Sensitivity of forest fragmentation estimates to forest cover mapping approaches in the conterminous U.S.

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Background

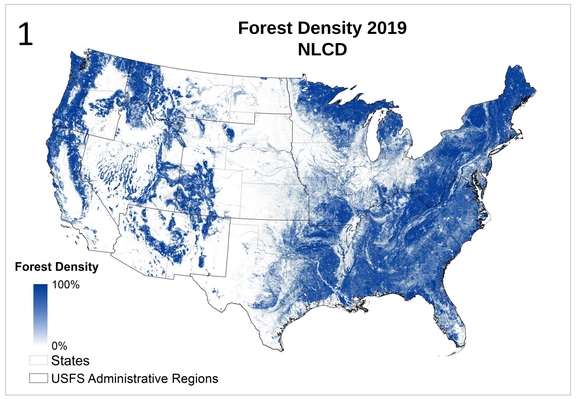
Estimates of forest fragmentation and connectivity typically rely on maps of forest cover where pixels are classified as forest or nonforest based on whether they exceed a set threshold value of tree cover. Another approach of land cover maps is to define forest in terms of a relative confidence of labeling a pixel as forest versus some other land cover. In this study we examined the sensitivity of forest fragmentation estimates to those considerations of mapping approaches. We developed several versions of binary forest/nonforest maps for the conterminous U.S. from four Landsat-derived land cover/use maps: National Land Cover Dataset (NLCD)[1] Land Cover, Land Change Monitoring, Assessment, and Projection (LCMAP) [2,3,4] Primary Land Cover, and Landscape Change Monitoring Systems (LCMS) [5] Land Cover and Land Use at 30m by 30m pixel (0.09 ha) resolution. The most conservative version was based solely on LCMAP Primary Land Cover 'forest' classification, and the most liberal version was based on LCMS Land Cover including all 'tree' land cover classifications (e.g. Barren & Trees Mix).

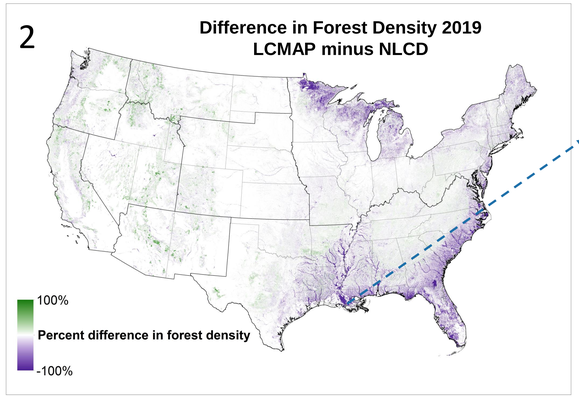
Methods

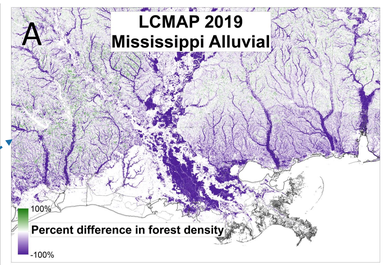
For each forest cover map version (NLCD, LCMAP, LCMS Land Cover, LCMS Land Use), we conducted a multi-scale analysis of forest fragmentation based on forest area density for 2019, and summarized the information to examine differences in overall fragmentation estimates and to understand the places/circumstances where the differences were most important. Forest area density, defined as the proportion of pixels that were forest land cover within the surrounding neighborhood was calculated at three scales: 7x7 pixels (4.41 ha), 13x13 (15.21 ha), and 27x27 (65.61 ha). Forest area density (Pf) was then classified into seven classes (below) [6]. Summaries for the smallest (7x7) and largest (27x27) pixel neighborhoods are shown here for each map version.

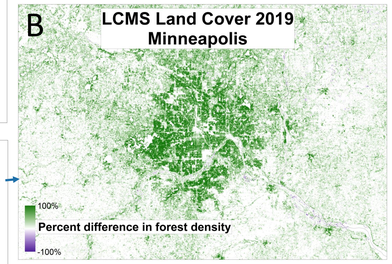
Forest Area Density (Pf) Class	
Core	Pf = 100%
Interior	90 ≤ Pf < 100%
Dominant	60 ≤ Pf < 90%
Transitional	40 ≤ Pf < 60%
Patchy	10 ≤ Pf < 40%
Rare	0 < Pf < 10%
None (not shown)	Pf = 0%

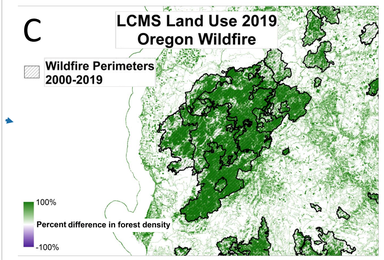
Results & Discussion

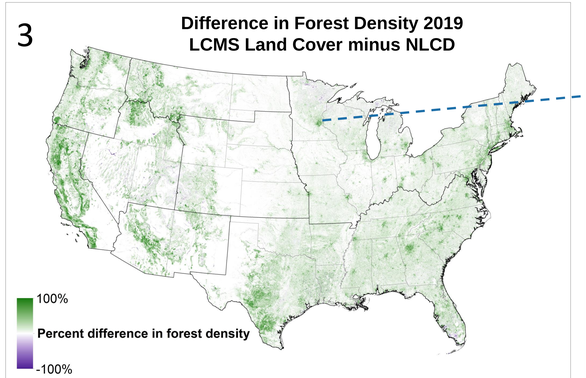


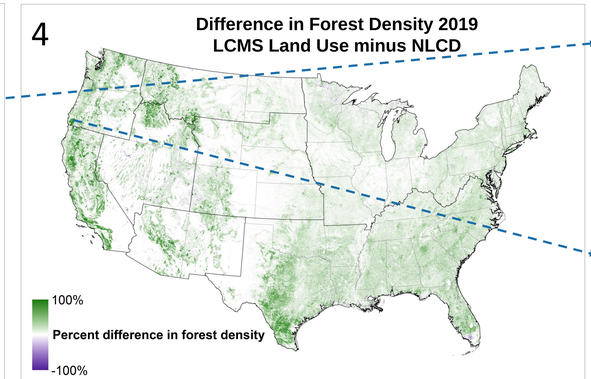


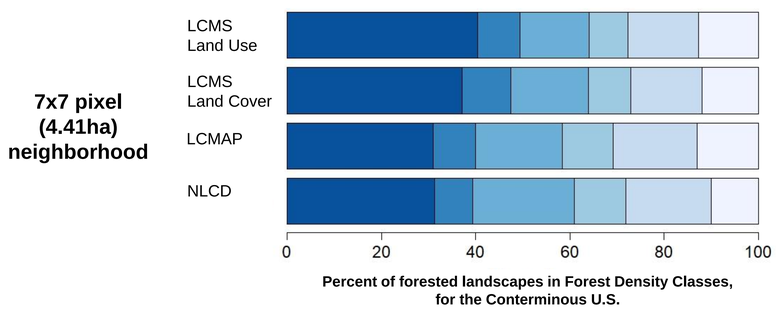


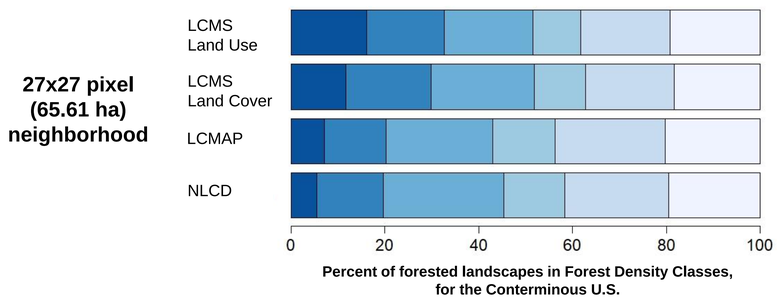












	NLCD	LCMAP	LCMS Land Cover	LCMS Land Use
Forest cover (km²) for the conterminous U.S.	2,318,110	2,047,082	3,003,453	3,155,160
Percent area difference from NLCD		-11.7%	+29.6%	+36.1%

Maps 1-4 show NLCD 2019 Forest Density compared to LCMAP, LCMS Land Cover, and LCMS Land Use calculated at 7x7 pixel neighborhoods. Forest cover based on LCMAP primary 'forest' land cover excluded lowland forests of the Mississippi Alluvial and Southeast Coastal Plains, and Mixed Wood Shield (aka Great Lakes) ecoregions, resulting in greater estimates of forest fragmentation in these regions (Map 2, Inset A). Using NLCD 'forest' and 'woody wetland' classifications to define forest cover, resulted in 11.7% greater overall forest cover compared to LCMAP, and decreased forest fragmentation, especially in lowland forests.

Forest density estimates surrounding urban centers also strongly differed between land cover classification approaches, with NLCD classifications of 'low' and 'open space' development reducing forest cover estimates, resulting in lower forest density compared to using LCMS (Map 3 & 4). These 'urban' forests in the eastern U.S. are most notable in the LCMS Land Cover based classifications (Inset B).

In the western U.S., differences in forest cover classification appear to be due to the different threshold values of tree cover between source datasets (NLCD > 20% tree cover, LCMAP > 10% tree cover, LCMS Land Cover 'live or standing dead trees', LCMS Land Use > 10% *potential* tree cover). Importantly, these varying thresholds result in many areas regenerating from forest disturbances to be classified as 'forest' by LCMS and as 'nonforest' by NLCD and LCMAP, increasing or decreasing forest density estimates respectively (Inset C).

Overall, LCMS based forest cover maps estimated greater forest cover area (+29.6% using Land Cover, and +36.1% using Land Use) compared to NLCD based maps. Forest density class distributions varied between source data (NLCD, LCMAP, LCMS Land Cover, LCMS Land Use), with LCMS based estimates classifying the greatest proportion of core and interior forest at both pixel neighborhood scales. As may be expected, the forest area density class distributions were highly sensitive to the size of the pixel neighborhood used, with larger neighborhoods estimating greater forest fragmentation. However, relative differences among the four mapping approaches were mostly scale invariant.

Conclusions

These results demonstrate the sensitivity of forest fragmentation estimates to forest cover mapping approaches in the conterminous U.S. and to the spatial scale used in analysis. This cautions special consideration when choosing forest fragmentation estimates to include in resource assessments and wildlife habitat connectivity analyses. Further research includes comparing estimates of change in forest fragmentation from 2001 to 2019 using these different approaches.

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[2]LCMAP Collection 1.0 Science Products courtesy of the U.S. Geological Survey.

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