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Mapping Young Forest in Wisconsin

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Abstract

Population declines of early successional forest-associated wildlife species have been linked to declines in habitat abundance. Forest Inventory and Analysis (FIA) data can be used to estimate composition and change in 'young' forest, but such information typically lacks spatial specificity for determining landscape patterns that also affect habitat suitability. We developed a satellite remote sensing approach for making spatially explicit maps of young forest, using Landsat time series stacks and a vegetation change tracker (VCT) algorithm to identify forest disturbances occurring since 1985, and corresponding estimates of stand age based on year of disturbance. Wisconsin statewide estimates of young forest (1-20 years), from VCT and FIA, respectively, were 923,000 and 836,000 ha. Compared to FIA-based estimates, VCT-based estimates were statistically significantly higher for forest age classes of 1-5, 6-10, and 11-15 years, and significantly lower for the 16-20 year age class. Ongoing studies are examining causes and potential corrections for discrepancies between VCT- and FIA-based estimates of young forest in Wisconsin.

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INTRODUCTION

Forest disturbance and post-disturbance recovery—both natural and anthropogenic—result in spatially heterogeneous canopy removal and subsequent regrowth of early successional forest (Stueve et al. 2011), which provides habitats for birds, mammals, and herpetofauna. Examples in the upper Great Lakes region of the United States include game species such as American woodcock (*Scolopax minor*), ruffed grouse (*Bonas umbellus*), and white-tailed deer (*Odocoileus virginianus*); neotropical migratory songbirds such as golden-winged warbler (*Vermivora chrysoptera*) and Kirtland's warbler (*Dendroica kirtlandii*); and dozens of other species. Population declines of young forest-associated wildlife species have been linked to declines in abundance of their habitats (Hunter et al. 2001). Total area of early successional forests can be estimated over large geographic extents from USDA Forest Service, Forest Inventory and Analysis program (FIA) data (Trani et al. 2001). FIA estimates have been conducted since the 1930s, with consistent published estimates readily available since the 1960s and online data available since the 1980s. These estimates allow comparisons of habitat abundance across space and time. However, historical FIA inter-inventory intervals typically exceed one decade and consequently may lack temporal as well as spatial specificity for determining local landscape patterns, which also affect habitat suitability. Thus, there is a need to complement FIA data with more spatially and temporally explicit information for assessing, mapping, and managing young forest habitats resulting from canopy disturbance. We present a satellite remote sensing approach for producing such information.

METHODS

We obtained Landsat time series stacks (LTSS) from 13 Path/Rows encompassing the entire state of Wisconsin, USA (145,000 km^2). Approximately biennial, mostly cloud-free imagery from the peak summer growing season was obtained from Landsat 5 Thematic Mapper and Landsat 7 Enhanced Thematic Mapper plus sensors, acquired between 1984 and 2009. The LTSS for each Path/Row was analyzed using a vegetation change tracker (VCT) algorithm, which first performed geometric and radiometric corrections, then detected and dated forest canopy disturbances. VCT uses spectral-temporal characteristics of land cover and forest change processes to simultaneously analyze all images within each LTSS (Huang et al. 2010). Resulting VCT outputs included year of first and last disturbance, magnitude of disturbance, rate of regrowth, plus several other derived products. VCT date of last disturbance was used to determine forest stand age, for which a Wisconsin-wide geospatial dataset was assembled. Results from the first and last year (1984 and 2009) in the series were omitted, due to added uncertainties resulting from lack of prior/posterior observation. Slight pixel misregistration between images in each LTSS resulted in considerable false detection of disturbance, which was mostly corrected by clumping (four connected neighbors) and eliminating pixel clusters of the same class smaller than about 0.4 ha in area, a size that corresponds to the minimum area of land required to meet FIA's definition of "forest land" (Reams et al. 2005). Young forest is defined as ≤ 20 years of age, associated with forest disturbance during the period 1989-2008. VCT-based forest age was categorized into four 5-year age classes, with older forest assigned to a single class of >20 years. Wisconsin-wide VCT-based forest age estimates were compared to FIA estimates (Perry et al. 2008) for each age class. FIA stand age is the average total age, to the nearest year, of the trees (plurality of all live trees not overtopped) in the predominant stand-size class (Woudenberg et al. 2010). Comparisons of estimates are conservatively reported as being statistically significantly different when VCT estimates fell outside 95 percent confidence intervals surrounding FIA estimates (± 95% C.I.).

RESULTS AND DISCUSSION

Figure 1 portrays the spatial distribution of VCT-based young forest in Wisconsin, with older forest and nonforest shown for context. Patterns of young forest vary geographically across the state, with numerous large patches within a predominately forested matrix in the northwest, fewer and smaller patches within a predominately forested matrix in the northeast, and small patches within a sparsely forested matrix in the south (Figure 1). Young forest resulting from specific disturbance events are evident, e.g., a long, narrow swath of catastrophic disturbance following a 2007 tornado in northeastern Wisconsin (Figure 1, third from top inset).

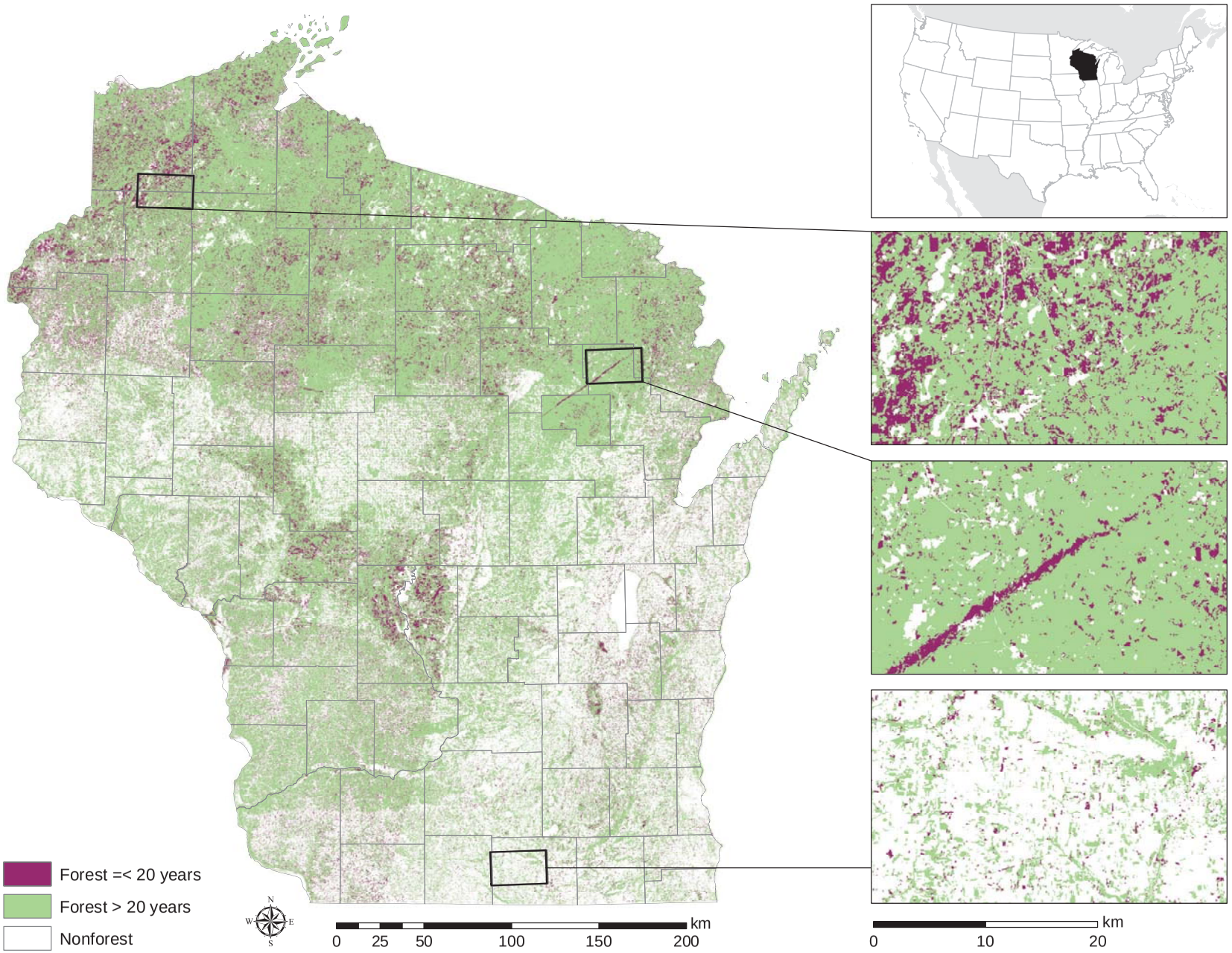

Figure 1.—Forest stand age-derived from VCT in Wisconsin, 2008. Insets include a predominately forested region in northwestern Wisconsin containing numerous larger patches of young forest (2nd from top), a predominately forested region in northeastern Wisconsin containing fewer smaller patches of young forest and one long swath resulting from a 2007 tornado (3rd from top), and a predominately nonforested region of south central Wisconsin, with smaller patches of young forest (4th from top).

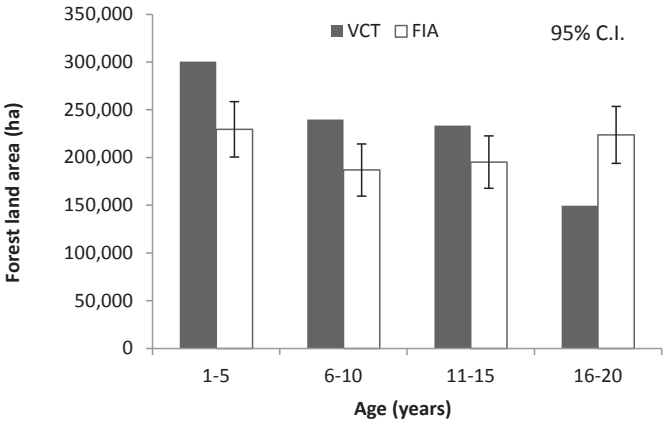

Figure 2.—Estimates of forest land area (ha) in Wisconsin, USA, based on VCT and FIA data, 2004-2008; lines show 95 percent confidence intervals.

Wisconsin young forest area estimates from VCT and FIA (± 95% C.I.), respectively, were 923,000 and 836,000 (± 54) ha, which is statistically significantly different. Estimates for 5-year age classes also differed with VCT-based estimates higher than FIA-based estimates for 1-5, 6-10, and 11-15 year age classes, and lower for 16-20 year age class estimates (Figure 2).

Young forest habitat maps produced from LTSS and VCT illustrate spatially explicit patches of young forest in Wisconsin, USA, but we detected some discrepancies between VCT- and FIA-based estimates. Previous studies revealed that slight pixel misregistrations between images within each LTSS produced false disturbance, which was mostly corrected by implementing a 1 acre minimum mapping unit in this study (Thomas et al. 2011). Some discrepancies between VCT- and FIA-based estimates may be due to issues associated with FIA definitions and estimates of stand age, e.g., "0" age assigned to 'nonstocked' stands even when some trees are present. Although FIA stand age is difficult to measure and has a number of caveats, the reliability of this attribute is believed to be relatively high for the young age classes of northern forest addressed within this study. Ongoing analyses are being conducted to identify and correct additional causes of discrepancy, e.g., false disturbance in the VCT maps associated with woody wetlands and agricultural croplands. Geospatial datasets produced from LTSS and VCT provide great potential for monitoring and managing habitat for early successional forest-associated wildlife species, e.g., for supporting the "Upper Great Lakes Young Forest Initiative".

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LITERATURE CITED

Huang, C.; Goward, S.N.; Masek, J.G.; Thomas, N.; Zhu, Z.; Vogelmann, J.E. 2010. **An automated approach for reconstructing recent forest disturbance history using dense Landsat time series stacks**. Remote Sensing of Environment. 114(1): 183-198.

Hunter, W.C.; Buehler, D.A.; Canterbury, R.A.; Confer, J.L.; Hamel, P.B. 2001. **Conservation of disturbance-dependent birds in eastern North America**. Wildlife Society Bulletin. 29(2):440-455.

Perry, C.H.; Everson, V.A.; Brown, I.K.; Cummings-Carlson, J.; Dahir, S.E.; Jepsen, E.A.; Kovach, J.; Labissoniere, M.D.; Mace, T.R.; Padley, E.A.; Rideout, R.B.; Butler, B.J.; Crocker, S.J.; Liknes, G.C.; Morin, R.S.; Nelson, M.D.; Wilson, B.T.; Woodall, C.W. 2008. **Wisconsin's forests, 2004**. Resour. Bull. NRS-23. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 104 p.

Reams, G.A.; Smith, W.D.; Hansen, M.H.; Bechtold, W.A.; Roesch, F.A.; Moisen, G.G. 2005. **The Forest Inventory and Analysis sampling frame**. In: Bechtold, W.A.; Patterson, P.L., eds. The enhanced Forest Inventory and Analysis program—national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 11-26.

Stueve, K.M.; Perry, C.H.; Nelson, M.D.; Healey, S.P.; Hill, A.D.; Moisen, G.G.; Cohen, W.B.; Gormanson, D.D.; Huang, C. 2011. **Ecological importance of intermediate windstorms rivals large, infrequent disturbances in the northern Great Lakes**. Ecosphere. 2(1):article 2: 1-21.

Thomas, N.E.; Huang, C.; Goward, S.N.; Powell, S.; Rishmawi, K.; Schleeweis, K.; Hinds, A. 2011. **Validation of North American forest disturbance dynamics derived from Landsat time series stacks**. Remote Sensing of Environment. 115(1): 19-32.

Trani, M.K.; Brooks, R.T.; Schmidt, T.L.; Rudis, V.A.; Gabbard, C.M. 2001. **Patterns and trends of early successional forests in the Eastern United States**. Wildlife Society Bulletin. 29(2): 413-424.

Woudenberg, S.W.; Conkling, B.L.; O'Connell, B.M.; LaPoint, E.B.; Turner, J.A.; Waddell, K.L. 2010. **The Forest Inventory and Analysis Database: Database description and users manual version 4.0 for Phase 2.** Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 336 p. Available at: http://www.fs.fed.us/rm/pubs/rmrs_gtr245.pdf. (Accessed 27 September 2012).

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