Geospatial Estimation of Forest Relative Density at Strategic Scales Across the Continental U.S.

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Growth Model User Group

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THE UNIVERSITY OF MAINE

Center for Advanced Forestry Systems

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Introduction

Stand density

- Trees need **limited** resources: water, light, nutrients & **growing space**

- Stand density is a quantitative measure of local conditions & **competition**

- Absolute measures SD

stem density, total basal area

- Relative measures of SD

stand density index, relative density

Citations: Oliver and Larson (1996); Vlad et al. (2020), nps.gov

Stand Density Index (SDI)

- Biologically based measure of SD

independent of site and stand age

- Maximum SDI: carrying capacity (#/ha)

- Relative Density= ratio of SDI/SDImax (0-1)

predicts phases of stand development

management decisions

Relative density	Stage of stand development
0.15	Crown closure
0.30	Lower bound of density management zone
0.55	Onset of imminent competition mortality
1	Maximum size-density

PERFECTING A STAND-DENSITY INDEX FOR EVEN-AGED FORESTS[1]

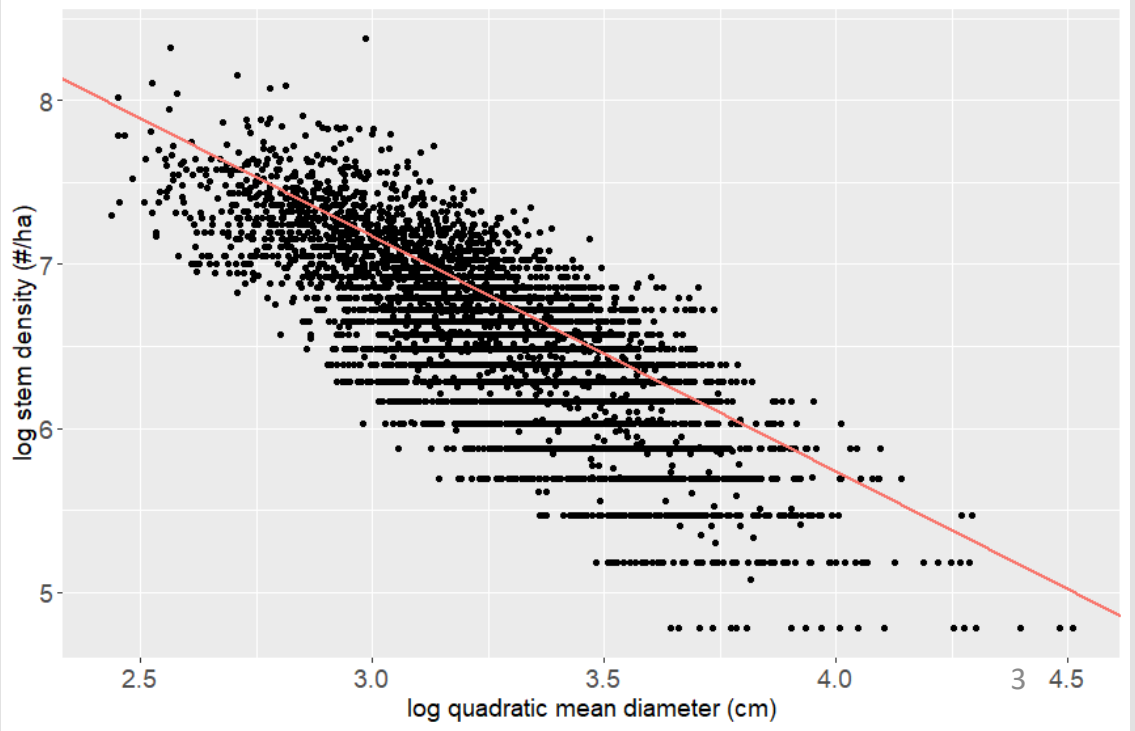
By L. H. Reineke

Associate Silviculturist, California Forest Experiment Station, Forest Service, United States Department of Agriculture

perfecting a stand-density index for even- aged forests

by LH REINEKE · Cited by 2481 — It is the purpose of this paper to present a **stand-density index** which does not require a yield table and which is not affected by possible errors in shap...

12 pages



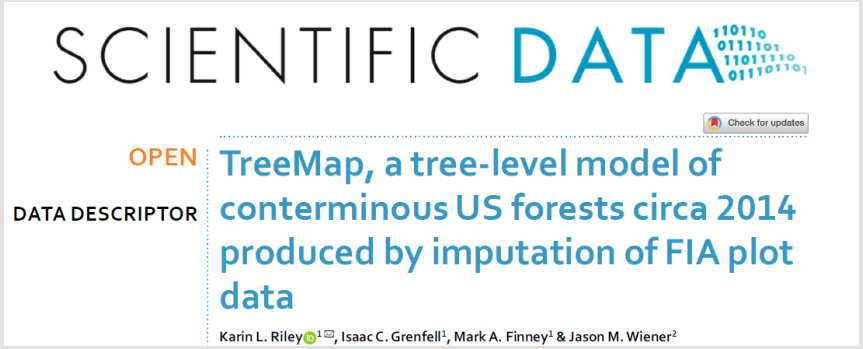
Why TREEMAP?

- National Forest Inventories assess forest attributes and ecosystem processes over large areas

- Sparse plot network: 1 plot per 24km2 (limited planning and management with FIA data alone)

Opportunity from landscape level generations of gridded maps: TREEMAP

- "Users can readily produce maps and summaries of these characteristics in a GIS".


SCIENTIFIC DATA

OPEN

DATA DESCRIPTOR

TreeMap, a tree-level model of conterminous US forests circa 2014 produced by imputation of FIA plot data

Karin L. Riley[1], Isaac C. Grenfell[1], Mark A. Finney[1] & Jason M. Wiener[2]


forests

MDPI

Article

A National Map of Snag Hazard to Reduce Risk to Wildland Fire Responders

Karin L. Riley [1,*], Christopher D. O'Connor [2], Christopher J. Dunn [3], Jessica R. Haas [4], Richard D. Stratton [5] and Benjamin Gannon [6]


esa

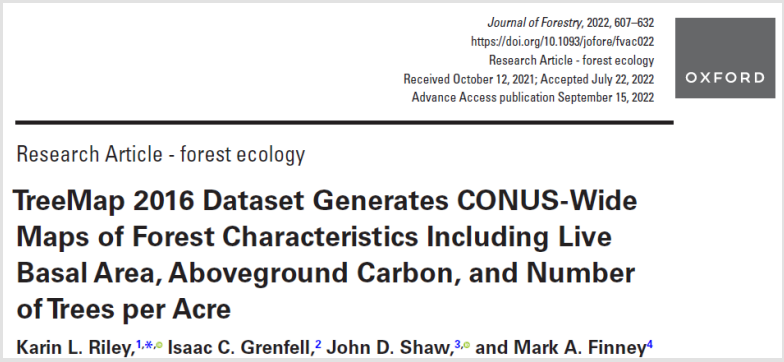
ECOSPHERE

Mapping forest vegetation for the western United States using modified random forests imputation of FIA forest plots

KARIN L. RILEY,[1,]† ISAAC C. GRENFELL,[2] AND MARK A. FINNEY[2]

[1]Forestry Sciences Laboratory, Rocky Mountain Research Station, U.S. Forest Service, 800 East Beckwith, Missoula, Montana 59801 USA

[2]Missoula Fire Sciences Laboratory, Rocky Mountain Research Station, U.S. Forest Service, 5775 Highway 10 West, Missoula, Montana 59812 USA


Journal of Forestry, 2022, 607–632
https://doi.org/10.1093/jofore/fvac022
Research Article - forest ecology
Received October 12, 2021; Accepted July 22, 2022
Advance Access publication September 15, 2022

OXFORD

Research Article - forest ecology

TreeMap 2016 Dataset Generates CONUS-Wide Maps of Forest Characteristics Including Live Basal Area, Aboveground Carbon, and Number of Trees per Acre

Karin L. Riley,[1,*,] Isaac C. Grenfell,[2] John D. Shaw,[3,] and Mark A. Finney[4]

Citations: USDA, (2005); Janowiak et al, (2017); Domke, (2023), D'Amato et al., (2022), Riley et al., (2022)

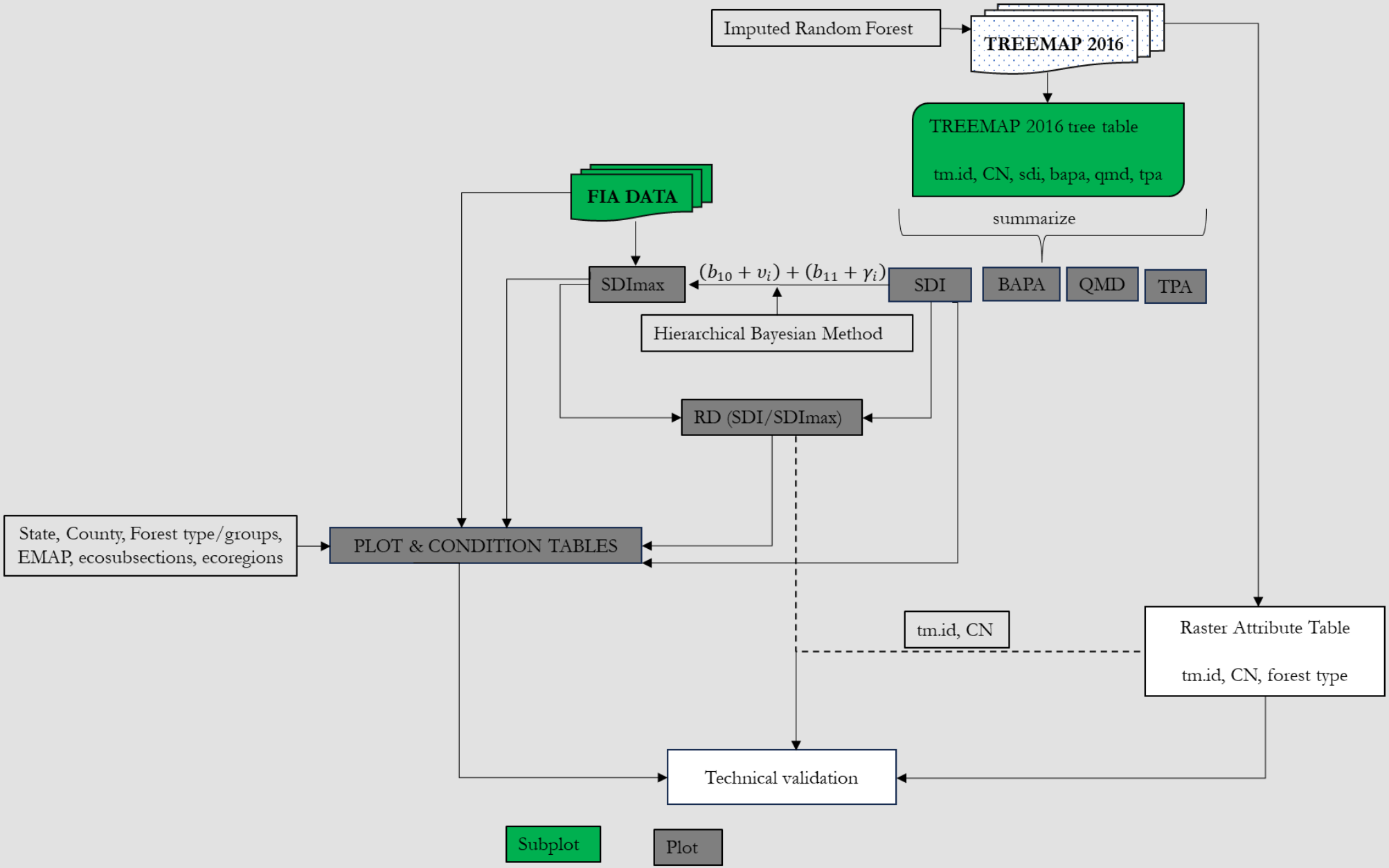
Objectives

(i) develop high resolution, spatially contiguous, and nationally consistent size-density metrics for CONUS and associated methods

(ii) summarizing the primary attributes across various metrics and spatial scales

(iii) evaluating key relationships across methods

Workflow


Imputed Random Forest
TREEMAP 2016
TREEMAP 2016 tree table
tm.id, CN, sdi, bapa, qmd, tpa
summarize
FIA DATA
SDImax
$(b_{10} + v_i) + (b_{11} + \gamma_i)$
SDI
BAPA
QMD
TPA
Hierarchical Bayesian Method
RD (SDI/SDImax)
State, County, Forest type/groups, EMAP, ecosubsections, ecoregions
PLOT & CONDITION TABLES
tm.id, CN
Raster Attribute Table
tm.id, CN, forest type
Technical validation
Subplot
Plot

Workflow

1. TREEMAP tree list

tm_id	CN	STATUSCD	TPA_UNADJ	SPCD	COMMON_NAI	SCIENTIFIC_	SPECIES_S	DIA	HT	ACTUALHT	CR	SUBP	TREE	AGENTCD
746	139994498010854	1	6.018046	131	loblolly pine	Pinus taeda	PITA	9.7	67	67	30	1	5	
746	139994498010854	1	6.018046	131	loblolly pine	Pinus taeda	PITA	11.8	75	75	30	1	7	
746	139994498010854	1	6.018046	131	loblolly pine	Pinus taeda	PITA	9.5	72	72	30	1	9	
746	139994498010854	1	6.018046	131	loblolly pine	Pinus taeda	PITA	13.8	75	75	35	1	10	
746	139994498010854	1	74.965282	611	sweetgum	Liquidamba	LIST2	3.5	23	23	45	2	1	
746	139994498010854	1	6.018046	131	loblolly pine	Pinus taeda	PITA	9.2	60	60	28	2	5	

2. Summarize and subset by subplot, tm.id and CN

tm_id	CN	SUBP	TPA	SDI.add	BAPA	QMD	SDI
746	139994498010854	1	24.07218	116.8569	67.48553	22.67201	89.55234
746	139994498010854	2	93.01942	141.2554	69.05249	11.66663	119.1299
746	139994498010854	3	311.8972	136.2541	63.1093	6.090926	140.7435
746	139994498010854	4	42.12632	199.6593	114.4833	22.32219	152.8537
1	175742190010854	1	471.1151	413.1346	167.1382	8.065231	333.6161
1	175742190010854	2	740.886	518.6204	199.7554	7.030982	420.9321
1	175742190010854	3	264.2734	267.8341	116.3496	8.984588	222.5451
1	175742190010854	4	66.19851	130.6309	60.83177	12.98026	100.6163

3. Merge to PLOT, GEOM, CONDITION tables by CN

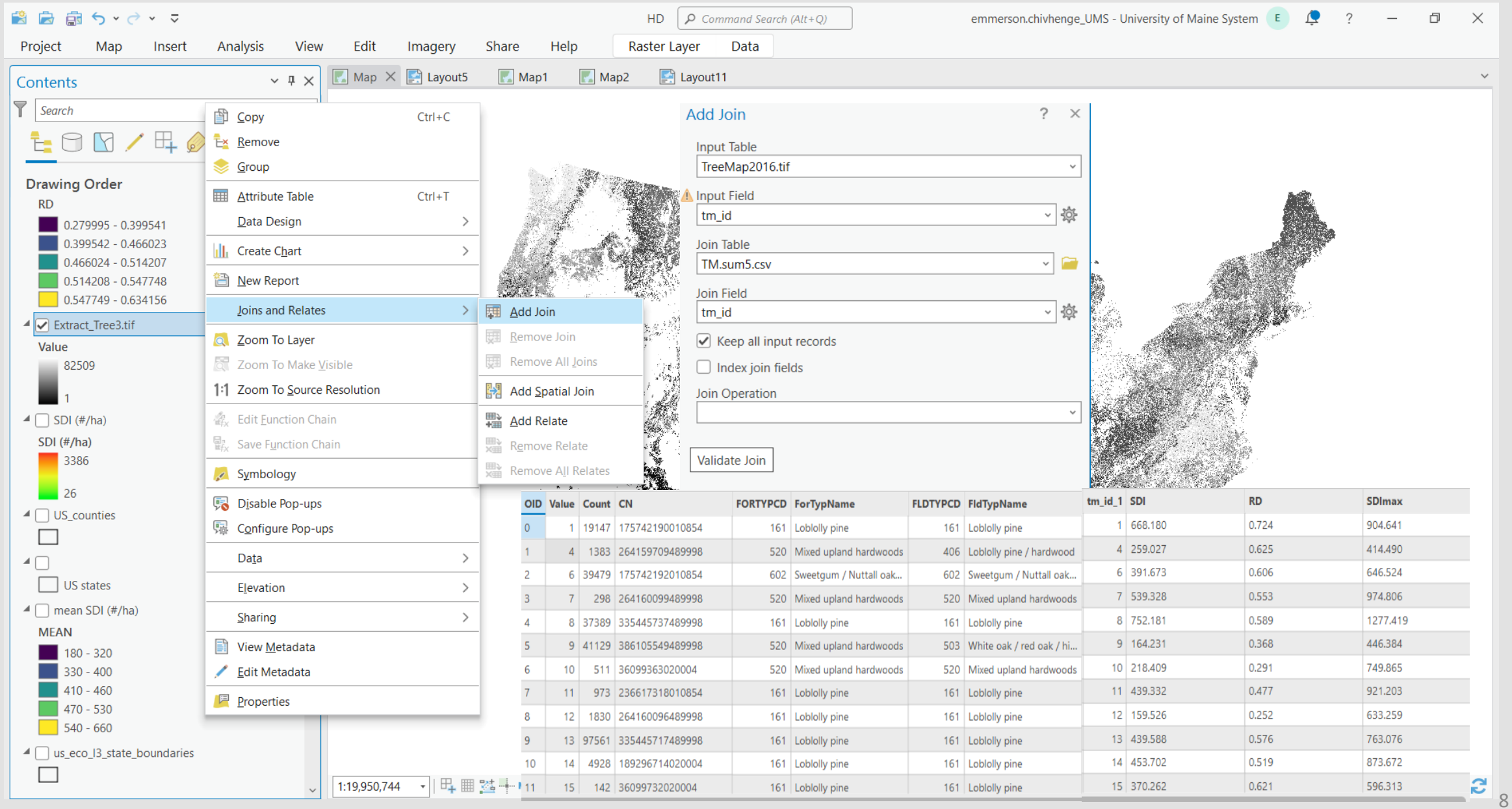
4 . Merge SDImax estimate by STATECD, UNITCD, COUNTYCD and PLOT

STATECD	UNITCD	COUNTYC	PLOT	ID	SDImax.mear
1	1	129	1	1-1-129-1	1562.85874
1	1	129	10	1-1-129-10	759.814344
1	1	129	100	1-1-129-100	579.65726
1	1	129	101	1-1-129-101	716.375292
1	1	129	102	1-1-129-102	993.664065
1	1	129	103	1-1-129-103	624.987955
1	1	129	104	1-1-129-104	802.378971
1	1	129	105	1-1-129-105	465.479266

4 . Subset by tm.id

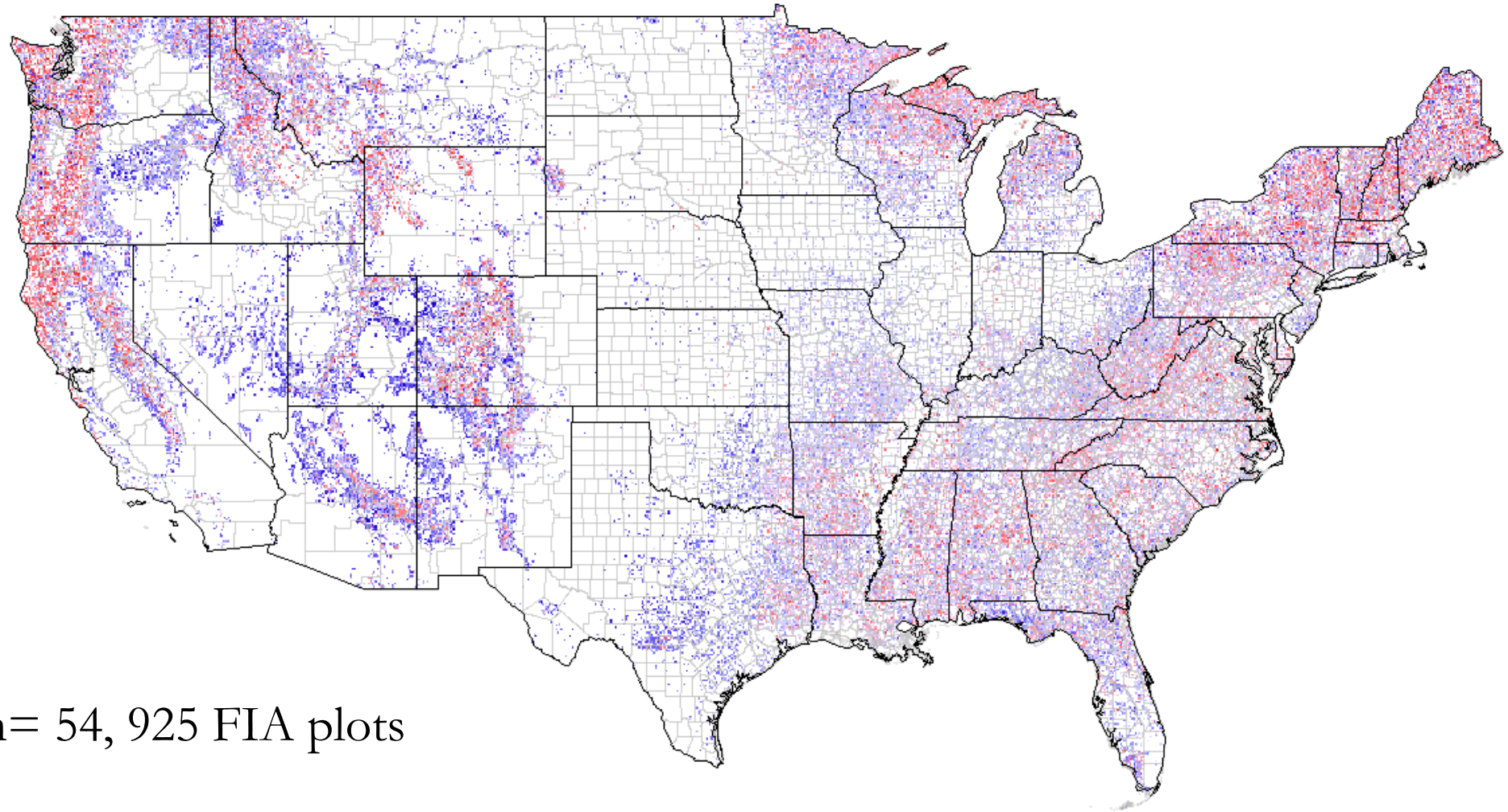
tm_id	SDImax	RD	SDI
1	1048.65	0.762281	824.7364
4	853.522	0.380316	324.6078
6	903.5175	0.500666	452.3607
7	878.5455	0.705757	620.0399
8	1005.36	0.883083	895.2332
9	852.6601	0.231825	197.668
10	752.3698	0.366168	275.4935
11	872.842	0.62486	545.4044
12	970.073	0.208752	202.5044

Workflow



OID	Value	Count	CN	FORTYPCD	ForTypName	FLDTYPCD	FldTypName	tm_id_1	SDI	RD	SDImax
0	1	19147	175742190010854	161	Loblolly pine	161	Loblolly pine	1	668.180	0.724	904.641
1	4	1383	264159709489998	520	Mixed upland hardwoods	406	Loblolly pine / hardwood	4	259.027	0.625	414.490
2	6	39479	175742192010854	602	Sweetgum / Nuttall oak...	602	Sweetgum / Nuttall oak...	6	391.673	0.606	646.524
3	7	298	264160099489998	520	Mixed upland hardwoods	520	Mixed upland hardwoods	7	539.328	0.553	974.806
4	8	37389	335445737489998	161	Loblolly pine	161	Loblolly pine	8	752.181	0.589	1277.419
5	9	41129	386105549489998	520	Mixed upland hardwoods	503	White oak / red oak / hi...	9	164.231	0.368	446.384
6	10	511	36099363020004	520	Mixed upland hardwoods	520	Mixed upland hardwoods	10	218.409	0.291	749.865
7	11	973	236617318010854	161	Loblolly pine	161	Loblolly pine	11	439.332	0.477	921.203
8	12	1830	264160096489998	161	Loblolly pine	161	Loblolly pine	12	159.526	0.252	633.259
9	13	97561	335445717489998	161	Loblolly pine	161	Loblolly pine	13	439.588	0.576	763.076
10	14	4928	189296714020004	161	Loblolly pine	161	Loblolly pine	14	453.702	0.519	873.672
11	15	142	36099732020004	161	Loblolly pine	161	Loblolly pine	15	370.262	0.621	596.313

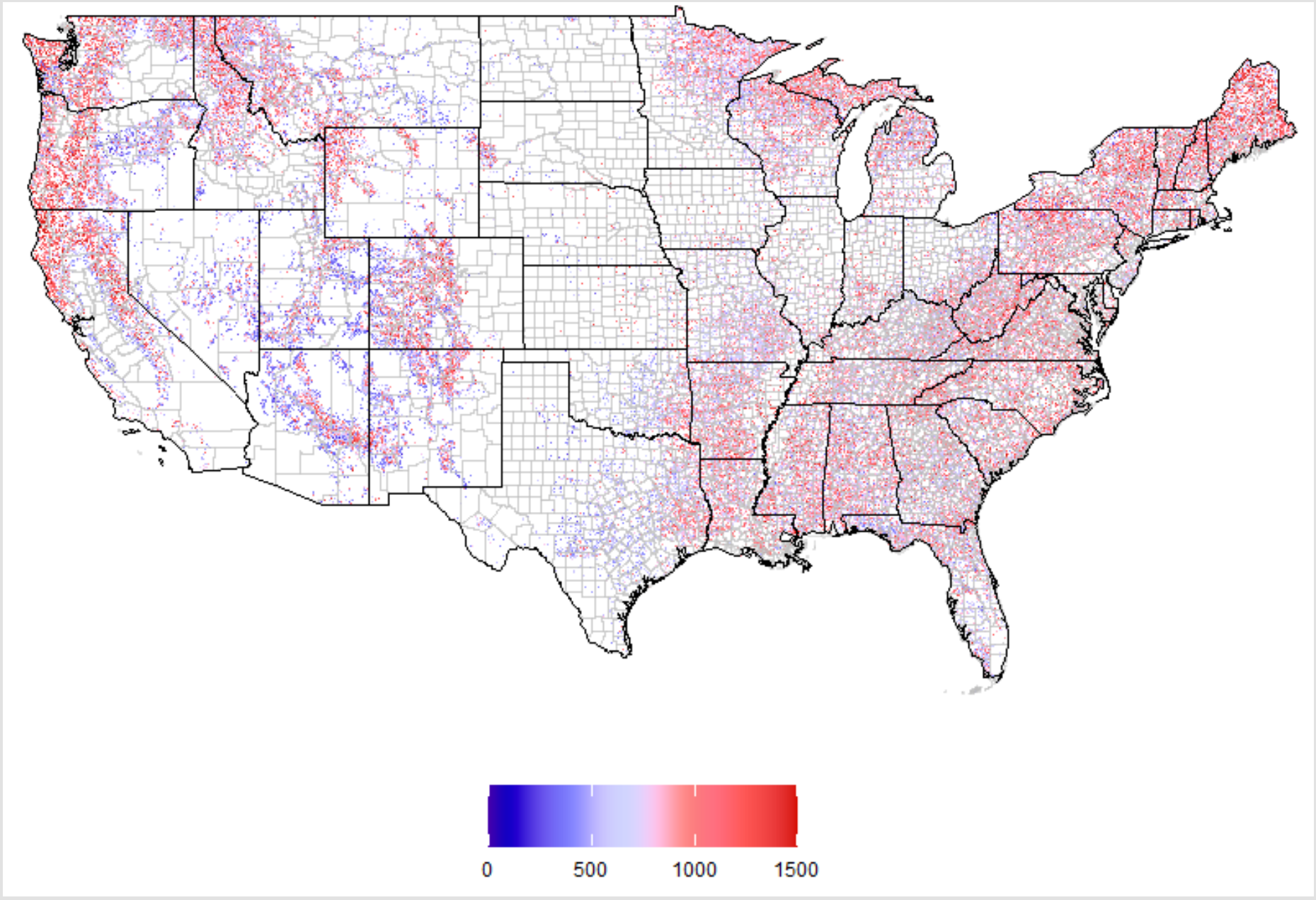
Stand density index (#/ha)



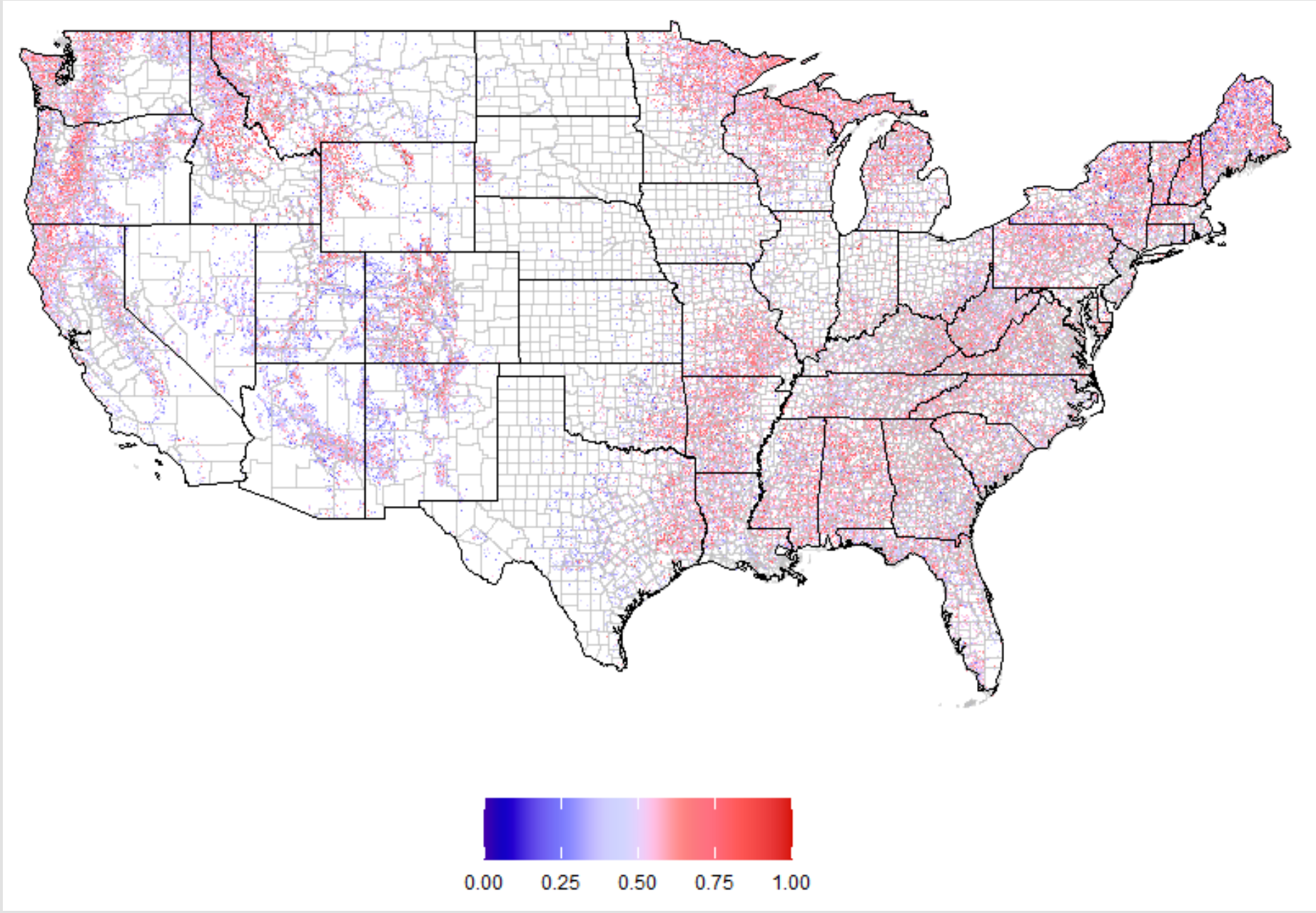
n= 54, 925 FIA plots

≈2,668,162,817 forested pixels

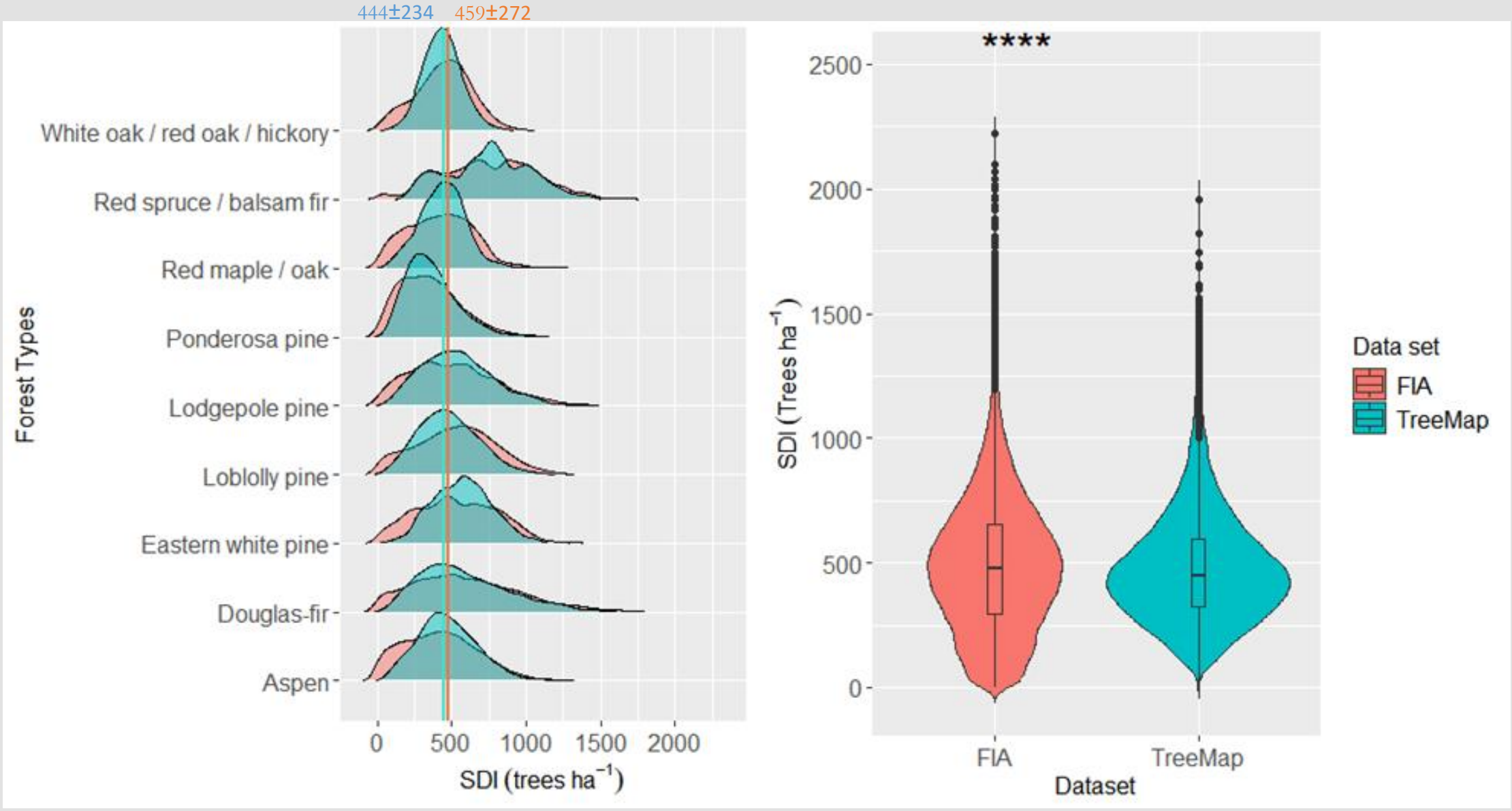
Maximum Stand Density Index (#/ha)



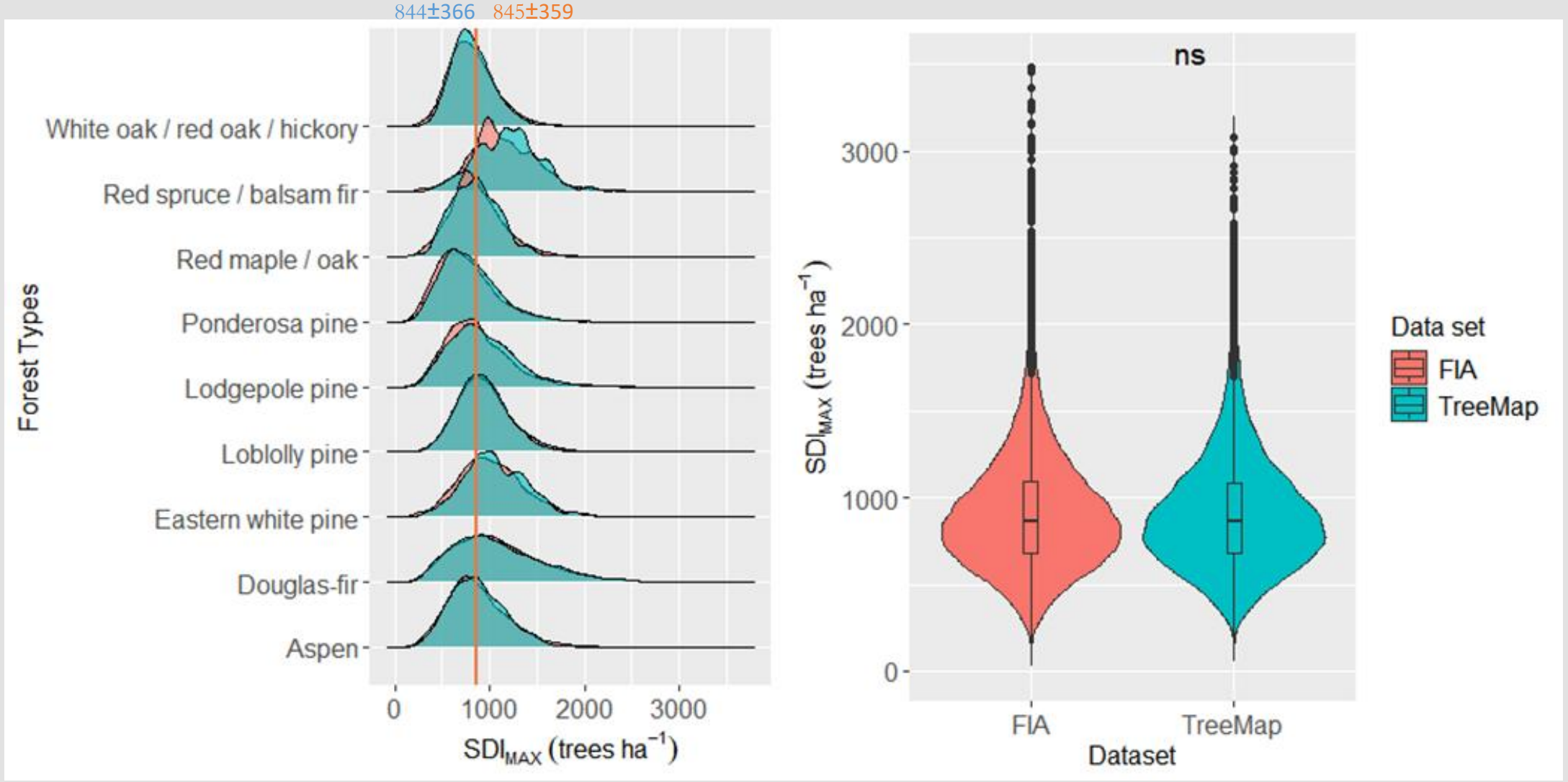
Relative density



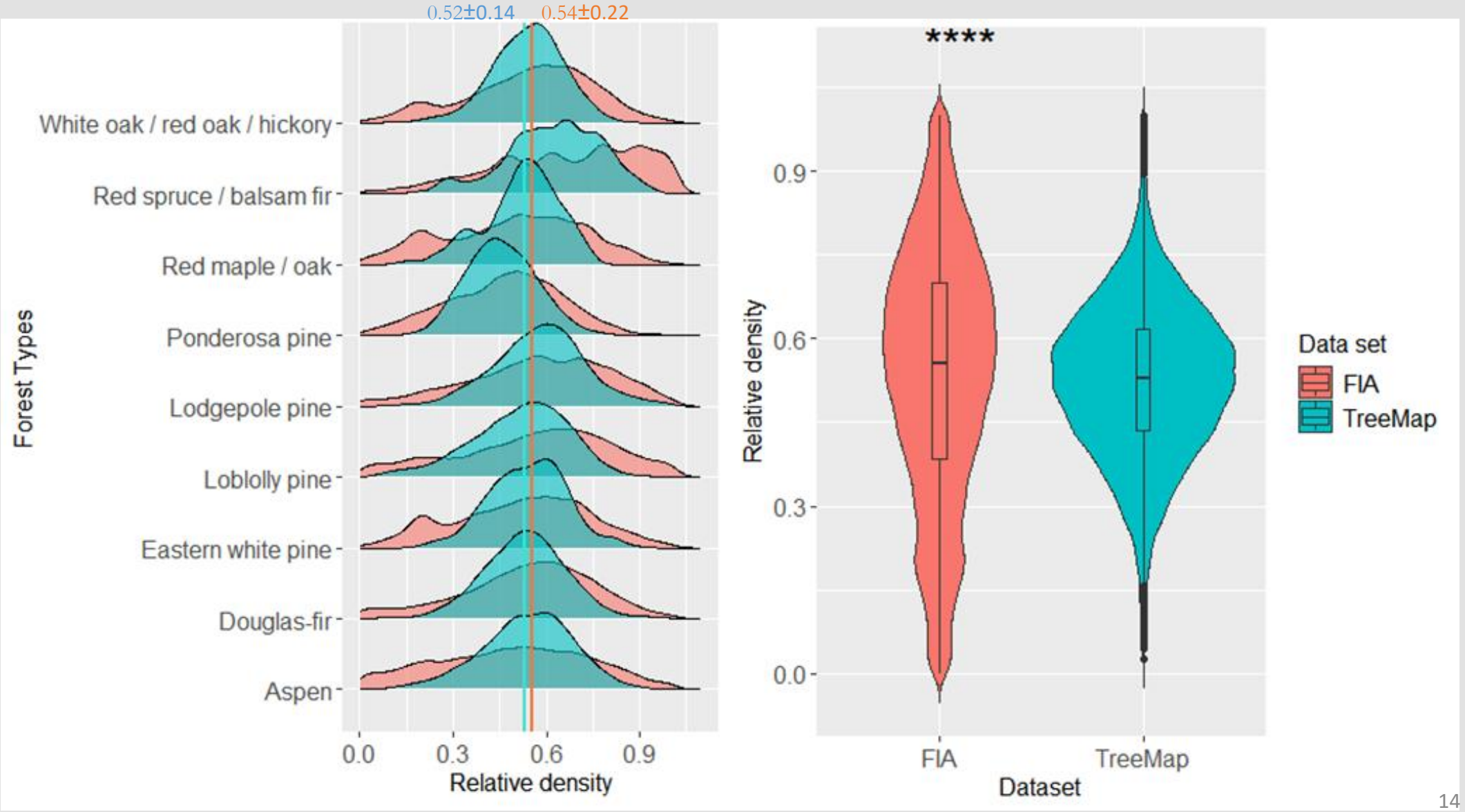
Size-density distributions of SDI across forest types



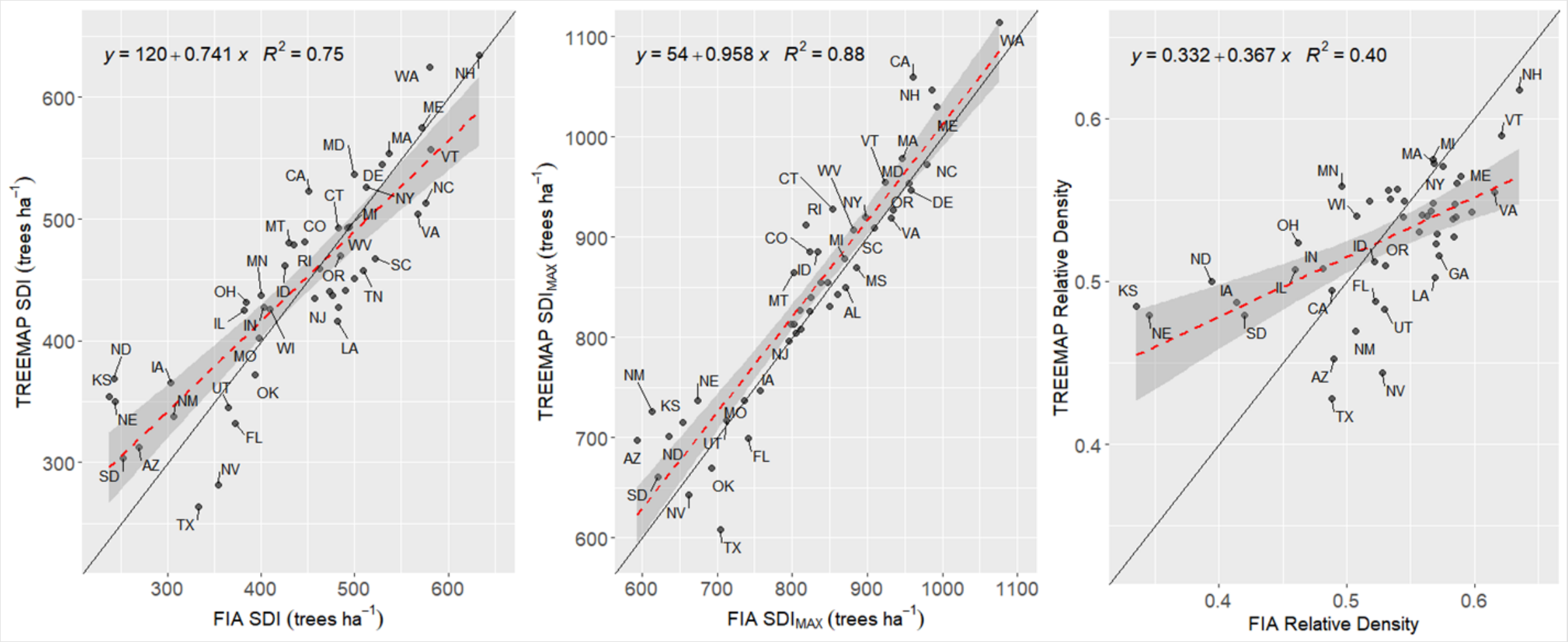
Size-density distributions of SDImax across forest types



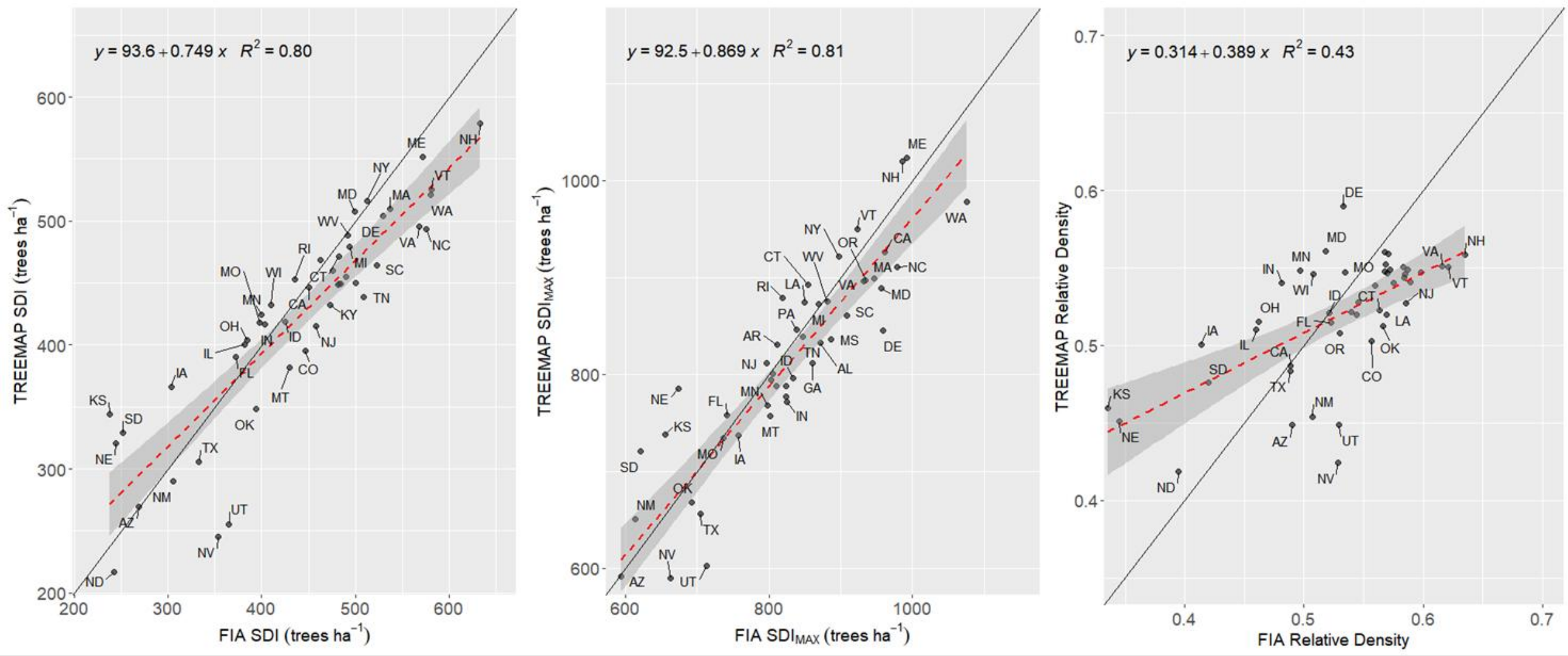
Size-density distributions of RD across forest types



State level comparison of plot level size-density metrics



State level size-density metrics derived from TREEMAP



Drivers of the differences

	Dataset	
Data element	**TREEMAP**	**FIA**
Data sources	Remote sensing and FIA	Field measurements
Model fit	Imputed random forest	Bayesian hierarchical modeling
Temporal resolution	Single year centered on a specific year (2016)	Differences between states and remeasurement periods
Forest definition	10% live tree cover excl disturbed areas	Minimum 10% live tree cover in the past incl disturbed plots

Strengths of the datasets

Dataset	
TREEMAP	**FIA**
Easy data integration	Coarse resolution for national assessments
Rapid mapping of forest attributes	Long term repeated measurements
Adjustability of their products	Standardized protocols

Limitations of the datasets

Dataset	
TREEMAP	**FIA**
Computationally complex	Plots do not cover heterogeneity of US forest types
Easily introduces uncertainty	Rapid forest changes not capture during sampling cycles
Under/over estimation of the true variability	Within plot variability may introduce uncertainty

Conclusions

- Nationally consistent high-resolution forest size-density raster data for users who relied on sparse inventory data.

- There are key differences in SDI, SDImax and RD based on FIA plot- and TREEMAP raster-level estimates across forest types and state levels.

Future updates

- The data is publicly available on FigShare https://figshare.com/authors/Emmerson_Chivhenge/18188932

- TREEMAP 2020 and 2022 have been approved!!!!!

- Datasets have been used characterize changes in density after disturbances in Wildfire Crisis Strategy landscapes, change in forested acreage in National Forest Service Lands

COMMENTS & QUESTIONS

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