predictive models of forest community gradients using G-LiHT." *NASA Biodiversity and Ecological Forecasting Team Meeting*, Silver Spring, MD. (poster)

2015 "Modeling tree species diversity in NC Piedmont forests based on forest structure." *NASA Carbon Cycle and Ecosystems Joint Science Workshop*, College Park, MD. (poster)

"Nested Vegetation Sampling in Dense Canopy: Generating sub-meter spatial accuracy using GCP triangulation." *Southern Research Circle Poster Session*, Chapel Hill, NC. (poster)

2014 "Modeling Forest Structure and Vascular Plant Diversity in Piedmont Forests." *American Geophysical Union (AGU) Fall Meeting*. San Francisco, CA.

2013 "Village Sacred Forests as Refugia and Source Populations for Reforestation Efforts in SW China." *Ecological Society of America (ESA) Annual Meeting,* Minneapolis, MN. (poster)

2012 "Quantifying Structural and Compositional Changes in Forest Cover in NW Yunnan, China." *American Geophysical Union (AGU) Fall* Meeting, San Francisco, CA. (poster)

"A Tool for Spatially Explicit Visual Depiction of Plot-level Forest Dynamics." *UNC Innovative Use of GIS*. Chapel Hill, NC.

"NSF EAPSI Preliminary Research Findings." *China-U.S. Young Scientist Forum*, Beijing, China.

"Quantifying Forest Cover Change in SW China." *US – International Association of Landscape Ecology (US-IALE) Annual Conference*, Newport, RI. (poster)

DATASETS

2019	Houston Subannual Percent Impervious Land Cover Dataset: 1997-2018
2018	Greater Houston Land Cover Change Dataset: 1997-2018
2015	Duke Forest (Blackwood) NASA G-LiHT vegetation sampling*
2012	NSF EAPSI NW Yunnan sacred forest vegetation sampling
2011 – 2015	Carolina Vegetation Survey (contributor)

* County record for *Fraxinus caroliniana* and *Acer rubrum* var. *trilobum* (Orange, NC).

TEACHING EXPERIENCE

Instructor

2014	Summer	GEOG 112	Environmental Conservation	UNC - Geography

Teaching assistant

2014	Spring	ENST 203	Environmental Problems	UNC - Ecology
2013	Fall	GEOG 477	Introduction to Remote Sensing	UNC - Geography
2013	Spring	ENST 203	Environmental Problems	UNC - Ecology
2012	Fall	GEOG 370	Introduction to Geographic Information	UNC - Geography
2012	Spring	ENST 203	Environmental Problems	UNC - Ecology
2011	Fall	GEOG 370	Introduction to Geographic Information	UNC - Geography

Student training / mentorship

2017 – 2019	GIS, remote sensing accuracy assessment (1 MS student)	Houston, TX
2015 – 2016	Plant identification, vegetation sampling (7 BS/MS students)	Chapel Hill, NC
2012	GIS, plant identification, vegetation sampling (1 MS student)	Yunnan, China

ACADEMIC SERVICE

2021–	Member	NASA Global Ecosystem Dynamics Investigation (GEDI) Science Team
2019–	Member	NSF MSB-NES Exploring New Dimensions of Forest Ecosystems with Structural Diversity
2019–	Member	NASA Surface Biology and Geology Designated Observables Algorithms Working Group
2019–	Member	NASA Surface Biology and Geology Designated Observables Applications Working Group

2019–	Member	NSF RCN: Cross-Scale Processes Impacting Biodiversity
2015–17	Team member	NASA Biodiversity and Ecological Forecasting
2013–16	Co-Founder/member	UNC Ecology Research Symposium Committee
2013–15	Member	UNC Ecology Seminar Committee
2012–13	Senator	UNC Graduate and Professional Student Federation

Manuscript Reviewer

Animals; Castanea; Climate; Ecohydrology; Ecological Applications; Ecological Modelling; Ecoscience; Environmental Sciences Europe; Forests; Harvard Asia Quarterly; Geomatics, Natural Hazards and Risk; Global Ecology and Biogeography; IEEE Geoscience and Remote Sensing Letters; International Journal of Applied Geospatial Research; ISPRS Journal of Photogrammetry and Remote Sensing; Land Degradation & Development; Landscape Ecology; Physical Geography; Plants; Plant Phenome Journal; International Journal of Environmental Research and Public Health; Remote Sensing; Remote Sensing of Environment; Royal Society Open Science; Sustainability

Grant Review

2021	Review Panelist	NASA, [remote panel due to Covid-19]
2019	Review Panelist	NASA, Silver Spring, MD
2018	Grant Reviewer	Belgian Remote Sensing Research Program (BELSPO)
	Review Panelist	NASA, Washington DC

Conference Services

2019 Session Chair, "Urbanization, Climate Change, and the Environment II," *American Geophysical Union (AGU) Fall Meeting*, San Francisco, CA.

Session Convener, "Automating land cover change analyses of multi-temporal satellite imagery I-II," *Association of American Geographers (AAG) Annual Meeting*, Washington DC.

SELECTED MEDIA

2020 Planetizen. The Social Dynamics of Houston's Urban Expansion

Urban Edge. The rapid urbanization of Houston: how it happened and why it matters

2019 Houston Public Media. New Growth Mapping Tool Meant to Help Houston Better Prepare for Flooding

ABC News: KHOU 11. Rice University researchers use satellite images to track Houston's growth, flooding risk

Rice University. Tracking Houston's growth from space: A new tool to fight flooding

Futurity. How will 20 years of Houston's growth affect flooding

2018 Kinder Urban Edge. Watch Two Decades of Growth in Houston

2015 UNC E3P. Chris Hakkenberg awarded prestigious NASA Earth and Space Science Fellowship

2012 UNC E3P. Student Summer Research in a Himalayan Forest, China

LANGUAGES

Native

English

Fluent

Mandarin Chinese (reading, writing, speaking)

Basic / Conversational (in decreasing order of proficiency)

Spanish, Dutch, Papiamentu