ROBERT E. KENNEDY

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SUMMARY

Humans depend on landscapes to provide sustainable services, yet most landscapes are under increasing stress as they respond to both natural and anthropogenic processes of change. Using satellite-based remote sensing as my primary tool, my goal is to develop new conceptual and analytical approaches to directly observe landscape change processes and relate those changes to driving forces.

My research program has been successful. For eight years after receiving my PhD in 2004, I supported myself at Oregon State University and a team of between two to six other colleagues entirely through more than \$1 million in competitive grants (NASA, USDA) and more than \$1 million in directed agreements with federal land management agencies (US Forest Service, National Park Service, National Marine Fisheries Service). Since beginning my position at Boston University in 2012, I have secured two more competitive grants for more than \$1.3 million, focusing on science questions related to land use change and carbon dynamics. My work and visualizations have been featured at Landsat Science Team meetings and NASA Centers (Ames, Goddard), and my algorithms will be a component of the USDA Forest Service's and USGS's national-scale Landscape Change Monitoring System (LCMS). I have currently authored or co-authored 32 peer-reviewed articles or reports, 13 invited presentations, as well as various other presentations, reports, book chapters, and software. I serve on four national-level science teams, and am responsible for one upper level/graduate remote sensing course.

EDUCATION AND EMPLOYMENT

Education

- PHD. 2004. Oregon State University. Thesis: "Causes and consequences of uncertainty in the application of a biogeochemical model to a large geographic region." Department of Forest Science. Advisors: Dr. Warren Cohen & Dr. David Turner
- MA. 1994. University of Colorado, Boulder. Thesis: "Monitoring vegetation from space: The effects of spatial scale and heterogeneity." Department of Environmental, Population, and Organismic Biology. Advisor: Dr. Carol Wessman.
- BS. 1988. University of Houston. Honors, Summa Cum Laude. Honors Thesis:"Considering gap analysis: A critical evaluation of a recent conservation practice."Department of Biology. Advisor: Dr. Guy Cameron.

Employment

- Assistant Professor, Department of Earth and Environment, Boston University (2012present)
- Assistant Professor, Senior Research (2010-2012); Research Associate (2008-2010): Department of Forest Ecosystems and Society, Oregon State University.
- Post-doctoral Research Ecologist (2004-2008): USDA Forest Service, Pacific Northwest Research Station.

Faculty Research Assistant (1996-1999): Department of Forest Science, Oregon State University.

SCHOLARSHIP AND CREATIVE ACTIVITY

Publications

<u>Peer reviewed articles</u>

- 38. <u>Kennedy, Robert E.</u>, Andréfouët, Serge, Gómez, Cristina, Griffiths, Patrick, Hais, Martin, Healey, Sean, Helmer, E. H., Hostert, Patrick, Lyons, Mitchell, Meigs, Garrett W., Pflugmacher, Dirk, Phinn, Stuart, Powell, Scott, Scarth, Peter F., Sen, Susmita, Schroeder, Todd A., Schneider, Anne-Marie, Sonnenschein, Ruth, Vogelmann, James E., Wulder, Michael A., & Zhu, Zhe (In press). Bringing an ecological view of change to Landsat-based remote sensing. *Frontiers in Ecology and Environment*
- Roy, D.P., Wulder, M.A., Loveland, T.R., Woodcock, C.E., Allen, R.G., Anderson, M.C., Helder, D., Irons, J.R., Johnson, D.M., <u>Kennedy, R.</u>, Scambos, T.A., Schaaf, C. B., Schott, J.R., Sheng, Y., Vermote, E.F., Belward, A.S., Bindschadler, R., Cohen, W.B., Gao, F., Hipple, J.D., Hostert, P., Huntington, J., Justice, C.O., Kilic, A., Kovalskyy, V., Lee, Z. P., Lymburner, L., Masek, J.G., McCorkel, J., Shuai, Y., Trezza, R., Vogelmann, J., Wynne, R.H., Zhu, Z. (In Press). Landsat-8: science and product vision for terrestrial global change research. *Remote Sensing of Environment*.
- 36. Main-Knorn, Magdalena, Cohen, Warren, <u>Kennedy, Robert E</u>, Grodzki, Wojciech, Pflugmacher, Dirk, Griffiths, Patrick, & Hostert, Patric. 2013. Monitoring coniferous forest biomass change using a Landsat trajectory-based approach. *Remote Sensing of Environment* 139:277-290.
- Powell, Scott L., Cohen, Warren B, <u>Kennedy, Robert E</u>, Healey, Sean P., & Huang, Chengquan. 2013. Empirical observation of trends in biomass loss due to disturbance in the conterminous U.S.:1986-2004. *Ecosystems* DOI: 10.1007/s10021-013-9713-9.
- 34. Sulla-Menashe, Damien, <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Krankina, Olga N., & Friedl, Mark A. (In press). Detecting forest disturbance in the Pacific Northwest from MODIS time-series using temporal segmentation. *Remote Sensing of Environment*
- 33. Masek, Jeffrey G, Goward, Samuel N, <u>Kennedy, Robert E</u>, Cohen, Warren B, Moisen, Gretchen G, Schleeweis, Karen, & Huang, Chengquan. 2013. United States Forest Disturbance Trends Observed Using Landsat Time Series. *Ecosystems*, 10.1007/s10021-013-9669-9, 1-18
- <u>Kennedy, Robert.E.</u>, Yang, Zhiqiang, Cohen, Warren B., Pfaff, Eric, Braaten, Justin, & Nelson, Peder. 2012. "Spatial and temporal patterns of forest disturbance and regrowth within the area of the Northwest Forest Plan." *Remote Sensing of Environment* 122:117-133.
- Pflugmacher, Dirk L., Cohen, Warren B., & <u>Kennedy, Robert E.</u> 2012. "Using Landsat-derived disturbance history (1972-2010) to predict current forest structure." *Remote Sensing of Environment* 122:146-165.
- 30. Ohmann, Janet L., Gregory, Matthew J., Roberts, Heather M., Cohen, Warren B., <u>Kennedy, Robert E.</u>, & Yang, Zhiqiang. 2012. "Mapping change of older forest with nearest-neighbor imputation and Landsat time series." *Forest Ecology and Management* 272:13-25.

- 29. Campbell, John L., <u>Kennedy, Robert E</u>, and Warren B Cohen. 2012. "Assessing the carbon consequences of western juniper (Juniperus occidentalis) encroachment." Rangeland ecology and management 65(3): 223-231.
- 28. <u>Kennedy, Robert E.</u> 2012. "New views on changing arctic vegetation." *Environmental Research Letters*, 7: 011001.
- Griffiths, Patrick, Kuemmerle, Tobias, <u>Kennedy, Robert E.</u>, Abrudan, Ioan V., Knorn, Jan, & Hostert, Patrick. 2012. "Using annual time-series of Landsat images to assess the effects of forest restitution in post-socialist Romania." *Remote Sensing of Environment*, 118: 199-214.
- 26. Meigs, Garrett W., <u>Kennedy, Robert E.</u>, & Cohen, Warren B. 2011. "A Landsat time series approach to characterize bark beetle and defoliator impacts on tree mortality and surface fuels in conifer forests." *Remote Sensing of Environment*. 115:3707-3718.
- 25. Pflugmacher, Dirk, Krankina, Olga N., Cohen, Warren B., Fried, Mark A., Sulla-Menashe, Damien, <u>Kennedy, Robert E.</u>, Nelson, Peder, Loboda, Tatiana V., Kuemmerle, Tobias, Dyukarev, Egor, Elsakov, Vladimir, & Kharuk, Viacheslav I. 2011. "Comparison and assessment of coarse resolution land cover maps for Northern Eurasia." *Remote Sensing of Environment* 115: 3539-3553.
- 24. Turner, David P., Ritts, W. David, Yang, Zhiqiang, <u>Kennedy, Robert E.</u>, Cohen, Warren B., Duane, Maureen V., Thornton, Peter E., & Law, Beverly E. 2011.
 "Decadal trends in net ecosystem production and net ecosystem carbon balance for a regional socioecological system." *Forest Ecology and Management*, 262: 1318-1325.
- Turner, David P., Göckede, Matthias, Law, Beverly E., Ritts, W. David, Cohen, Warren B., Yang, Zhiqiang, Hudiburg, Tara, <u>Kennedy, Robert</u> E., & Duane, Maureen. 2011. "Multiple constraint analysis of regional land-surface carbon flux." *Tellus Series B-Chemical and Physical Meteorology*, 63: 207-221.
- 22. <u>Kennedy, Robert E.</u>, Yang, Zhigiang, & Cohen, Warren B. 2010. "Detecting trends in forest disturbance and recovery using yearly Landsat time series: 1. LandTrendr Temporal segmentation algorithms." *Remote Sensing of Environment* 114: 2897-2910.
- Cohen, Warren B., Yang, Zhiqiang, & <u>Kennedy, Robert E.</u> 2010. "Detecting trends in forest disturbance and recovery using yearly Landsat time series: 2. TimeSync - Tools for calibration and validation." *Remote Sensing of Environment* 114:2911-2924.
- 20. Powell, S.L., Cohen, Warren B., Healey, Sean P., <u>Kennedy, Robert E.</u>, Moisen, Gretchen G., Pierce, Kenneth B., & Ohmann, J.L. 2010. "Quantification of live aboveground forest biomass dynamics with Landsat time-series and field inventory data: A comparison of empirical modeling approaches." *Remote Sensing of Environment*, 114, 1053-1068.
- 19. <u>Kennedy, Robert E.</u>, Townsend, Philip A., Gross, John, Cohen, Warren B., Bolstad, Paul, Wang, Y.Q., & Phyllis Adams. 2009. "Remote Sensing Change Detection Tools for Natural Resource Managers: Understanding concepts and tradeoffs in the design of landscape monitoring projects." *Remote Sensing of Environment* 113:1382-1396.
- Pflugmacher, Dirk, Cohen, Warren, <u>Kennedy, Robert E.</u>, & Lefsky, Michael. 2008.
 "Regional applicability of forest height and aboveground biomass models for the Geoscience Laser Altimeter System." *Forest Science* 54:647-657.
- 17. Goward, Samuel N., Masek, Jeffrey G., Cohen, Warren B., Collatz, G. Jim, Healey, Sean, Houghton, Richard A., Huang, Chengquan, <u>Kennedy, Robert</u>, Law, Beverly,

Powell, Scott, Turner, David, & Wulder, Michael A. 2008. "Forest disturbance and north American carbon flux." *EOS* 89:105-106.

- Kennedy, Robert E., Cohen, Warren B. & Schroeder, T. A. 2007. "Trajectory-based change detection for automated characterization of forest disturbance dynamics. *Remote Sensing of Environment* 110:370-386.
- 15. Cohen, Warren B., Maiersperger, Thomas K., Turner, David P., Ritts, W. David, Pflugmacher, Dirk, Kennedy, Robert E., Kirschbaum, Alan A. Running, Steven W., Costa, Martin, & Gower, S. Thomas. 2006. "MODIS land cover and LAI collection 4 product quality across nine sites in the western hemisphere." *IEEE Transaction on Geoscience and Remote Sensing* 44, 1843-1857.
- 14. <u>Kennedy, Robert E.</u>, Turner, David P., Cohen, Warren B., & Guzy, Michael. 2006.
 "A method for efficient spatial modeling of biogeochemical models." *Landscape Ecology* 21: 213-224.
- Lee, Kyu-Sung, Cohen, Warren B., <u>Kennedy, Robert E.</u>, Maiersperger, Thomas K., & Gower, S. Thomas. 2004. "Hyperspectral versus multispectral data for estimating leaf area index in four different biomes." *Remote Sensing of Environment* 91:508-520.
- Kennedy, Robert E., & Warren B. Cohen. 2003. "Automated designation of image tie-points for multiple-image coregistration." *International Journal of Remote Sensing*,24(17): 3467-3490.
- Parmenter, Andrea. W., Hansen, Andy, <u>Kennedy, Robert E.,</u> Cohen, Warren B., Langner, Ute, Lawrence, Rick, Maxwell, Bruce, Gallant, Alisa, & Richard Aspinall. 2003. "Greater Yellowstone Land Cover Change." *Ecological Applications* 13(3): 687-703.
- Morisette, Jeffrey T., Nickeson, Jaime E., Davis, Paul, Wang, Yuije, Tian, Yuhong, Woodcock, Curtis E., Shabanov, Nikolay, Hansen, Matthew, Cohen, Warren B., Oetter, Doug R., & <u>Kennedy, Robert E</u>. 2003. "High spatial resolution satellite observations for validation of MODIS land products: IKONOS observations acquired under the NASA Scientific Data Purchase." *Remote Sensing of Environment* 88:100-110.
- 9. <u>Kennedy, Robert E.</u>, Cohen, Warren B., & Gen Takao. 1997. "Empirical methods to compensate for a view-angle-dependent brightness gradient in AVIRIS imagery," *Remote Sensing of Environment* 62:277-291.

Peer reviewed reports

- Moeur, Melinda, Ohmann, Janet L., <u>Kennedy, Robert E.</u>, Cohen, Warren B., Gregory, Matthew J., Yang, Zhiqiang, Roberts, Heather, Spies, Thomas A., & Fiorella, Maria (2011). Northwest Forest Plan–the first 15 years (1994–2008): status and trends of late-successional and old-growth forests. General Technical Report PNW-GTR-853. Portland, OR: F.S. U.S. Department of Agriculture, Pacific Northwest Research Station. <u>http://www.fs.fed.us/pnw/pubs/pnw_gtr853.pdf</u>
- Kennedy, Robert E., Cohen, Warren B., Kirschbaum, Alan A., & Haunreiter, Erik. 2007. Protocol for Landsat-based Monitoring of Landscape Dynamics at North Coast and Cascades Network Parks. In, U.S. Geological Survey Techniques and Methods, http://pubs.usgs.gov/tm/2007/tm2g1/: USGS Biological Resources Division.

<u>Scientific Visualizations</u>

6. "The Secret Life of Forests": <u>http://svs.gsfc.nasa.gov/goto?11144</u>. Writer: Ellen Gray. Animators: Greg Shirah, Alex Kekesi, Horace Mitchell. Producer and video editor: Matthew R. Radcliff. Narrator: Robert Kennedy. Scientists: Robert Kennedy, Zhigiang Yang, Justin Braaten. Published 12/11/2012.

<u>Book chapters</u>

- Kennedy, Robert E., Yang, Zhiqiang, Braaten, Justin, Nelson, Peder, & Cohen, Warren B. 2011. "Monitoring landscape dynamics of national parks in the western United States." Chapter 3 *In* Remote sensing of protected lands. Editor: Y.Q. Wang. CRC Press.
- Healey, Sean P., Cohen, Warren B., Yang, Zhiqiang, & <u>Kennedy, Robert E</u>. 2007. "Remotely sensed data in the mapping of forest harvest patterns." *In* M.A. Wulder & S.E. Franklin (Eds.), Understanding forest disturbance and spatial pattern: remote sensing and GIS approaches. Boca Raton, FL: CRC Press.

PHD Dissertation

3. Kennedy, Robert E. 2004. "Causes and consequences of uncertainty in the application of biogeochemical models to large geographic regions." Oregon State University. Dr. Warren Cohen and Dr. David Turner, Co-Major Professors.

<u>Software</u>

2. LandTrendr. <u>Http://landtrendr.forestry.oregonstate.edu</u>. More than 50 registered users beyond our lab from around the world have downloaded the software. The site has had more than 1,600 unique visitors (February 2010 until February 2012), with visits from all populated continents.

1. ITPfind. A tool written in the IDL language (ITTVis) for identifying matching tie points in paired images.

Publications in revision, review, or preparation

In review or revision:

He, Yin, Pflugmacher, Dirk, <u>Kennedy, Robert</u>, Sulla-Menashe, Damien, Hostert, Patrick. Mapping annual land cover changes using MODIS time series. *In Review, Journal of Selected Topics in Applied Earth Observations and Remote Sensing*.

Bright, Benjamin, Hudak, Andrew, Kennedy, Robert, Meddens, Arjan. LandTrendr and lidar as predictors of live and dead basal area across five bark beetle-affected forests. *In Review, Journal of Selected Topics in Applied Earth Observations and Remote Sensing.*

In preparation:

<u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Nelson, Peder, Pfaff, Eric, Cohen, Warren B, & Jordan, Chris (In preparation). Yearly land cover in the Puget Sound, USA, developed from Landsat time series. Planned submission to International Journal of Applied Earth Observation and Geoinformation. <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Thompson, Catharine, Antonova, Natalya, & Jordan, Chris (In preparation). Attribution of change agent using Landsat time series data. Planned submission to Remote Sensing of Environment.

Presentations

Invited Oral Presentations

- Kennedy, Robert, Neeti, Miller, David, Perkins, James, Yang, Zhiqiang, Braaten, Justin, Meigs, Garrett, Nelson, Peder, Cohen, Warren, Pflugmacher, Dirk.
 "Adventures in space-time: Landsat time-series analysis for fun and profit." University of Maryland Department of Geography Seminar Series. College Park, MD, February 20, 2014.
- 32. Kennedy, Robert E., Ohmann, Janet, Kane, Van, Powell, Scott, Yang, Zhiqiang, Braaten, Justin, Gregory, Matthew, Robert, Heather, Cohen, Warren, and Jim Lutz. "Did a tree really fall in the forest? Incorporating uncertainty into regional-scale monitoring of forest growth and mortality processes." *Annual meeting of ASA, CSSA, and SSSA,* Cincinnati, OH, October 22, 2012.
- 31. <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Cohen, Warren B., Nelson, Peder, Pfaff, Eric. "Characterizing landscape changes in the Puget Sound 1986 to 2008." *NMFS Recovery Implementation Technical Team meeting*, Seattle, WA, October 18, 2011.
- 30. <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Cohen, Warren B., Nelson, Peder, Pfaff, Eric. "A satellite's view of recent trends in forest harvest intensity in the Pacific Northwest." *Density Management in the 21st Century*, LaSells Stewart Center, Oregon State University. October 4, 2011.
- <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Cohen, Warren B., Meigs, Garrett, Braaten, Justin, Nelson, Peder, & Pfaff, Eric. "Landscape change characterization using LandTrendr." *National Disturbance Characterization Workshop*, EROS Data Center, Sioux Falls, SD, December 1-2, 2010.
- <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Nelson, Peder, Cohen, Warren B., & Pfaff, Eric. "Land cover change in national parks of the western U.S." *NASA Land Cover / Land Use Change annual meeting*, Bethesda MD, April 20-22, 2010.
- <u>Kennedy, Robert E.</u>, Meigs, Garrett, Yang, Zhiqiang, Cohen, Warren B. "Mapping insects and wildfire: New research and applications." *Forest Health in Oregon: State of the State*, LaSells Stewart Center, Oregon State University, February 24, 2010.
- 26. <u>Kennedy, Robert E.</u>, Cohen, Warren B., Yang, Zhiqiang, Nelson, Peder, Pfaff, Eric. "Monitoring yearly land cover state and change using new techniques to tap the Landsat archive." USDA Forest Service workshop on Monitoring Trends in Land Cover Change, Salt Lake City, UT, September 1-3, 2009.
- 23, 24, 25. <u>Kennedy, Robert E.</u>, Cohen, Warren B., Yang, Zhiqiang, Nelson, Peder, & Pfaff, Eric. "Monitoring vegetation change in western national parks." *NASA Earth-to-Sky V*, Shephardstown, WV, September 29, 2011. *NASA Earth-to-Sky IV*, Harper's Ferry, VA, February 3, 2010. *NASA Earth-to-Sky III*, Harper's Ferry, VA, January 26-30, 2009.
- 22. <u>Kennedy, Robert E.,</u> Cohen, Warren B., & Zhiqiang, Y. "Challenges and successes in developing Landsat based monitoring protocols in several national park systems."

North American Network for Remote Sensing Park Ecological Condition (NARSEC) meeting, Sante Fe N.M. March 6-8, 2007.

- <u>Kennedy, Robert E.</u>, Cohen, Warren B., & Zhiqiang, Y. "Monitoring change in national parks and forests from space." *Oregon Remote Sensing Workshop*, Oregon State University, Corvallis, OR, February 14, 2007.
- <u>Kennedy, Robert E.</u>, Warren B. Cohen, & Janet L. Ohmann. "Critical components of a framework for integrating field-measured ecological information into a large-area monitoring system." *Conference and Workshop on Detection and Monitoring of Invasive Exotic Plants*, Florida Int'l Univ, Miami, FL, February 2003.

Volunteered Oral Presentations

- Kennedy, Robert E., Andréfouët, Serge, Fraser, Robert, Gómez, Cristina, Hais, Martin, Helmer, Eileen, Hostert, Patrick, Pflugmacher, Dirk, Griffiths, Patrick, Main-Knorn, Magdelena, Phinn, Stuart, Scarth, Peter, Sonnenschein, Ruth. "Using timeseries approaches to improve Landsat's characterization of landscape dynamics." Oral Presentation at the *Landsat Science Team Meeting*, Washington DC, December 12, 2012.
- 18. <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Nelson, Peder, Cohen, Warren, Ohmann, Janet, Gregory, Matthew, Roberts, Heather, Meigs, Garrett, Nelson, Peder, and Pfaff, Eric. "Life-histories from Landsat: Algorithmic approaches to distilling Earth's recent ecological dynamics." Oral presentation at *AGU Fall Meeting*, San Francisco, CA, December 2012.
- 17. <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Nelson, Peder, Cohen, Warren, and David Thoma. "Detection and characterization of diverse landscape change agents through temporal segmentation of the Landsat archive." Oral presentation at the ForestSat 2012 meeting, Corvallis, OR, September 12, 2012.
- 16. <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Cohen, Warren B., Braaten, Justin, Pflugmacher, Dirk, Meigs, Garrett, Nelson, Peder, & Pfaff, Eric. "Ecosystems in action: How free Landsat data are changing how we see landscapes." Oral presentation at *AGU Fall Meeting*, San Francisco, CA, December 2011.
- 15. <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Cohen, Warren B., Braaten, Justin, Pflugmacher, Dirk, Meigs, Garrett, Nelson, Peder, Pfaff, Eric. "Life and death on the land: New analytical approaches capture Landsat's unique view of evolving landscapes." Oral presentation at *Pecora 18 meeting*, Washington, DC., November 2011.
- 14. <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Cohen, Warren B., Pflugmacher, Dirk, Meigs, Garrett, Nelson, Peder, & Pfaff, Eric. "A sea change on land: New insights into terrestrial processes facilitated by the open Landsat archive." Oral presentation at *Landsat Science Team meeting*, Sioux Falls, SD, August 2011.
- 13. <u>Kennedy, Robert E.</u>, Yang, Zhiqiang, Braaten, Justin, Cohen, Warren B. "Not just detection: moving toward attribution of change agent using Landsat time series information." Oral presentation at *Landsat Science Team meeting*, Phoenix, AZ, March 2011.
- 12. <u>Kennedy, Robert E.</u>, Cohen, Warren B., Yang, Zhiqiang, Nelson, Peder, & Pfaff, Eric. "Tools to tap the Landsat archive for monitoring and validation." Oral presentation at *Landsat Science Team meeting*, Mountain View, CA, January 2010.

- 11. <u>Kennedy, Robert E.</u>, Cohen, Warren B., & Yang, Zhiqiang. "The promise of an open Landsat archive: A new era for landscape monitoring and management?" Oral presentation at *Landsat Science Team meeting*, USGS Headquarters, Reston, VA, July 2008.
- 10. Kennedy, Robert E., Yang, Zhiqiang, Cohen, Warren B., Fiorella, M., Moeur, M. and Pfaff, E. "Capture of diverse forest dynamics with new approaches to tap the Landsat archive." Oral presentation at *Forest Inventory and Analysis (FIA) program biennial meeting*, October 2008, Park City, UT.
- <u>9. Kennedy, Robert E.</u> "A new approach for mapping subtle insect-related mortality and recovery dynamics in mesic and dry conifer forests." Oral presentation at *International Association of Landscape Ecology North American chapter's annual meeting*, Madison, WI, April 2008.
- 8. Kennedy, Robert E., Schroeder T.A. and Cohen, Warren B. "Mapping yearly forest disturbance and recovery processes in western Oregon, U.S.A." Oral presentation at the *International Association of Landscape Ecology North American chapter's annual meeting*, Tucson AZ, April 10 2007.
- 7. Kennedy, Robert E., David P. Turner, and Michael Guzy. "A Method to Incorporate Fine-Grain-Size Drivers of a Complex Biogeochemical Model Over a Large Spatial Extent." Oral presentation at the *International Association of Landscape Ecology North America chapter's annual meeting*, Banff, Canada, April 5, 2003.
- <u>6. Kennedy, Robert E.</u>, Warren B. Cohen. "Automated designation of tie-points for multiple-image registration." Oral presentation at the *USGS EROS data center*, Sioux Falls, SD, January 25. 2000.
- 5. Kennedy, Robert E., Warren B. Cohen, and Gen Takao. 1998. "A BRDF-related brightness gradient in AVIRIS imagery: lessons from an empirical compensation method." Oral presentation at the *Seventh Annual JPL Airborne Earth Science Workshop*, Jet Propulsion Laboratory, Pasadena, CA, January 12, 1998.

Volunteered Poster presentations

- <u>4. Kennedy, Robert E.</u>, Yang, Zhiqiang, Cohen, Warren B., Pfaff, Eric, & Braaten, Justin. "Amplifying the temporal domain: Annual forest change patterns in the forests of the Northwest Forest Plan." Poster presented at 2011 Meeting of the US Chapter of the *International Association of Landscape Ecology North America Chapter's annual meeting*, Portland, OR, April 2011.
- <u>3. Kennedy, Robert E.</u>, Cohen, Warren B., Moisen, G.G, Goward, S.N., Wulder, M., Powell, S.L., Masek, J.G, Huang, C., Healey, Sean P. "A sample design for Landsatbased estimation of national trends in forest disturbance and regrowth." Poster presented at *Joint Workshop on NASA Biodiversity, Terrestrial Ecology, and Related Applied Sciences, Adelphi, MD.*, August 21-25, 2006.
- 2. Kennedy, Robert E., Schroeder, T., Cohen, Warren B. "Automated characterization of disturbance year, intensity, and regrowth rates in a two-decade stack of yearly Landsat Thematic Mapper imagery." Poster presented at *Joint Workshop on NASA Biodiversity, Terrestrial Ecology, and Related Applied Sciences,* Adelphi, MD., August 21-25, 2006.
- <u>1. Kennedy, Robert E</u>, David P. Turner, Michael Guzy, and Warren B. Cohen. 2004. "Spatial patterns of uncertainty in modeled carbon metrics caused by natural variation

in leaf traits." Poster presented at *Ecological Society of America 89th Annual Meeting*, Portland, OR, August 5.

Research support

Competitive Grants: Principal investigator

- 20. "Using time-series approaches to improve Landsat's characterization of land surface dynamics." Robert E. Kennedy, Serge Andréfouët, Robert Fraser, Cristina Gómez, Martin Hais, Eileen Helmer, Patrick Hostert, Dirk Pflugmacher, Patrick Griffiths, Patrick, Magdelena Main-Knorn, Stuart Phinn, Peter Scarth, Ruth Sonnenschein. A USGS sponsored project for the Landsat Science team (one of nine funded projects nationally) from 10/17/2012-10/16/2017, \$924,214.
- "Integrating and expanding a regional carbon monitoring system into the NASA CMS." Robert E. Kennedy, Scott Powell, Van Kane, Jerry Franklin, Gretchen Moisen, Janet Ohmann, Rachel Riemann, Barry Wilson. A NASA Carbon monitoring system project for 7/1/2012 – 12/31/2013, \$413, 507.
- 18. "Integrated, observation-based carbon modeling for wooded ecosystems in Washington, Oregon, and California." Robert E. Kennedy, Warren Cohen, Janet Ohmann, Jerry Franklin, Van Kane, James Lutz, Scott Powell. A NASA / USDA-NIFA project for the period 5/1/2011 to 4/30/2014. \$770, 843.
- 17. "Leveraging temporal variation in climate and management across national parks in the western U.S. to characterize three decades of landscape vegetation dynamics." Robert E. Kennedy, Anita Davis. A NASA New Investigator Project for the period 6/1/2008 to 1/31/2012 \$320,438.

Competitive grants: Co-investigator

- 17. "Time series analysis of disturbance impacts on the Pacific Northwest regional carbon balance." Turner, David P., <u>Kennedy, Robert E.</u>, & Gray, Andrew. A project to NASA's Terrestrial Ecology program to incorporate disturbance information into biogeochemical models of carbon flux for Washington, Oregon, Idaho and portions of Montana. 2012-2015
- 16. "Development of Landsat-based landscape dynamics maps in the Greater Yellowstone Ecosystem." Powell, Scott L., and Kennedy, Robert E. A NASA-EPSCOR project to investigate bark beetle related mortality in and around Yellowstone National Park. 2012-2013.
- 15. "Tradeoffs among carbon and other ecosystem services associated with different forest management strategies." Spies, Thomas, Harmon, Mark, Cohen, McComb, Brenda, Morzillo, Anita, Warren B., Kennedy, Robert E., Kline, Jeff. A NASA-Carbon cycle science project for 2011-2014.
- 14. "Influence of Disturbance and Seasonality on Regional Carbon Flux Upscaling." Smithwick, Erica, Davis, Ken, Keller, Klaus, Naithani, Kusum, Masek, Jeffrey, and Kennedy, Robert E. A NASA-Carbon cycle science project for 2011-2014.
- "Contribution to studies of LCLUC in Northern Eurasia." Krankina, Olga, <u>Kennedy</u>, <u>Robert E.</u>, Cohen, Warren, & Pflugmacher, Dirk. A NASA Land Use/ Land Cover Change Program project 2009-2012.

- "Developing and testing a system to inventory and project regional forest carbon stores." Harmon, Mark, <u>Kennedy, Robert E.</u>, Gray, Andrew, Krankina, Olga, Ohmann, Janet, Cohen, Warren, & Yost, Andrew. A NASA Applications Project for two years. 2009-2011.
- 11. "Role of North American Forest Disturbance and Regrowth in the NACP: Integrated Analyses of Landsat and US Forest Service FIA Data – Phase 2." Goward, Sam, Masek, Jeffrey, Cohen, Warren, Moisen, Gretchen, Huang, Chengquan, <u>Kennedy</u>, <u>Robert</u>, Powell, Scott, & Healey, Sean. A NASA Terrestrial Ecology Program Project for the period 2009-2011.

<u>Other Agreements</u>

- "Monitoring existing forest vegetation in support of Northwest Forest Plan Effectiveness Monitoring." A joint venture agreement with the USDA Forest Service Pacific Northwest Research Station from July, 2011 to present (\$195,600). Principal Investigator. Builds on prior mapping for the Northwest Forest Plan (NWFP) area by incorporating temporal history, coordinating more closely with gradient-nearest-neighbor mapping, and attribution of change.
- 9. "Developing yearly maps of land cover and land use to monitor freshwater habitat for salmonids in the western U.S." A project with the National Marine Fisheries Service from July, 2010 to 2012 (\$152,381). Principal Investigator. This project focuses on characterizing land cover transitions and agent of change in the Puget Sound, Lower Columbia, and Willamette Valley basins from 1985 to 2008, to aid in modeling potential risks to threatened salmonid species.
- 8. "Testing and Applying a New Remote Sensing Tool (LandTrendr) to Detect and Monitor Landscape Dynamics." A cooperative agreement with the National Park Service from September 2010 to 2012 (\$46,770). Principal investigator. Train staff in use of LandTrendr for monitoring in national parks, and develop specific tools and protocols for use in the Great Lakes monitoring network.
- 7. "Using LandTrendr to Characterize Land Cover Dynamics in Juniper Woodlands of Dinosaur National Monument." A cooperative agreement with the National Park Service (NPS) from August, 2010 to 2012 (\$29,922). Principal Investigator. Apply LandTrendr approaches to sparse-vegetation systems, focusing on potential for mapping encroachment into sagebrush by juniper woodlands.
- 6. "Application of LandTrendr results to NCCN Landscape Dynamics Monitoring." A cooperative agreement with the National Park Service (NPS) from May, 2010 to December 2011 (\$13,077). Principal Investigator. Develop attribution approaches and apply to mapping landscape change in North Cascades, Mt. Rainier, and Olympic National Parks.
- 5. "Pacific Coast States Forest Disturbance, Regrowth, and Biomass Dynamics." An agreement with the USDA Forest Service for the period 5/1/2009 7/31/2010 (\$1,022,326.00). Principal Investigator. Includes analysis and mapping for the Forest Service on three related projects: 1. USDA Forest Service Forest Health Monitoring Insect and Fire mapping; 2. USDA Forest Service Region 6 Effectiveness Monitoring Program disturbance mapping; 3. National Marine Fisheries Service Disturbance analysis in the Ecologically Significant Unit of the Coastal Oregon Coho Salmon.

- 4. "Using trajectory-based methods to Improve Landsat-based monitoring of landscape dynamics in the parks of the Colorado Plateau." An agreement with the National Park Service for the period 9/1/2008-8/31/2020 (\$23,651). Principal Investigator.
- "Development of a Landscape Dynamics Monitoring Protocol for Sierra Nevada Network Parks." A cooperative agreement funded by the National Park Service for the period 8/1/2007 through 12/31/2008 (\$100,000) Co-Investigator.
- "Developing a protocol for remote-sensing based monitoring of vegetation changes in the national parks of the Southwest Alaska Network (SWAN)." An interagency agreement funded by the National Park Service for the period February 2006 to March 2007 (\$78,325) and March 2007 to December 2007 (\$79,825). Principal Investigator.
- "Determining Viable Methods to Monitor Landscape Patterns in National Park Service Units of the Northern and Southern Colorado Plateau Networks: Project to Support Monitoring Protocol Development." A cooperative agreement funded by the National Park Service for the period 8/1/2005 through 8/31/2006. Co-Investigator.

TEACHING AND ADVISING

Instructional summary

Credit courses

Boston University:

GE440/640: Spring 2013. Digital Image Processing for Remote Sensing. 16 registered upper level and graduate students. Professor. In this cornerstone class in the department, I introduce students to the concepts and practice of extracting useful information from remotely-sensed images

Oregon State University:

FOR420/520: Spring 2000. Advanced air photo interpretation and remote sensing (Ripple, Carson). 14 students. Graduate teaching assistant. I worked with the faculty members to design the course, and designed and taught several classes and labs in my specialties (see Curriculum Development below).

Guest lectures on remote sensing:

I have provided lectures and labs on remote sensing for several courses in the prior Department of Forest Science. My goal has been to provide students with enough information on the fundamentals of remote sensing to be savvy users of data in their projects.

<u>FOR421/521</u>: Spatial analysis of forested landscapes (Wing) 2009, 2010, 2011: Lecture
<u>FS646</u>: Forest ecosystem analysis (Waring, Cromack, Harmon, Turner, Krankina) 2000, 2001, 2002, 2003, 2004: Lecture and lab. 2005-2008: Lecture
<u>FS599/699</u>: Ecology of Forest Landscapes (Harmon) 2004. Lecture and lab.
FS599/699: Wildlife Landscape Ecology (Betts) 2008. Lecture.

Workshops/trainings

May 23-25, 2006. Training for Landsat-based monitoring of landscape dynamics at North Coast and Cascades Network Parks. Participants: 6 to 10 (on different days).

I organized and led this three-day workshop for GIS specialists, natural resource scientists, and managers on implementation of the protocol that I developed for the park service Inventory & Monitoring network that includes parks such as Olympic, North Cascades, Mt. Rainier, and Lewis & Clark. Contact: Andrea Woodward (see Professional References)

December 5, 2008. Webinar for the Integrated Geospatial Education and Technology Training (iGett) program. Participants: 20+.

I presented a two-hour training on remote sensing-based change detection to instructors at community colleges around the country. The goal of the iGett program is aid these instructors in developing and improving education programs focused on geospatial information, particularly remote sensing. Contact: Jeannie Allen (see Professional References).

January 26-30, 2009. Training for NASA's Earth-to-Sky III workshop for National Park Service interpreters and education specialists, Harper's Ferry W. Va. Participants: 50+.

I presented two lectures on remote sensing change detection and climate change science, and helped a group of six National Park Service interpreters begin developing programs and education curricula for outreach in their respective national parks. For Earth-to-Sky IV and V (in years 2010 and 2011), I also presented work on change detection in national parks (See Presentations below).

Contact: Anita Davis (see Professional References).

June 7-11, 2010. Training lecture and lab on change detection, for participants in a CalGETT (California Geospatial Education Technology Training) workshop, West Valley College, California. Participants: ~15.

I led a group of high-school and community-college instructors through the concepts and practice of detecting landscape change using remotely-sensed images. My component was part of a larger workshop organized by Dr. Chris Cruz, West Valley College, CA, under the CalGETT program.

February 1-4, 2011. Training on LandTrendr and TimeSync, for participants from the National Park Service and USDA Forest Service. Participants: 10.

I led a team organizing and teaching this three-day workshop for ecologists, managers, and GIS specialists on the use of our tools for annual monitoring in and around national parks. Participants represented parks inAlaska, Washington state, and Utah, as well as the Forest Service's national remote sensing center in Utah (the "Remote Sensing Applications Center").

Curriculum development

GE 440/640. Building from existing material developed by prior instructors, I consulted with a range of colleagues at other institutions to rework the curriculum to more quickly bring students into practical data manipulation, while maintaining a rigorous theoretical

underpinning in pre-processing, basic image manipulation, multivariate statistics, and change detection.

FOR420/520 Part of a team of four, I helped design curriculum for the overall course, and taught three 1.5 hour lecture sections and one lab, and graded labs. The lectures I developed on fundamental classification, change detection, and validation have been used in the course repeatedly since.

<u>Graduate advising</u>

I currently advise one PhD student whose project was selected for support under a NASA Earth System Science fellowship for the years 2011-2014.

Garrett Meigs, PhD, Department of Forest Ecosystems and Society, anticipated 2014 I have served on graduate committees for two students.

Dirk Pflugmacher, PhD, Department of Forest Ecosystems and Society, 2011 Dirk Pflugmacher, M.S., Department of Forest Science, 2008 Al Kirschbaum, M.S., Department of Forest Science, 2008

Student Evaluations

At Boston University, I have taught one course to date: Digital Image Processing, a split upper level/ graduate level course with 16 students. I take great personal satisfaction in knowing the students really enjoyed and learned from the class. On our standard ratings forms, the seven undergraduates responding rated the overall class and my teacher at 4.4 and 4.7, respectively, on a 1-5 scale. For six graduate students responding, the scores were 4.8 and 5.0. Sample comments include "Dr. Kennedy is one of the best professors I've had in my four years at BU", "Dr. Kennedy is a natural teacher", "Great class! Useful and helpful for me," "Lots of work but I've learned a lot."

At Oregon State University, my predominant interaction with students was through guest lectures, for which no formal evaluations have been conducted. I am unaware of any evaluations of these lectures, but have received consistently positive feedback from the primary instructors.

In the course whose curriculum I helped design and that I helped teach as a graduate student (FOR 420/520 Spring 2000), the "Course Reaction Survey" predated the SET forms now in use. The class was rated in the Strongly Agree or Agree category by at least 80 percent of the students for all ten evaluation questions, which covered classroom instruction, teachers, feedback, and grading. I remain in contact with two of the students in the class, both of whom are willing to provide evaluations of my contributions to the class (Dr. Steven Petersen and Dr. Mounir Louhaichi).

Advising

I currently advise one PhD student, Garrett Meigs. Based on initial research conducted just before and during his first year of studies, Garrett garnered a NASA Earth System Science Fellowship to support his studies for three years (2011-2014). In addition to general career and academic guidance, I focus most of my advising effort on incorporation of spatial dimensions and remote sensing technology to Garrett's field ecological background. Our collaboration has already resulted in one peer-reviewed article (Meigs et al. 2011; Paper # 26 above).

I took an active role in thesis projects when I served on the committees of both Dirk Pflugmacher and Al Kirschbaum. Both relied on my expertise in remote sensing, statistical analysis, and field sampling when designing and carrying out their studies. I also gave them advice on coursework options. Al Kirschbaum now works as a remote sensing analyst for the Great Lakes Network of the National Park Service Inventory and Monitoring program, and I continue to advise and work with him to continue his professional development. Dr. Pflugmacher published throughout his academic studies here (Peer Review #18, #25, and #30 above), most recently using my approaches to Landsat time-series analysis to improve predictions of biomass in the current day (#30 and one paper in preparation). He now holds a post-doctoral position with Dr. Patrick Hostert (Humboldt University, Berlin, Germany).

SERVICE

Science team memberships

North American Carbon Program (NACP) Science Steering Group (2014-2017). The NACP SSG advises interagency federal partners on progress and problems advancing understanding of the North American carbon cycle. Members provide an opportunity for direct communication between a diverse group of scientific community members and funding agencies responsible for implementing goals set out in various community planning documents, including the US Carbon Cycle Science Plan (2011) and the NACP Science Plan (2002).

Landsat Science Team. USGS/NASA. The current Landsat Science Team (2012-2017) advises the USGS and NASA on mission and design criteria for upcoming Landsat satellites, and on products and data delivery for the entire Landsat archive. Based on an open competition, my project was one of nine selected for funding in the U.S. My role focuses on developing better conceptual frameworks to characterize yearly land cover dynamics in ecosystems globally.

Carbon Monitoring System Science Team. NASA. The goal of the NASA CMS science team is to develop a cohesive carbon monitoring framework across all states (water, land, air) using the unique satellite, computational, and modeling capabilities of NASA. My competitively selected project focuses on utilizing my yearly carbon monitoring maps in Washington, Oregon, and California to evaluate efficacy of national-scale, single-date biomass maps from a variety of different projects.

Landcover Change Monitoring System (LCMS) science team. The LCMS science team (2011-2012) is working at several pilot areas to develop consistent, annual time-step land cover change maps across all lands. The intention is to build techniques that can eventually by taken on by the USDA Forest Service and the USGS. LandTrendr will be integrated along with several other change and disturbance mapping approaches.

Service to profession

I provide peer review for the following journals: Remote Sensing of Environment (frequent), Canadian Journal of Remote Sensing, Environmental Monitoring and Assessment, Global Change Biology, Frontiers in Ecology and the Environment, Journal of Environmental Management, Ecological Applications.

- I was a collaborating member on the 2006-2011 Landsat Science Team (with Dr. Warren Cohen), and I am currently a member of science tema for the Landscape Change Monitoring System (USDA Forest Service / USGS).
- I organized a special session at the 2011 Pecora conference, a land-surface remote sensing meeting focused this year on the use of Landsat data over four decades. My session focused on long-term monitoring of trends and dynamics.
- I also organized a special session at the 2011 American Geophysical Union (AGU) annual Fall meeting in San Francisco. The focus was on the new utility of long-term remote sensing datasets for use in environmental and ecological arenas. The session had among the highest number of abstract submissions in the Biogeosciences section, resulting in a well attended poster session and two separate oral sessions.

I was an organizing committee member for two remote-sensing related workshops:

NARSEC 2007 (North American Network for Remote Sensing Park Ecological Condition) workshop, Held in Santa Fe, N.M., March 6-8

Oregon Remote Sensing workshop. Held at Oregon State University, February 14, 2007.

Service to the Public

In addition to the three trainings described in the "Teaching/Advising" section above, which were aimed primarily at teachers and park service interpreters who then interact with the broader public, I have provided two informational presentations to describe the use and potential of remote sensing in natural resource monitoring and management.

Trainings/Outreach

- 2. Kennedy, Robert E., Yang, Zhiqiang, Cohen, Warren B., Nelson, P., and Pfaff, E. LandTrendr and TimeSync: Leveraging the Landsat archive to monitor landscape dynamics. Oral video presentation to Washington Geographic Information Council (WAGIC) meeting, October 2008.
- <u>1. Kennedy, Robert E.,</u> Cohen, Warren B. Applied change detection: New approaches for monitoring national parks and forested lands at regional and national scales. Invited speaker, Association of Photogrammetry and Remote Sensing Society's student chapter at Portland State University, April 27 2007.

AWARDS

- National Science Foundation Doctoral Dissertation Improvement Grant, \$8,037 for conduct of field research in aid of PhD project, June 2002-May 2003
- NASA Earth System Science Fellowship (of 50 nationally), \$16,000 stipend and \$6,000 tuition/research for three years of graduate research, Fall 2000 to Summer 2003
- **Oregon NASA Space Grant Fellowship**, \$14,000 and tuition waiver for first year of graduate study, Fall 1999 to Summer 2000

Professional References

Primary:

- Dr. Tom Loveland, Senior Scientist, USGS Earth Resources Observation and Science (EROS) Center. (605) 594-6066
- Dr. Gretchen Moisen, Research Scientist, USDA Forest Service, FIA Lab Ogden UT (801) 625-5384
- Dr. Mark Friedl, Professor, Boston University, (617) 353-5745

Other:

- Dr. Curtis Woodcock. <u>curtis@bu.edu</u>. Professor, Boston University. (617) 353-5746.
- Dr. Warren Cohen. <u>warren.cohen@oregonstate.edu</u>. Research Forester, USDA Forest Service, PNW Research Station. (541) 750-7322.
- Dr. Randy Wynne. <u>wynne@vt.edu</u>. Professor, Virginia Tech University (540) 231-7811.
- Dr. Michael Lefsky. lefsky@cnr.colostate.edu. Associate Professor, Colorado State University (970) 491-0602.
- Dr. Jeffrey Masek, Research Scientist, NASA Goddard Space Flight Center, Greenbelt MD (301) 614-6629
- Dr. Richard Waring. Professor Emeritus, Oregon State University (541) 737-6087
- Dr. Carol Wessman. Associate Professor, Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder. (303) 492-1139
- Dr. Beverly Law. Associate Professor, Department of Forest Ecosystems & Society, Oregon State University. (541) 737-6111
- Dr. Bill Ripple. Professor, Department of Forest Ecosystems& Soceity, Oregon State University. (541) 737-3056
- Dr. David Turner. Associate Professor, Department of Forest Ecosystems& Soceity, Oregon State University. (541) 737-5043