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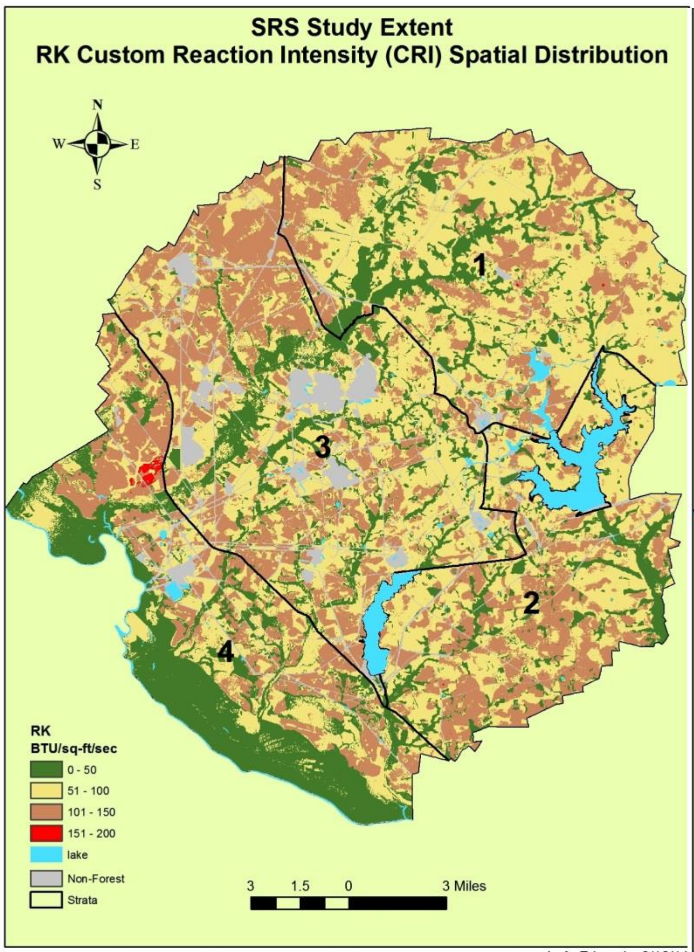
SRS 2010 Vegetation Inventory GeoStatistical Mapping Results for Custom Reaction Intensity and Total Dead Fuels

L. A. Edwards and Bernard Parresol

September 2014



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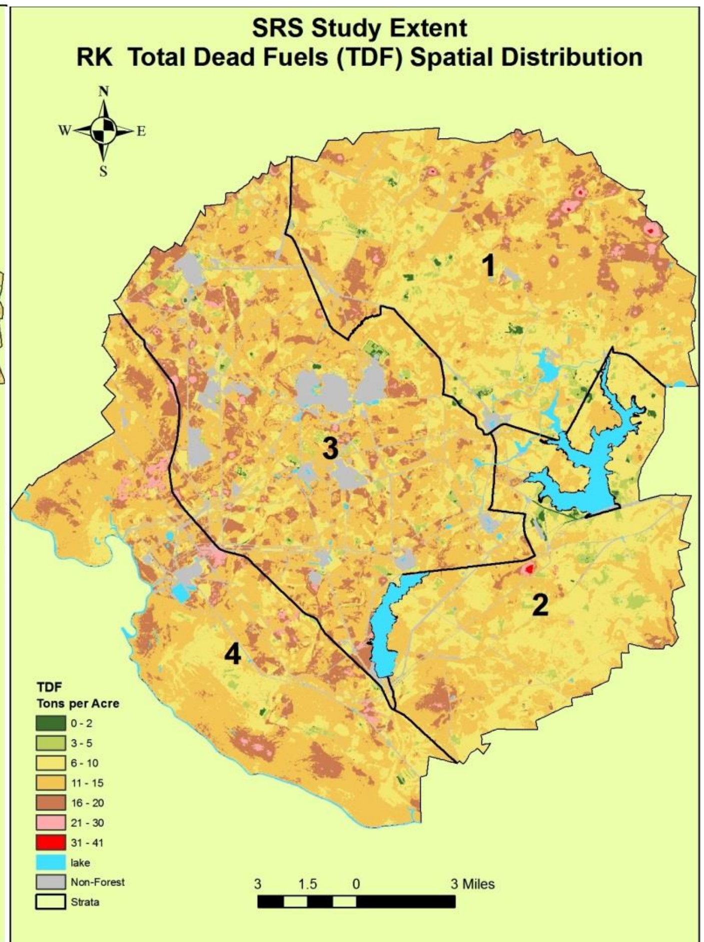

L. A. Edwards 9/16/14

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Table of Contents:

This report of the geostatistical analysis results of the fire fuels response variables, custom reaction intensity and total dead fuels is but a part of an SRS 2010 vegetation inventory project. For detailed description of project, theory and background including sample design, methods, and results please refer to USDA Forest Service Savannah River Site internal report "SRS 2010 Vegetation Inventory GeoStatistical Mapping Report", (Edwards & Parresol 2013).

4. Results:

4.1 Study Extent Spatial Distribution of Dependent Variables Custom Reaction Intensity (CRI) & Total Dead Fuels (TDF):

The following subsection includes statistics and map images (Figures. 4.1a-b) of dependent variables. CRI and TDF 1679 observation point values spatial distribution for the study extent. Statistics and number of per strata points used in per strata analysis listed in Table 4.1a.

Fig. 4.1a CRI

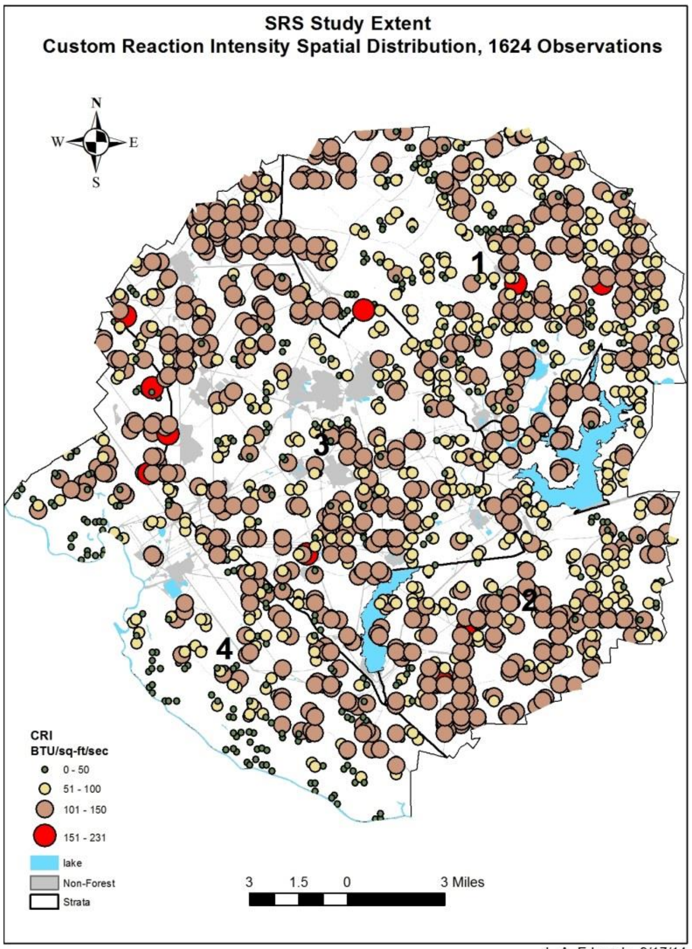

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Fig. 4.1b TDF

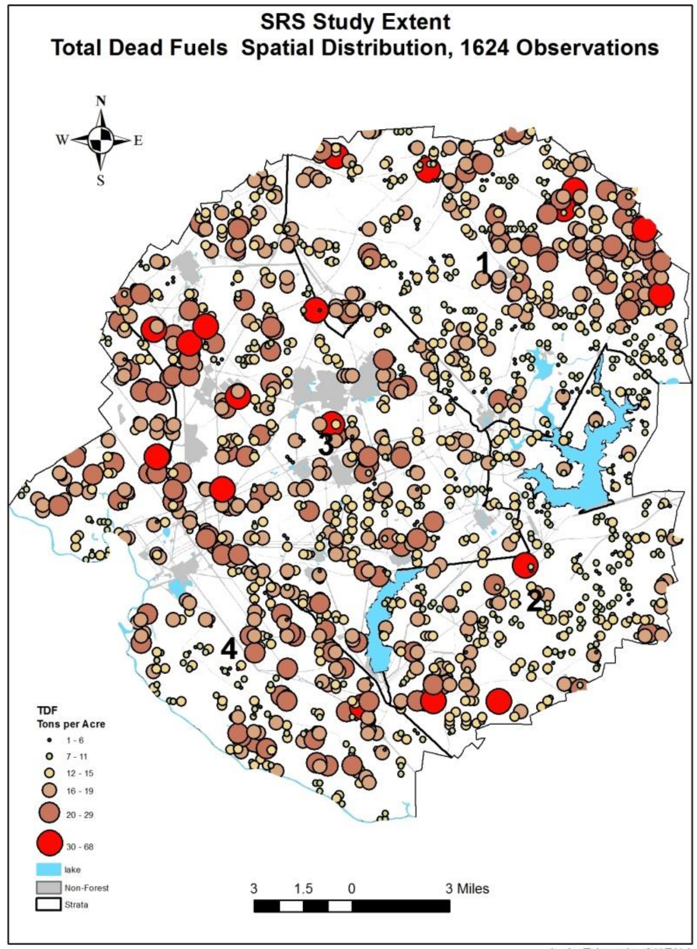

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Table 4.1a: Extent and per strata statistics for dependent variables CRI (BTU/sq-ft/sec) and TDF (tons per acre)

CRI	Min	Mean	Median	Max		TDF	Min	Mean	Median	Max
Strata 1 (515 points)	0.4	81	86	169		**Strata 1 (516 points)**	0	4.2	1.8	79
Strata 2 (366 points)	9	88	95	154		**Strata 2 (367 points)**	0	4.5	2.8	66
Strata 3 (481 points)	7	86	93	154		**Strata 3 (481 points)**	0	5.4	1.8	100
Strata 4 (345 points)	9.6	72	56	231		**Strata 4 (345 points)**	0	9.0	4.0	96
Extent (1625 points)	0.4	82	86	231		**Extent (1625 points)**	0.6	12.4	11.6	158

4.2 Dependent Variables Custom Intensity Reaction (CRI) and Total Dead Fuels (TDF) per Strata Best Fit Model Results:

Table 4.2: Contains a listed by variable per strata best fit model R squared and adjusted R squared results between dependent variables **CRI** and **TDF** ~ explanatory variables selected to create prediction models.

	CRI				TDF			
Strata's 1-4	1	2	3	4	1	2	3	4
R-squared	0.5144	0.5252	0.4832	0.7704	0.3061	0.3949	0.4016	0.2705
Adjusted R-squared	0.5047	0.5105	0.471	0.7606	0.2852	0.3779	0.3862	0.2464
average R-squared: 0.5733					average R-squared: 0.3432			

4.3 Dependent Variable ~ Explanatory Variables per Strata Geostatistical Best Fit Model Results: The following tables are of dependent variables (CRI & TDF) ~ explanatory variables significance and best fit model coefficients results. Selected best fit model explanatory variables criteria was based on Pr (>|t|) <= 0.05.

4.3.1 CRI and TDF per Strata Best Fit Model Results:

Table 4.3.1a: Dependent variables **CRI** and **TDF** per strata continuous forest stand, environmental and LIDAR explanatory variables best fit model significance.

CONTINUOUS	CRI - Strata's 1-4				TDF - Strata's 1-4			
FOREST STAND & ENVIRONMENTAL VARIABLES	1	2	3	4	1	2	3	4
age	0.002746 **	0.006938 **			4.66e-05 ***	6.37e-14 ***	7.28e-11 ***	
agenum			0.00692 **					
aspect				0.030486 *				
ba (basal area)			0.00326 **	0.008266 **		4.17e-06 ***		
biomass								
canopy	0.001241 **				0.032663 *		0.034848 *	
gw	0.000314 ***	0.001792 **	0.00422 **		0.002934 **	0.000420 ***		
lorey				0.000540 ***	5.38e-06 ***		2.58e-05 ***	6.17e-08 ***
numbrns	0.036485 *						0.006722 **	
numthins					3.19e-07 ***	3.61e-09 ***		
slope				0.012956 *				
vol		0.000707 ***	0.00430 **					
gw*slope							2.35e-06 ***	

4.3.1 Continued CRI and TDF per Strata Best Fit Model Results:

Table 4.3.1b: Dependent variables **CRI** and **TDF** per strata ~ explanatory categorical treatment variables best fit model significance.

CATEGORICAL	CRI - Strata's 1-4				TDF - Strata's 1-4			
TREATMENT VARIABLES	1	2	3	4	1	2	3	4
Years ago last burned (lstbrncat)	1	2	3	4	1	2	3	4
1								
3	0.053429 .			0.000167 ***		0.032777 *		0.003168 **
6				0.005531 **	0.000112 ***	7.82e-05 ***		
10					0.018735		0.009344 **	
20	0.001275 **	0.04584 *	0.00395 **					
30								
40							3.20e-05 ***	0.000373 ***
no record burned 99			9.17e-05 ***	0.012698 *				
Years ago last thinned (lstthincat)	1	2	3	4	1	2	3	4
2								
5					2.95e-07 ***			
8					0.015285 *			0.006063 **
11					0.000282 ***			9.68e-06 ***
15					5.85e-05 ***	0.000125 ***		9.07e-06 ***
no record thinned 99								
Numthins	1	2	3	4	1	2	3	4
0								
1		0.02703 *	0.00159 **	1.08e-06 ***				2.28e-09 ***

Table 4.3.1c: Dependent variables **CRI** and **TDF** per strata ~ explanatory categorical forest stand and environmental variables best fit model significance.

ENVIRONMENTAL	CRI - Strata's 1-4				TDF - Strata's 1-4			
CATEGORICAL VARIABLES	1	2	3	4	1	2	3	4
Land type (type)	1	2	3	4	1	2	3	4
1- Non-wetland area								
2- wetland area								

Soils (soils)	1	2	3	4	1	2	3	4
1- Chastain-Tawcaw-Shellbluff								
2- Rembert-Hornsville								
3- Blanton-Lakeland								0.041101 *
4- Fuquay-Blanton-Dothan					0.006320 **		0.004430 **	7.90e-06 ***
5- Orangeburg							0.009686 **	
6- Vaucluse-Ailey					0.043259 *		0.006766 **	
7- Troup-Pickney-Lucy	0.017448 *				0.000135 ***		6.79e-05 ***	
Historic landuse-cover lulc)	1	2	3	4	1	2	3	4
1- Developed								
2 - Open								
3 - Canopy								
4 - Cut over								
7- Orchards								
8- Carolina bays						0.002611 **		
Forest group forgroup)	1	2	3	4	1	2	3	4
1- Loblolly pine								
2- Longleaf pine		0.000707 ***		0.000677 ***				0.004163 **
3- Slash pine		0.000806 ***		1.06e-10 ***				
4- Pine-Hardwood mix	7.62e-14 ***	1.04e-12 ***	5.83e-08 ***	1.02e-13 ***				
5- Hardwood-Pine mix	< 2e-16 ***	1.75e-11 ***	3.20e-10 ***	< 2e-16 ***	0.007090 **			
6- Hardwoods	< 2e-16 ***	< 2e-16 ***	< 2e-16 ***	< 2e-16 ***		0.003964 **	0.000176 ***	
7- Bald cypress-Tupelo		6.50e-09 ***	0.00303 **	< 2e-16 ***		0.001609 **		0.041437 *

4.3.1 Dependent Variables CRI and TDF per Strata Best fit model Equations:

The following equations are the best fit model equations for the dependent variables **CRI** and **TDF**. These regression equations include the intercept and best fit model explanatory variables and their coefficients.

Variable CRI Equations:

Strata 1 CRI best fit model equation: R-squared: 0.5144, Adjusted R-squared: 0.5047
CRI = 4281 + 34.274(gw) + 9.848(age) + 10.611(canopy) + -87.698(numbrns) + -1985(forgroup4) + -3931(forgroup5) + -3203(forgroup6) + 275.81(lstbrncat3) + 785.39(lstbrncat20) + -493.05(soils7)

Strata 2 CRI best fit model equation: R-squared: 0.5252, Adjusted R-squared: 0.5105
CRI = 5.608e+03 + 36.11(gw) + -11.44(age) + 0.1784(vol) + -4.778e+02(forgroup2) + -1.371e+03(forgroup3) + -1.806e+03(forgroup4) + -3.199e+03(forgroup5) + -3.726e+03(forgroup6) + -5.135e+03(forgroup7) + 4.180e+02(lstbrncat20) + 4.101e+02(numthins1)

Strata 3 CRI best fit model equation: R-squared: 0.4832, Adjusted R-squared: 0.471
CRI = 5.395e+03 + -1.405e+03(forgroup4) + -2.758e+03(forgroup5) + -2.934e+03(forgroup6) + -3.247e+03(forgroup7) + 6.034e+02(numthins1) + -7.288e+02(lstbrncat99) + -5.403e+02(lstbrncat20) + 20.58(gw) + 13.34(agenum) + 9.093(ba) + -0.22(vol)

Strata 4 CRI best fit model equation: R-squared0.7704, Adjusted R-squared: 0.7606
CRI = 7058 + -809.39(forgroup2) + -3110(forgroup3) + -2028(forgroup4) + -3765(forgroup5) + -3485(forgroup6) + -4614(forgroup7) + 1155(numthins1) + -730.83(lstbrncat3) + 859.32(lstbrncat6) + -472.86(lstbrncat99) + 6.386(ba) + 1.548(aspect) + -146.78(slope) + -12.76(lorey)

Variable TDF Equations:

Strata 1 TDF best fit model equation: R-squared: 0.3061, Adjusted R-squared: 0.2852
TDF = 3.6640 + 0.0447(age) + 0.0923(gw) + 0.0267(canopy) + 0.0695(lorey) + 4.59394(numthins) + -3.10127(forGroup5) + -1.50217(soils4) + -1.5619(soils6) + -2.7314(soils7) + -7.7402(lstthincat5) + -4.1221(lstthincat8) + -5.8490(lstthincat11) + -5.1488(lstthincat15) + -2.7629(lstBrnCat6) + 3.7745(lstBrnCat10)

Strata 2 TDF best fit model equation: R-squared: 0.3949, Adjusted R-squared: 0.3779
TDF = 2.144001 + 0.07569(age) + .0273(ba) + 0.1048(gw) + 3.160339(numthins) + 2.0761(forgroup6) + 7.7047(forgroup7) + 4.7964(lulc8) + -3.2397(lstthincat15) + 1.0377(lstbrncat3) + 3.7298(lstbrncat6)

Strata 3 TDF best fit model equation: R-squared: 0.4016, Adjusted R-squared 0.3862
TDF = 5.1780 + 0.0852(age) + 0.0609(lorey) + 0.0241(canopy) + -2.6016(forgroup6) + 3.8120(lstbrncat40) + 4.5034(lstbrncat10) + -1.8805(soils4) + -2.6409(soils5) + -2.0319(soils6) + -3.7356(soils7) + -0.5652(numbrns) + 0.0212(gw * slope)

Strata 4 TDF best fit model equation: R-squared: 0.2705, Adjusted R-squared: 0.2464
TDF = 7.3991 + 0.0681(lorey) + 8.2630(numthins1) + -1.9736(lstbrncat3) + 5.5726(lstbrncat40) + -6.2471(lstthincat8) + -7.8583(lstthincat11) + -10.6451(lstthincat15) + 2.8051(soils3) + 3.0746(soils4) + -2.5648(forgroup2) + 1.5390(forgroup7)

4.4: Dependent Variable CRI Geostatistical Mapping Strata 1 – 4 RK, CS and Leave One Out Cross Validation (loocv) Prediction Error Best Fit Model Plot Results: Figures 4.4a-b

Fig. 4.4a CRI RK Strata 1 (20m)

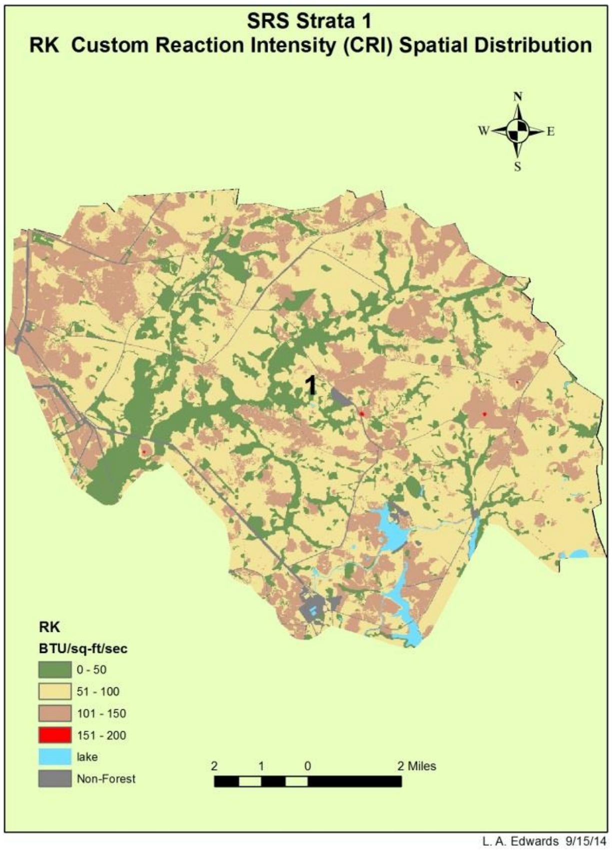
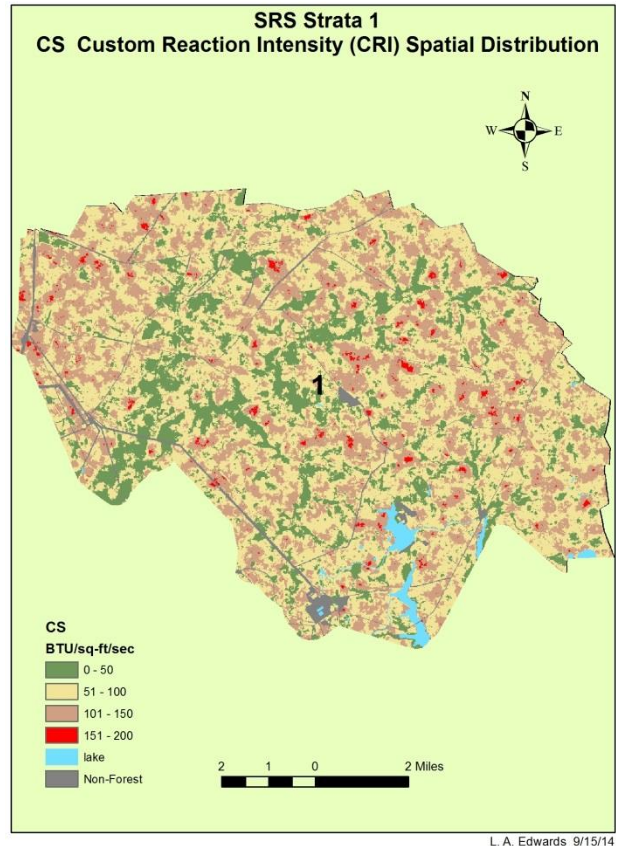


Fig. 4.4b CRI CS Strata 1 (20m)



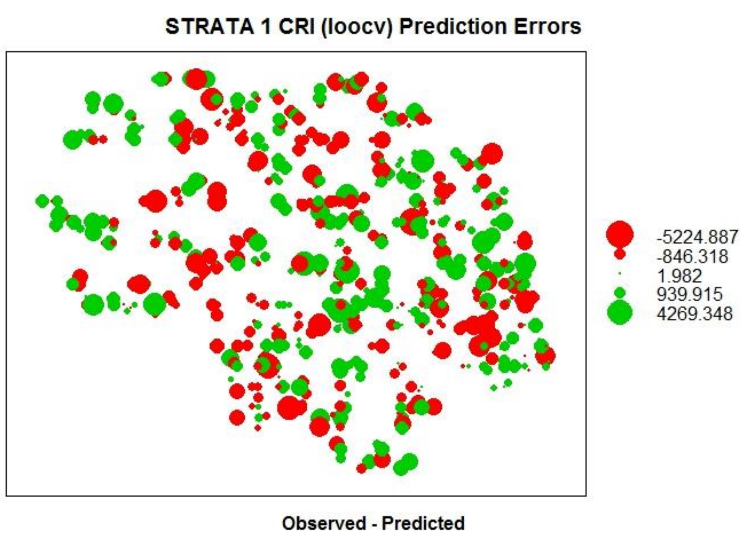


Fig.4c

4.4: Dependent Variable CRI Geostatistical Mapping Strata 2 RK, CS and Leave One Out Cross Validation (loocv) Prediction Error Best Fit Model Plot Results: Figures 4.4d-f

Fig. 4.4d CRI RK Strata 2 (20m)

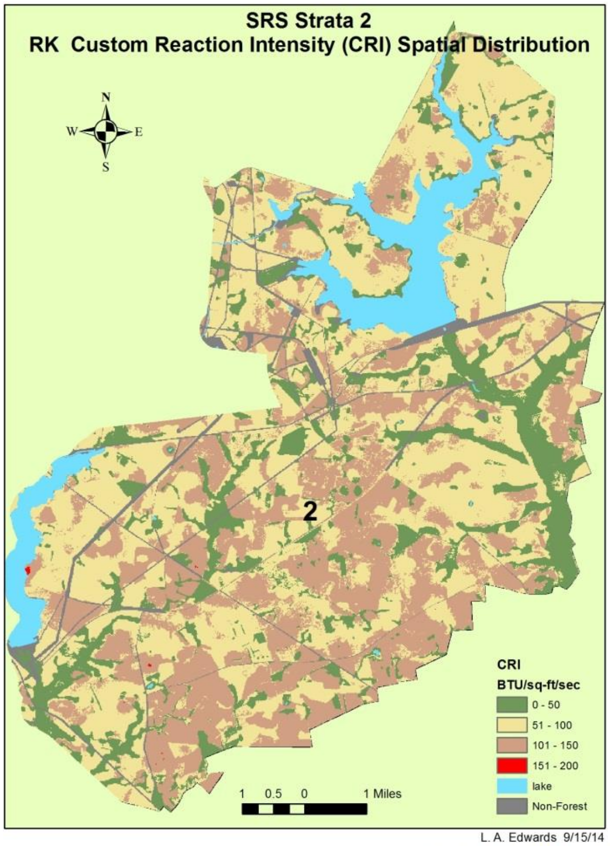
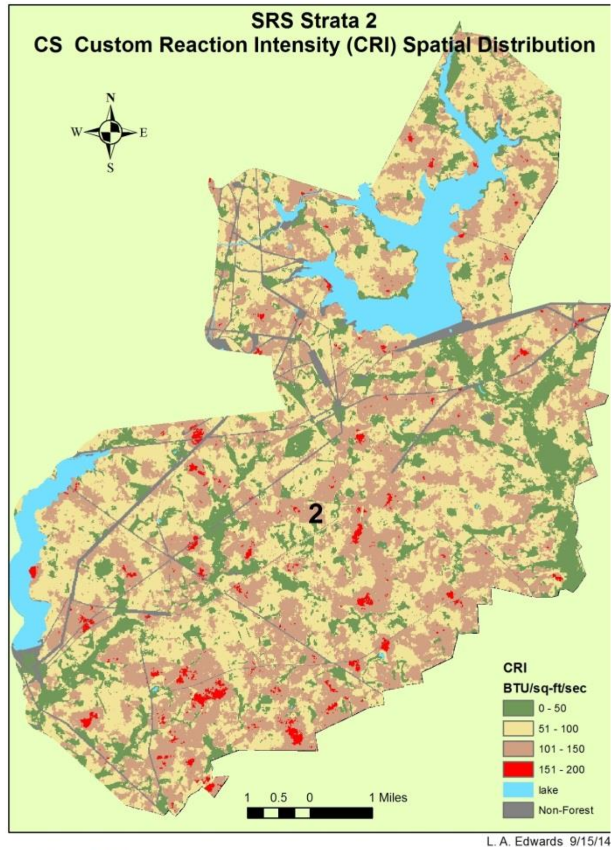


Fig. 4.4e CRI CS Strata 2 (20m)



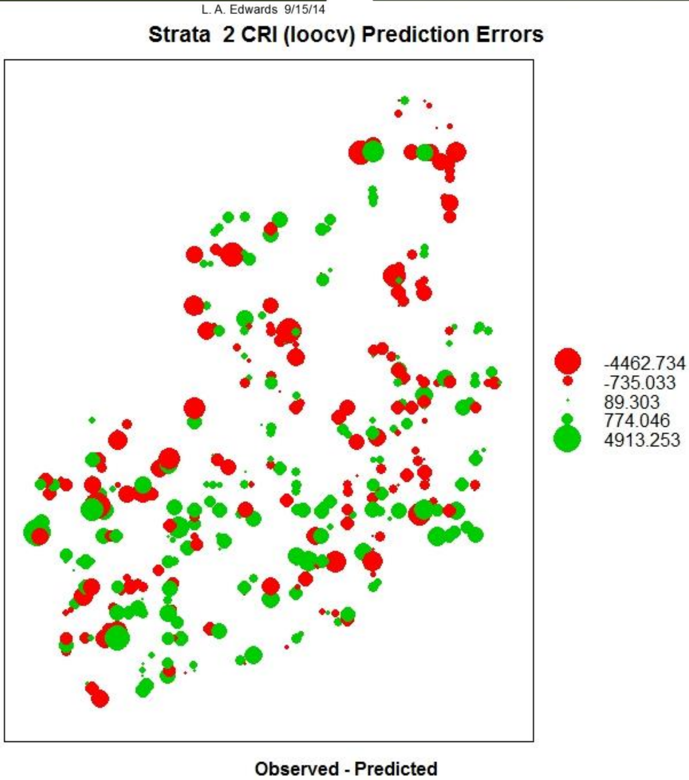


Fig. 4.4f

4.4: Dependent Variable CRI Geostatistical Mapping Strata 3 RK, CS and Leave One Out Cross Validation (loocv) Prediction Error Best Fit Model Plot Results: Figures 4.4g-i

Fig. 4.4g CRI RK Strata 3 (20m)

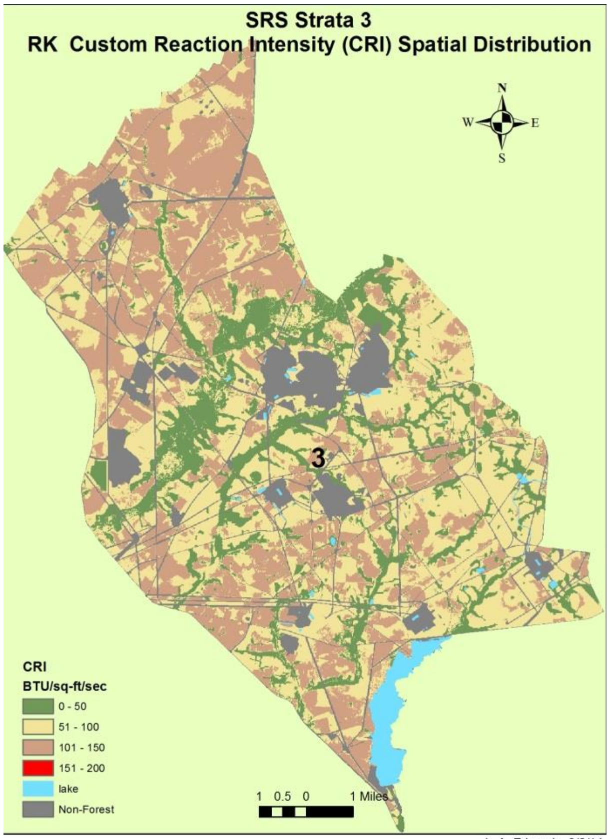
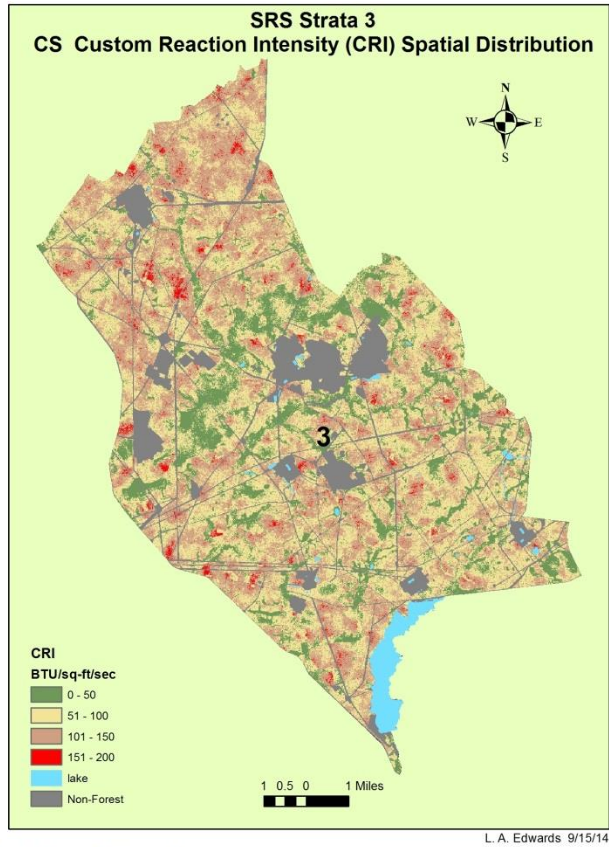


Fig. 4.4h CRI CS Strata 3 (20m)



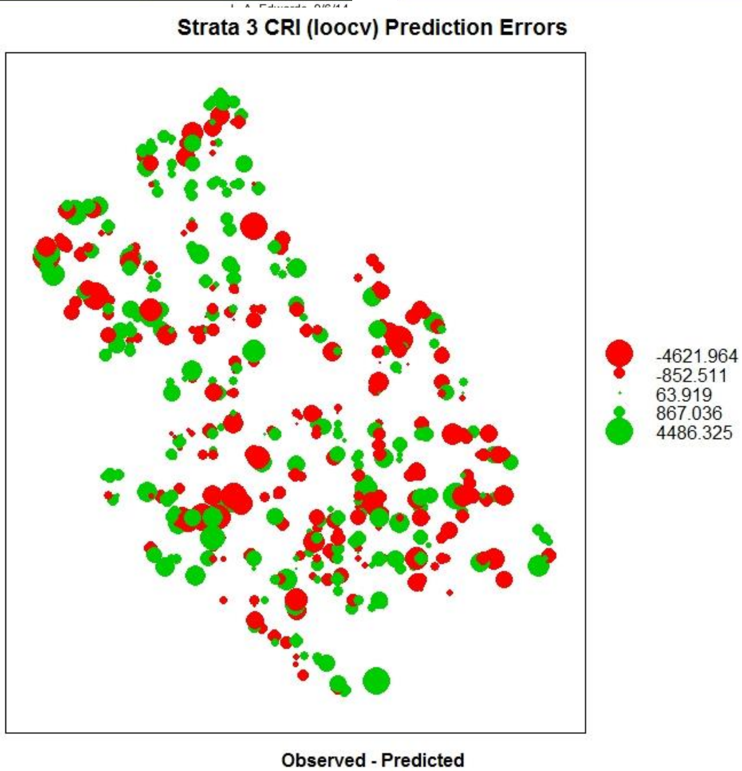


Fig. 4i

4.4: Dependent Variable CRI Geostatistical Mapping Strata 4 RK, CS and Leave One Out Cross Validation (loocv) Prediction Error Best Fit Model Plot Results: Figures 4.4j-l

Fig. 4.4j CRI RK Strata 4 (20m)

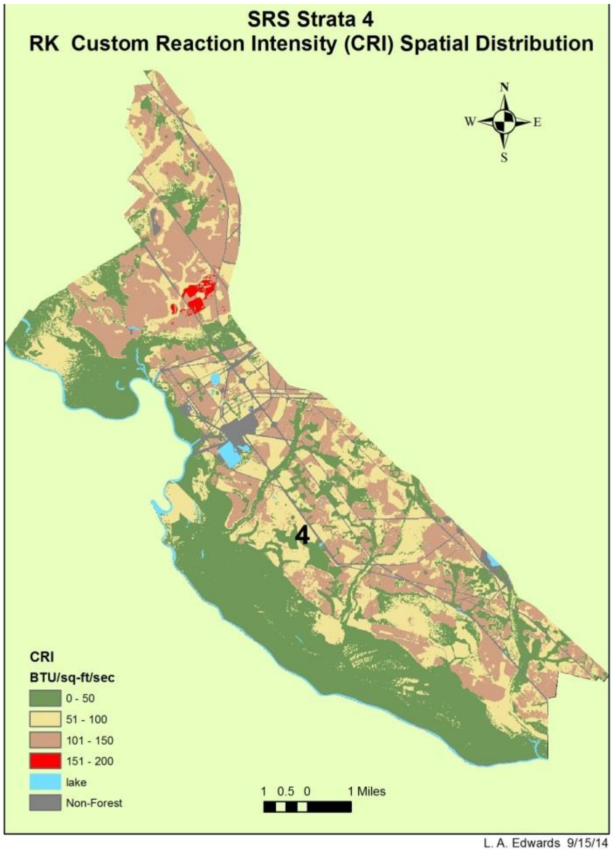
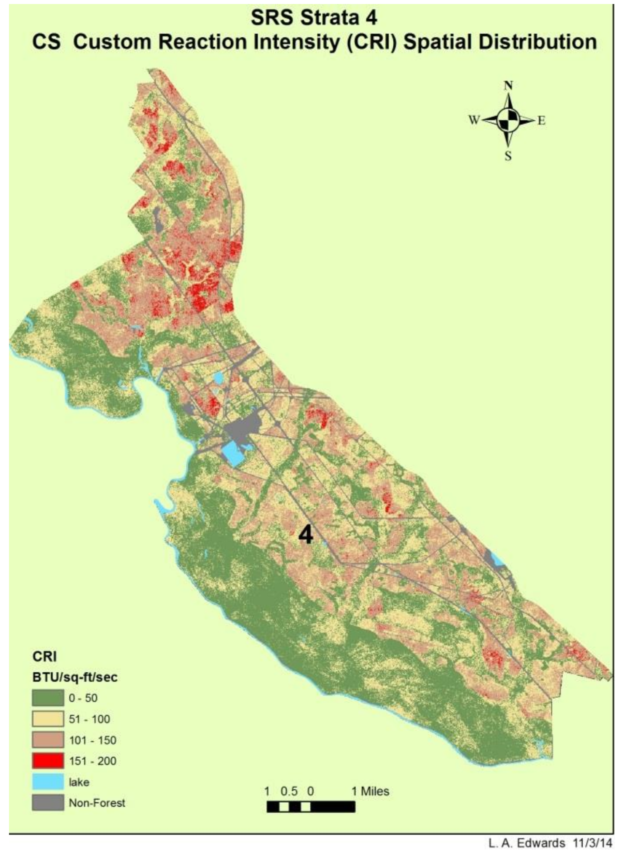


Fig. 4.4k CRI CS Strata 4 (20m)



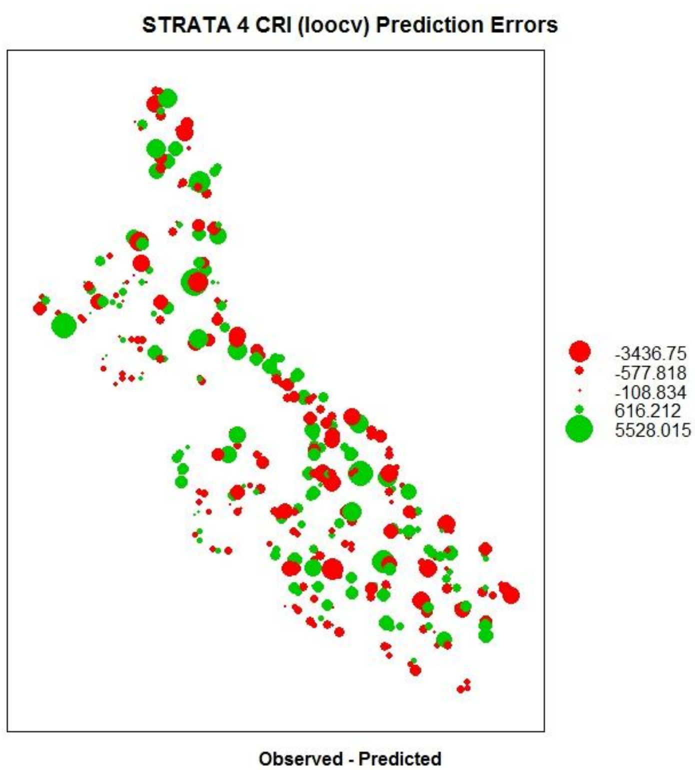


Fig. 4l

4.5: Dependent Variable TDF Geostatistical Mapping Strata 1 RK, CS and Leave One Out Cross Validation (loocv) Prediction Error Best Fit Model Plot Results: Figures 4.5a-c

Fig. 4.4a TDF RK Strata 1 (20m)

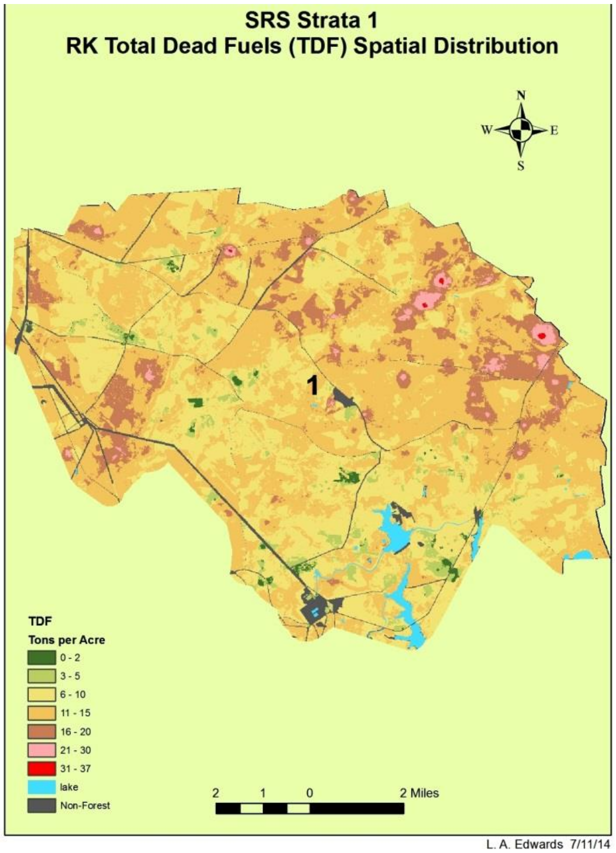
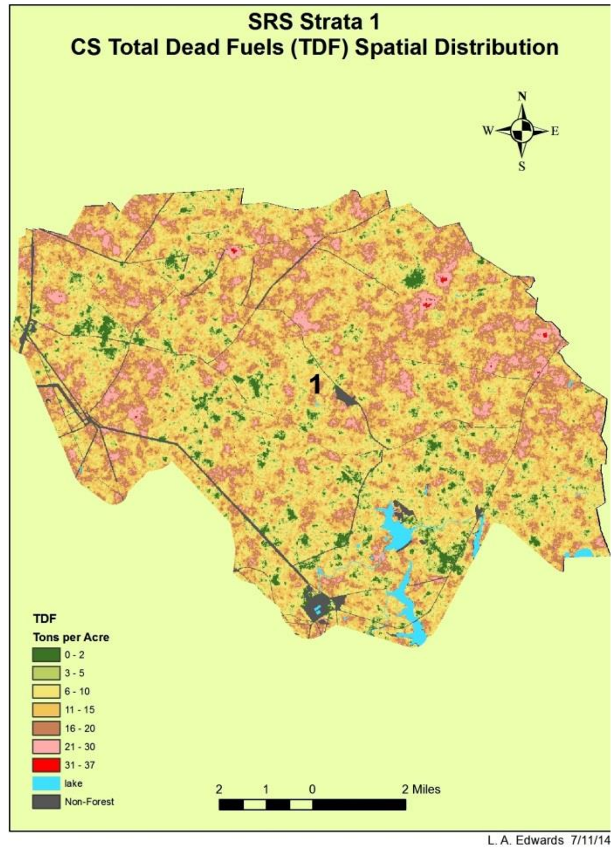


Fig. 4.4b CRI CS Strata 1 (20m)



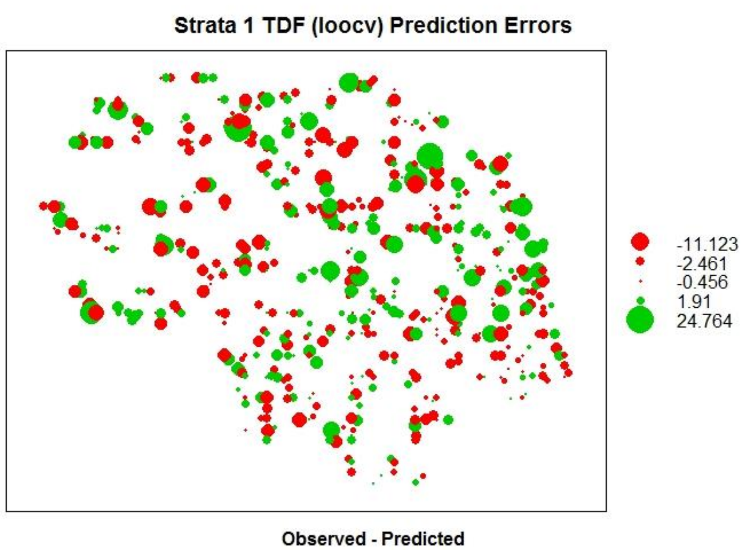


Fig. 4.5c

4.5: Dependent Variable TDF Geostatistical Mapping Strata 2 RK, CS and Leave One Out Cross Validation (loocv) Prediction Error Best Fit Model Plot Results: Figures 4.5d-f

Fig. 4.4d TDF RK Strata 2 (20m)

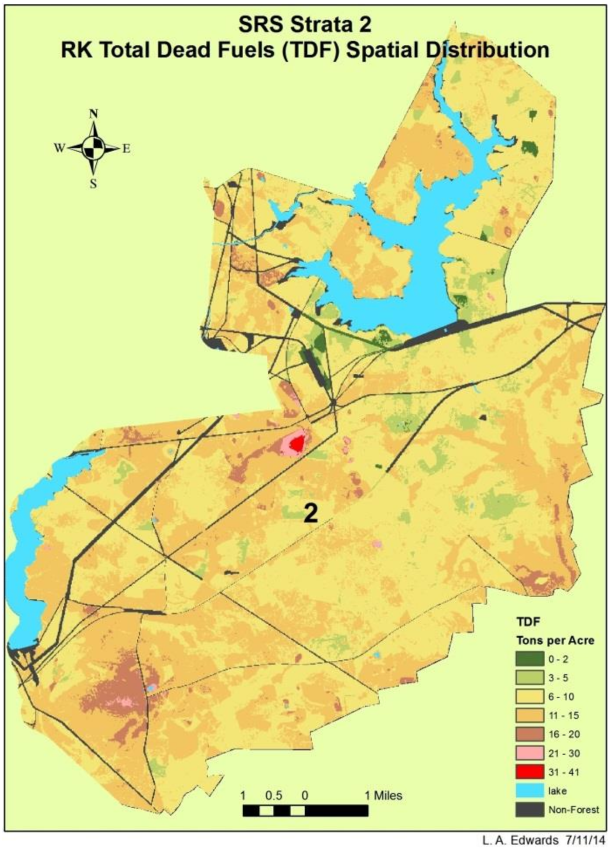
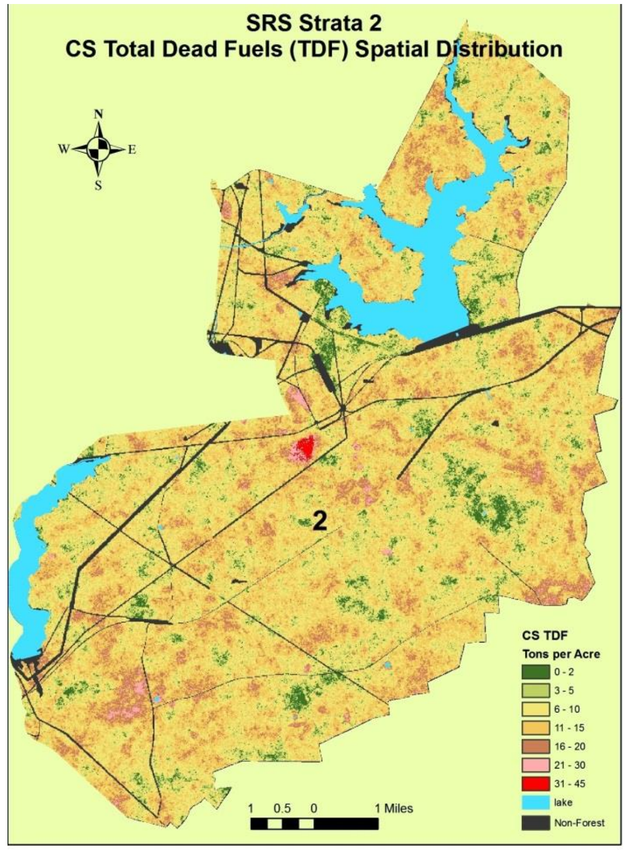


Fig. 4.4e: TDF CS Strata 2 (20m)



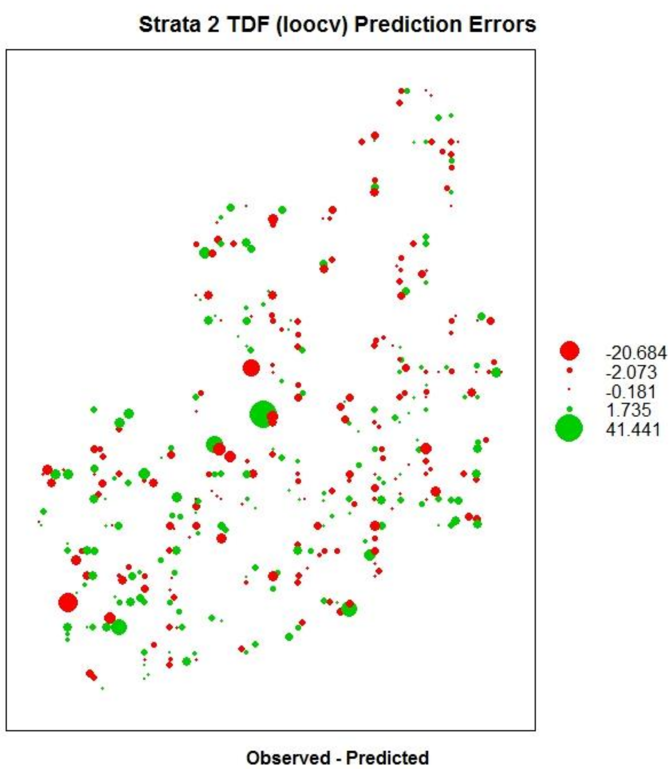


Fig. 4.4f

4.5: Dependent Variable TDF Geostatistical Mapping Strata 3 RK, CS and Leave One Out Cross Validation (loocv) Prediction Error Best Fit Model Plot Results: Figures 4.5g-i

Fig. 4.4g TDF RK Strata 3 (20m)

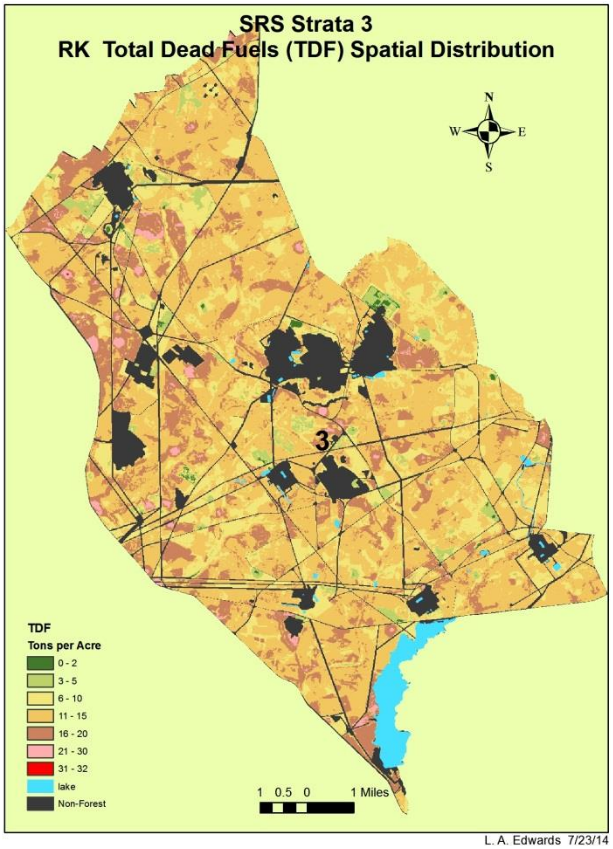
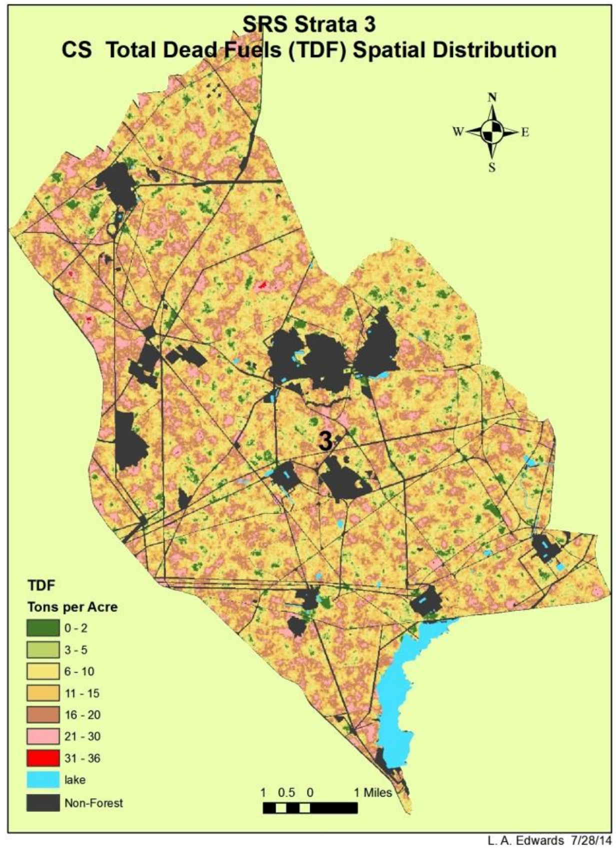


Fig. 4.4h: TDF CS Strata 3 (20m)



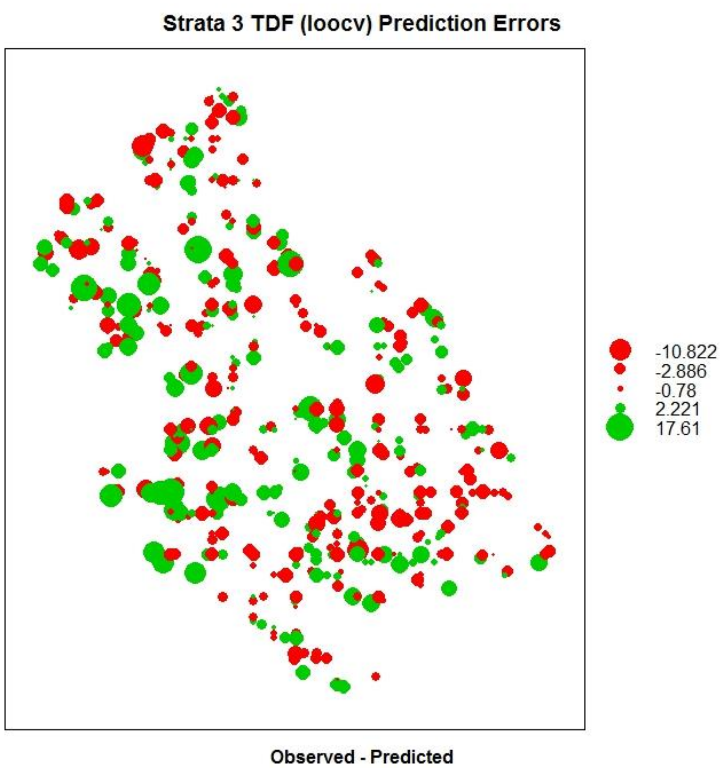


Fig 4.51

4.5: Dependent Variable TDF Geostatistical Mapping Strata 4 RK, CS and Leave One Out Cross Validation (loocv) Prediction Error Best Fit Model Plot Results: Figures 4.5j-l

Fig. 4.4g TDF RK Strata 3 (20m)

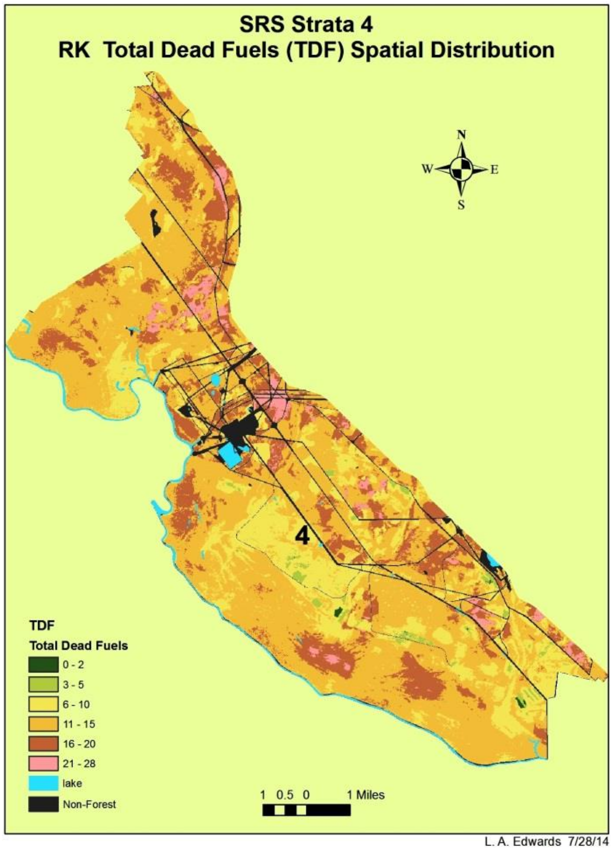
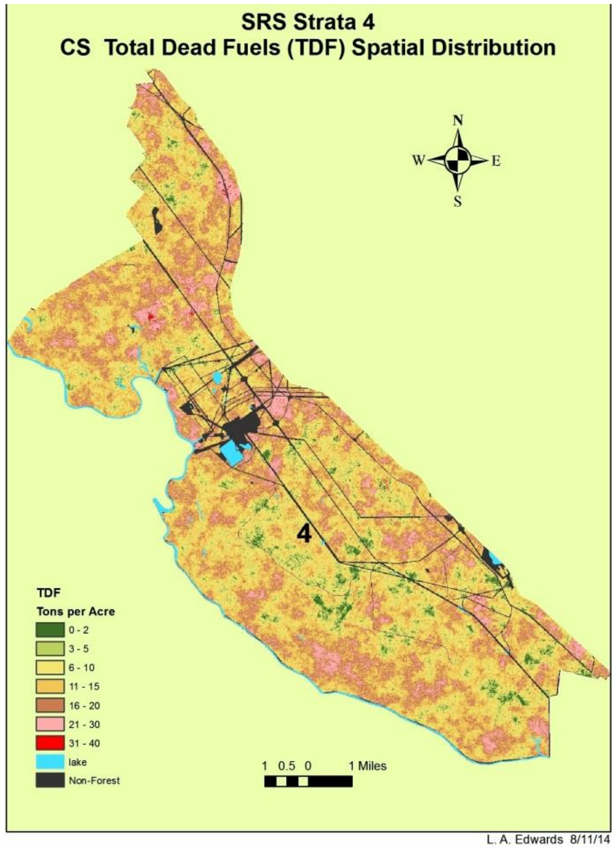


Fig. 4.4h: TDF CS Strata 3 (20m)



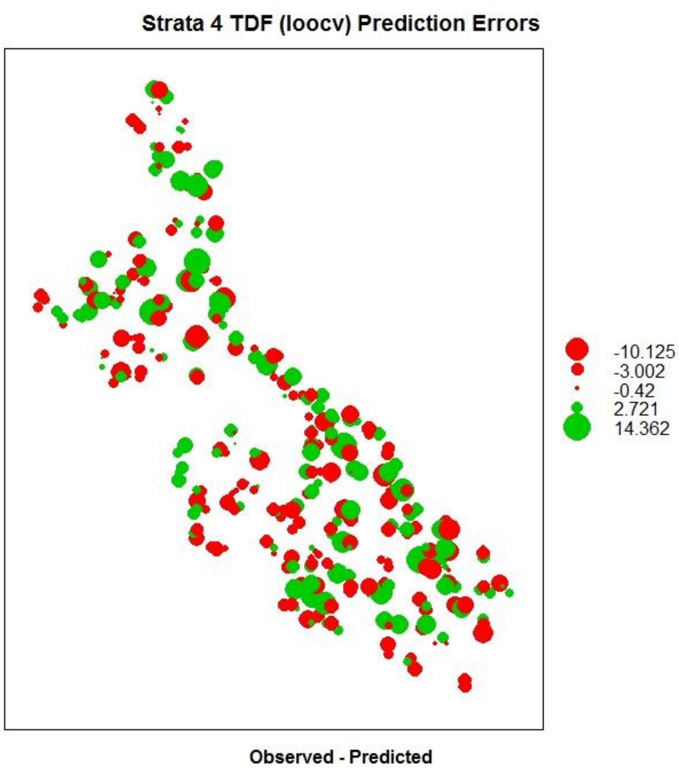


Fig4.5l

4.6: Visualizing Local Spatial dependence via the Fitted Residuals Variogram Model:

Once the best fit regression model (deterministic part of variation) has been determined, then a fitted regression model residuals variogram (RVGM) is developed to enable the RK and CS process. The following (Figs.... 4.5a & b) are fitted residuals variograms corresponding to the above examples of dependent variables CRI and TDF geostatistical mapping best fit modelling results. Local spatial dependence can initially be determined by visualization of variogram parameters which characterize spatial dependence such as the **sill's** maximum semi-variance which represents variability in the absence of spatial dependence, the **range** (distance), the separation between point-pairs at which the sill is reached. The range represents the distance at which there is no evidence of spatial dependence and the **nugget**, the semi-variance at which the separation distance between points approaches zero. The nugget represents variability at a point that can't be explained by spatial structure. Distance units are meters.

Fig. 4.5a CRI Strata 2

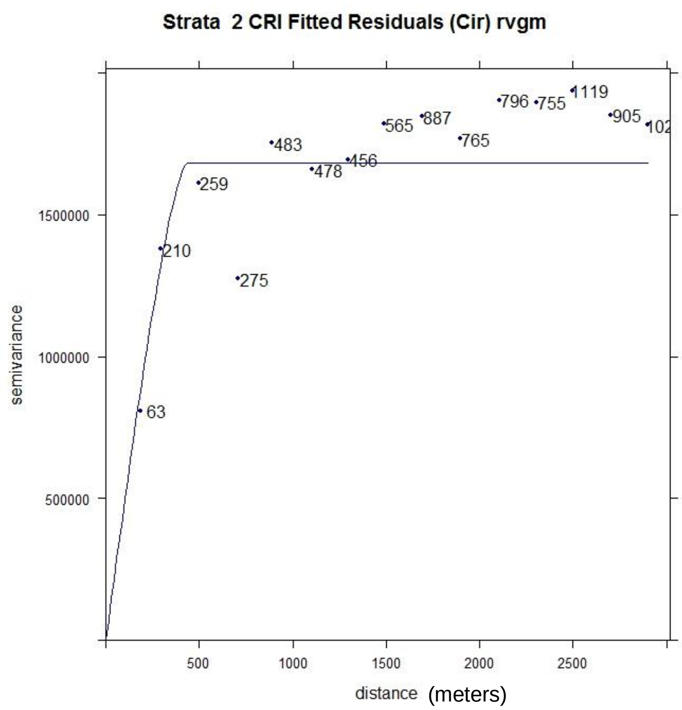
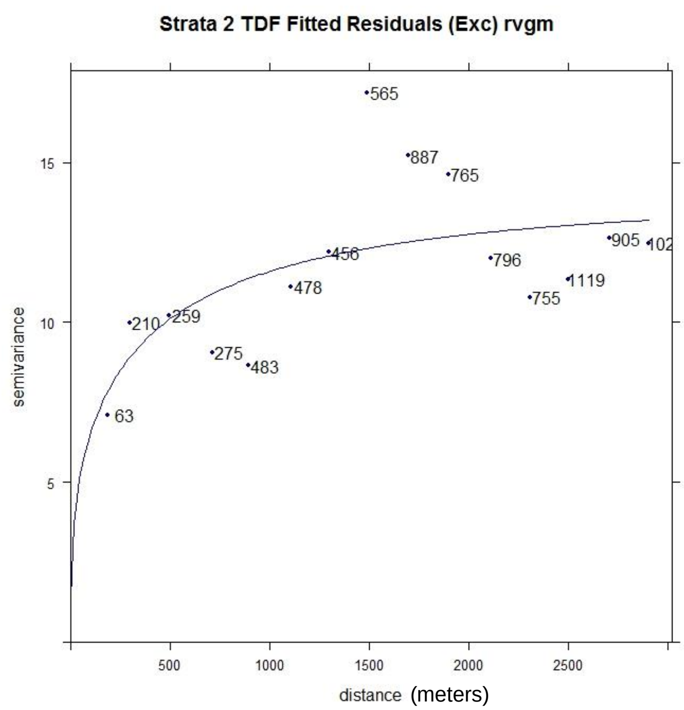


Fig. 4.5b TDF Strata 2



Appendix A:

Data Description of Dependent Variables Custom Reaction Intensity (CRI) and Total Dead Fuels (TDF) and the Independent Variables Used in Support of SRS 2010 Vegetation Inventory Fire Fuels Geostatistical Analysis and prediction modelling:

The analysis data were collected from United States department of Energy (DOE) Savannah River Site boundary, located in southeastern United States along the Savannah River in Aiken, South Carolina. The analysis extent is approximately 198,000 acres.
The 1679 point variables attributes values used in this geostatistical analysis consist of 1) information derived from plot based measures, e.g. the fire fuel response variables total dead fuels and custom reaction intensity 2) point values extracted from geospatial layers of, for example vegetation, soils, depth to ground water, forest group, inventory strata, treatment, and historic land use-land cover, and 3) point values extracted from LIDAR forest metric layers created from the 2009 LIDAR overflight (Reutebuch and McGaughey 2011).

1.2: Dependent Variables CRI and TDF

Fire fuel variable values for TDF and CRI were created and merged into an overall fire fuels project point file (1679ProjectPts6.shp) using the following steps: 1. convert field measured value source data files (Crosswalk Fuelbed ID Plot ID.xlsx and SRS_1680_batch_summary.xlsx) to dbf files and join the 2 files by the common attribute fuelbedNum, thus creating the combined data file firefuelsData.dbf. 2. Because the fireFuelsData.dbf file were not georeferenced, points were selected from 1670ProjectPts5.shp file by distance = 0, 0.125 & 0.250. 3. The selected by attribute by distance point files were then joined to 1679projectPts5.shp file by their common attribute plot_id and exported as new point files, sequentially named: firePtsDist0.shp, firePtsDist0.125.shp and firePtsDist0l.25.shp. 4. These 3 files were then merged together to create an overall project file 1679ProjectPts6.shp. The overall project point file (1679ProjectPts6.shp) specific to the dependent variables CRI and TDF field measured attribute values were used to compute the CRI and TDF final point values used to create the parsimonious regression model.

- **Total dead fuels (TDF)**, units: tons per acre, field plot measured values, information source files: crosswalk Fuelbed ID Plot ID.xlsx and SRS_1680_batch_summary.xlsx). The steps used to compute the final TDF values were as follows: 1. the attributes LLM_litter and totalDuff values were corrected per age and forest group. 2. attribute 1_10_100 hr = Woody_soun + Woody_so_1 + Woody_so2. 3. TDF is then derived by summation of attributes i.e. TDF = 1_10_100 + totalDuff + LLM_litter.

- **Custom reaction intensity (CRI):** units: BTU/sq-ft/sec, field plot measured values, information source files: crosswalk Fuelbed ID Plot ID.xlsx and SRS_1680_batch_summary.xlsx). CRI for the surface fuels was derived from the Fuel Characterization and Classification System (FCCS). The calculation included the available surface dead fuels and the available surface live fuels (grasses, forbs, vines, shrubs) based on cover and height. The custom value was determined for the 97% percentile environmental conditions at the Savannah River Site using a 10 mph wind speed. The calculations were performed in batch mode by Anne Andreu (University of Washington) as part of the Pacific

Northwest Experiment Station Fire Lab (Seattle, WA) project. The class values in BTU/sq-ft/sec are based upon the standard class breaks for reaction intensity and fire spread corresponding to safe limits for hand line, machine and aerial attack.

2: Plot Based Measured Data:

For methods for collecting plot based measurements see summarization section 3.3.1 Plot Based Measurement Design and Field Data (p. 8-19) (Parresol and Blake 2010).

2.1: Field and Point Data Files:

The following are data descriptions of the overall fire fuel project point file, the primary project point file's information source are excel files (populated with relevant field based measures), and the GPS collected geo-referenced coordinate variables.

- **1679ProjectPts6.shp**: An ArcGIS created 1679 point shape file which contains all relevant 2010 vegetation inventory geostatistical modeling response and predictor variable 1679ProjectPts6.shp points geographic coordinates originated from a spatial points file (named 1679ProjectPts.shp) which were collected GPS Utm17_NAD83 X Y coordinates (source: basic2010.xlsx) recorded at each of the originally 1680 Plot based measured sample points. As a result of the data integrity process one sample point was found erroneous and deleted, thus 1679 points. The field collected plot based measured fire fuels data values was input into excel worksheets named Crosswalk Fuelbed ID Plot ID.xlsx and SRS_1680_batch_summary.xlsx. Fire fuels data these worksheets were used to populate potential model variable values, either by direct measure or derived calculations.

- **1625FireFuelPts.shp:** Original 1679ProjectPts6.shp with additional fire fuels data values and w/ out tail pts.

- **strat1CRIPts.shp (515 pts.):** relative to CRI analysis**,** selected points from 1625FireFuelPts.shp that are w/in 500 meter buffer polygon surrounding strata 1.

- **strat1FirePts.shp: (514 pts.):** relative to TDF analysis**,** selected points from 1625FireFuelPts.shp that are w/in 500 meter buffer polygon surrounding strata 1.

- **strat2FirePtsVegCov2.shp (366 pts.): r**elative to CRI analysis**,** selected points from 1625FireFuelPts.shp that are w/in 500 meter buffer polygon surrounding strata 2.

- **strat2FirePts (366 pts.):** relative to TDF analysis**,** selected points from 1625FireFuelPts.shp that are w/in 500 meter buffer polygon surrounding strata 2.

- **strat3FirePts2 (481 pts.):** relative to CRI analysis**,** selected points from 1625FireFuelPts.shp that are w/in polygon of strata 3 boundary. Includes agenum variable.

- **strat3FirePts.shp (481 pts.):** relative to TDF analysis**,** selected points from 1625FireFuelPts.shp that are w/in polygon of strata 3 boundary.

- **strat4FirePts2.shp (345 pts.): r**elative to CRI analysis**,** selected points from 1625FireFuelPts.shp that are w/in 500 meter buffer polygon surrounding strata 4. Includes agenum variable

- **strat4FirePts.shp (345 pts.): r**elative to TDF analysis**,** selected points from 1625FireFuelPts.shp that are w/in 500 meter buffer polygon surrounding strata 4. Includes agenum variable

- **Crosswalk Fuelbed ID Plot ID.xlsx:** Microsoft excel file, input data from plot based measures from data collected as part of the 2010 vegetation inventory project process.

- **SRS_1680_batch_summary.xlsx:** Microsoft excel file, input data from plot based measures from data collected as part of the 2010 vegetation inventory project process.

- **basic2010.xlsx**: Microsoft excel file, input data from plot based measures data collected as part of the 2010 vegetation inventory project process. Field collected GPS coordinate Utm17_NAD83 information in this file were used to create study extent point file (1679ProjectPts).

3: GeoSpatial Explanatory Data:

3:1 GeoSpatial LIDAR Derived Explanatory Data (Reutebuch & McGaughey 2011)

- **lorey (loreys height):** units: feet, spatial data source: 20 meter grid, name: **llor_hs_3in,** a derived 2009 LIDAR dataset layers. All live hardwood and softwood trees greater than or equal to 3” DBH.

- **ba (basal Area):** units: square feet per acre, spatial data source 20 meter grid, name: **lba_hs_3in,** a derived 2009 LIDAR dataset layer. All live hardwood and softwood trees greater than or equal to 3” DBH.

- **canopy:** units: 0-100 percent, spatial data source: 20 meter grid, name: **PC1stRTsCC** a derived 2009 LIDAR dataset layer. All live hardwoods and softwood trees.

- **vol:** units: cubic feet per acre, spatial data source: 20 meter grid, name: **lvol_hs_3in,** a derived 2009 LIDAR dataset layer. All live hardwood and softwood trees greater than or equal to 3” DBH.

- **biomass:** live above ground biomass for all hardwood and softwoods. units: tons per acre, spatial data source: 20 meter grid, name: **lbbm_hs_3in** a derived 2009 LIDAR dataset layer

3.2: GeoSpatial Forest Stand and Environmental Continuous and Categorical Explanatory Data:

3.2.1: Continuous Data:

- **slope:** units: percent slope, spatial data source: 20 meter grid, name: slope_deg, derived from 2009 LIDAR BARE_EARTH_ELEV layer for SRS using ESRI Spatial Analyst.

- **ground water (gw):** units: meters, spatial data source: 20 meter grid, name: **gw**, Depth from land surface to ground water,

- **aspect:** units: degrees azimuth**.** Derived from 2009 LIDAR BARE_EARTH_ELEV layer for SRS using ESRI Spatial Analyst.

- **age**: Derived from field and stands forest layer information

- **agenum**: Index created by age/(numbrns + 1)

- **numbrns**: units nominal, spatial data source 20 meter grid. The total number of burns per stand lifetime.

3.2.2: Categorical Data:

- **Soils (SOILS):** units: **c**ategorical, spatial data source: 20 meter grid name: **soilsEx.img,** created by reclassifying original source 20 meter grid **gen_soils** to seven soil types (classes) values (1-7), variable SOILS values are as follows:
  1 = Chastain-Tawcaw-Shellbluff Association. Poorly drained, somewhat poorly drained, and well drained soils that are clayey or loamy throughout and are subject to flooding.
  2 = Rembert-Hornsville Association. Poorly drained and moderately well drained soils that have clayey subsoil.
  3 = Blanton-Lakeland Association, Somewhat excessively drained and excessively drained soils that have a loamy subsoil or that are sandy throughout.
  4 = Fuquay-Blanton-Dothan Association. Well drained and somewhat excessively drained soils that have loamy subsoil.
  5 = Orangeburg Association,. Well drained soils that have loamy subsoil.
  6 = Vaucluse-Ailey Association. Well drained soils that have a loamy subsoil with dense, brittle layers
  7 = Troup-Pickney-Lucy Association. Well drained and very poorly drained soils, some have a sandy surface layer and loamy subsoil and some are sandy throughout and are subject to flooding. **Source:** gen_soils, digitized vector layer of NRCS 1:190,080 General Soil Map of SRS (from the 1990 Soil Survey of the Savannah River Plant), converted to 20 meter raster grid.

3.2.2: Categorical Data continued:

- **Forest Group (FORGROUP):** units: categorical, spatial data source: polygon vector, name: **Forest Type.lyr** (polygon.lyr file), categorized **standsForTypeFi.shp** to 8 groups from original forest stands inventory data vector layer.
  Variable FORGROUP values are as follows:
  1 = Loblolly pine. Forest types included in group, 25, 29, 31, 32, 35
  2 = Longleaf pine. Forest types included in group, 21, 26, 27, 34
  3 = Slash pine. Forest types included in group, 22
  4 = Pine-Hardwood mix. Forest types included in group, 10, 12, 13, 14, 35
  5 = Hardwood-Pine mix. Forest types included in group, 42-44, 46-49
  6 = Hardwoods. Forest types included in group, 50-54, 56-58, 61-64, 68, 72-76, 80, 82, 85, 87, 98, 99
  7 = Bald cypress-Tupelo. Forest types included in group, 67
  8 = Non forest

Source: See **standsForTypeFi.shp** metadata abstract:
The dataset is a forest type attribute edited/updated version of a downloaded from T: drive Savannah River Sites stands layer (standPort20110920.shp, originally 8672 polygons) on Sept. 20, 2011. After updating the layer now has 8874 polygons:
The 2009 NAIP CIR imagery and polygons w/ year 2000 & 2010 plot inventory data point samples were used in validating polygons to correct forest types, in other words match the measured point forest type to the stands polygon. If a single stands polygon was found to contain multi observation points with different forest types then thiessens process was applied to the polygon producing a quantitative segregated polygon identified with field measured forest type.

The Description of standsForTypeFi.shp File Attributes are as Follows:

forType: used in validating and editing to correct polygons containing 1680 measured observation points.
FID_2: relate back to Sept. 20, 2011 stands layer
stand_id: stand identification number
status: used to identify process progress of polygons (3461 of the total 8874 polys). The following are edit code descriptions:
FE: final visual edits

2.2.3: Continued standsForTypeFi.shp File Attributes

FA: final added polys
F: final no edits left per ev_code
FFTG: final forest type group
FFTGA: final forest type group added polys
FMP: moved sample point to correct poly (issue of scale)
FT = final thiessens (where thiessens process applied to polygon),
F= final
comments: R = revised, all other comments self-evident
group: 8 major group categories and group Names are as follows
group 1: Loblolly pine
group 2: Longleaf pine
group 3: Slash pine
group 4: Pine-Hardwood mix
group 5: Hardwood-Pine mix
group 6: Hardwoods
group 7: Bald cypress-Tupelo
group 8: Non forest
forTypeInc: forest type code included in group e.g. group 2 includes forest type codes: 21, 26, 27, and 34
EV_CODE: original forest type code from original stands layer
EV_NAME: evCode description taken from original stands layer
Age_2010: age corrections relevant to the attribute VSVEG_Ageper per Parresol
Corrected_: forest type code corrections per Parresol
forTypeCor: this is the updated corrected forest type code

- **Land type: (TYPE):** units: categorical, spatial data source: polygon vector, name: **SRS_Strata.shp,** added attribute TYPE, categorical values are defined as 1 = non-wetland, and 2 = wetland.

- **Land use/land Cover (LULC):** units: categorical, spatial data source: 20 meter grid, name: **lulcExt20m.img**.
  The original source 5 meter raster (srs51lulc5m) was resampled to 20 meter for project analysis. Base source map is a 1 meter 1951 black and white aerial. This layer originally comprised of 8 levels categorized by the following land use land cover types.
  Note: The farm developed class, value = 6 in sample point dataset were reclassed to the value 2 (open) for purpose of geostatistical analysis. LULC values are as follows:

  1 = Developed,
  2 = open agriculture,
  3 = canopy,
  4 = cut over,
  5 = water,
  6 = farm developed,
  7 = orchards, and
  8 = Carolina bays

  The Savannah River Site historic land use land cover dataset (srs51lulc) was derived from a geo-referenced mosaic of a mosaic 1951 black and white aerial photos at a scale of 1:20,000. The aerial photos were taken in May of 1951 as part of Park Aerial Surveys in cooperation with the USDA Agricultural Stabilization and Conservation Service. Eight LULC types were classified. The three primary ones were canopy, open-agriculture, and cut-over. A simplified example of the process involved in the creation of the historic LULC dataset (srs51lulc) is as follows: 1. Process used the four strata polygons to stratify Savannah River Site's spatial extent 2. An object oriented feature extraction model was developed for each stratum. 3. Then based on the statistical combination of pixel and object metrics, object oriented feature extraction model results were classified 4. Classification results were edited 5. An accuracy assessment error matrix was created to validate edited classification results. 6. Data results considered final and metadata information was created and can be viewed in ArcCat.

3.3: GeoSpatial Categorical Treatment Data Description, Followed by the Data used to Create GeoSpatial Explanatory Categorical Treatment Data:

Note: Treatment data is primarily concentrated in Strata's 1 and 2.

Explanatory Treatment Variable:

- **Last Burned (lstbrncat):** units: categorical, 8 class values indicate number of years since 2010 stand last burned, spatial data source: Created from 20 meter grid **year_burn** GIS Process steps are as follows:

.	**original = reclass**
1-2 = 1
2-3 = 3
4-6 = 6
7-10 = 10
11-20 = 20
21-30 = 30
31-40= 40 (max value on record)
-9999 = 99 (no burn record)

- **Year last burned (year_burn):** units: year stand last burned, spatial data source: Created from 20 meter grid. The period of record is complete beginning in 1971 (no missing values). There are no electronic database records of treatments prior to this period.

- **Thinning year (lstthincat):** units: categorical, values indicate years since 2010 stand last thinned, spatial data source: 20 meter raster (**thinning**)

  original = reclass

  1-2 = 2
  3-5 = 5
  6-8 = 8
  9-11 = 11
  12-15 = 15
  -9999 = 99 (no thin history)

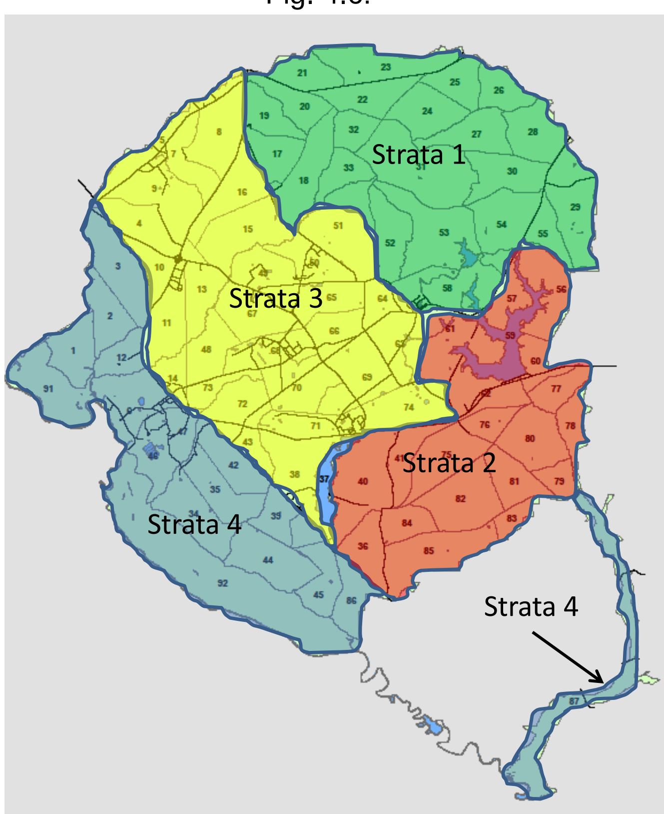
- **Number of thins (numthins):** binary layer, 0 = no record of thinning and 1 = thinned, spatial data source: 20 meter raster (**thinning**)

- **Stand thinned (thinning):** units: the year stand last thinned, spatial data source: 20 meter grid. The period of record is complete beginning in 1996 (no missing values). There are no electronic database records of treatments prior to this period and therefore confounded (not thinned = unknown).

3.4: GeoSpatial Ancillary Data Used to Stratify Study Extent:

There were three major strata identified based on scale factors. These factors are identified in Fig. 2.5. At the largest scale, there is a gradient in soil-geologic landform conditions from the north east representing the Sand hills to the southwest representing the Savannah River swamp. Within the Red-cockaded Woodpecker Management Areas (RCW MA) (strata 1 & 2) fire frequency is high, generally every 2-4 years, whereas in other areas such as the supplemental and industrial area (strata 3), limited prescribed burning is done. We therefore divided the Site into four major strata of approximately similar area. The northern RCW MA is split from the southern area as a result of general productivity difference. The lands below Hwy 125, including the swamp, are aggregated with the Lower three runs tail as these areas occupy wetlands or are on the Sunderland terrace. The latter upland areas are also burned occasionally.
The remaining portions of the Supplemental RCW Management Area and the Industrial Management Area are consolidated. Within each strata there are easily delineated medium scale topographic gradients representing two substrata that separate the wetland and adjacent riparian slopes or zones from the topographic uplands (Fig. 4.6). The former are dominated by hardwoods and wetland species and higher productivity. The latter are dominated by pines planted on old-fields and hardwood-pine remnant savanna fragments interspersed between old-fields. The resulting strata tend to overlap with major stand types. The third stratum is the "stand". Disturbance history, management and land use are strongly linked to a stand; therefore the stand will be the conceptual "kernel" for minimum variance. However, the median size and range of stand size is small (~30 ac, 2-160 ac), requiring substantial investment in sampling at the local scale. These conditions are reflected in the dominate influence of basal area, and stand age in the 2000 inventory model.

Fig. 4.6:



3.4: Continued GeoSpatial Ancillary Data Used to Stratify Study Extent:

The following polygon vector data were not used in geostatistical analysis**,** but rather used for the purpose of stratifying the project points (**1679ProjectPts**) used in analysis, first by entire study extent boundary minus the tail part of strata 4, and then stratifying the study extent per the individual strata boundary, see Fig. 2.5.

3.4.1 Polygon Data:

- **Study Extent:** units: meters, spatial data source: polygon, name: **extentPoly.shp.**

- **Strata 1:** units: meters, spatial data source: polygon, name: **strat1PolyMask.shp**
  For the purpose of mosaicking strata's 1 - 4 a 500 meter buffer applied when selecting points that are completely within strata 1 polygon boundaries.

- **Strata 2:** units: meters, spatial data source: polygon, name: **strat2PolyMask.shp.**
  For the purpose of mosaicking strata's 1 - 4 a 500 meter buffer applied when selecting points that are completely within strata 2 polygon boundaries.

- **Strata 3:** units: meters, spatial data source: polygon vector, name: **strat3Poly.shp.**

- **Strata 4:** units: meters, spatial data source: polygon vector, name: **strat4PolyMask.shp**
  For the purpose of mosaicking strata's 1 - 4 a 500 meter buffer applied when selecting points that are completely within strata 4 polygon boundaries.

3.5: Non-Analysis Overall Project Points File (1679ProjectPts.shp) Attributes Data:

- **Feature identification (FID):** unique feature (point) identification code.

- **Feature type (shape):** defines what type of feature, for example: a point, polygon, or line**.**

- **Plot-distance Identification number (UniqueID):** combination of plotId and distance values.

3.6: Regression Kriging (RK), conditional simulation (CS) and variance grids (20m) results per dependent variable TDF per strata

- **TDF Strata 1:**
  - **tdfcsfi1: conditional simulation**
  - **tdfrkfi1: regression kriging**
  - **vartdffi1: RK variance**

Continued:

3.6: Regression Kriging (RK), conditional simulation (CS) and variance grids (20m) results per dependent variable TDF per strata

- **TDF strata 2:**
    - **tdf_csfi2: conditional simulation**
    - **tdf_rkfi2: regression kriging**
    - **tdfvar2: RK variance**

- **TDF strata 3:**
    - **tdf_csfi3: conditional simulation**
    - **tdfrkfi3: regression kriging**
    - **tdf_vargwslo3: RK variance**

- **TDF Strata 4:**
    - **tdf_csfi4: conditional simulation**
    - **tdf_rkfi4: regression kriging**
    - **tdf_varfi4: RK variance**

- **TDF Extent:**
    - **tdfextcsfi20m: conditional simulation**
    - **tdfextrkfi20m: regression kriging**
    - **tdfextvarfi: RK variance**

3.7: Regression Kriging (RK), conditional simulation (CS) and variance grids (20m) results per dependent variable CRI per strata

- **CRI Strata 1:**
    - **cri_csfi1sec: conditional simulation**
    - **cri_rkfi1sec: regression kriging**
    - **cri_var1: RK variance**

- **CRI strata 2:**
    - **criI_csfi2sec: conditional simulation**
    - **cri_rkfi2sec: regression kriging**
    - **cri_var2: RK variance**

- **CRI strata 3:**
    - **cri_csfi3: conditional simulation**
    - **cri_rkfi3: regression kriging**
    - **cri_var3: RK variance**

Continued

3.7: Regression Kriging (RK), conditional simulation (CS) and variance grids (20m) results per dependent variable CRI per strata

- **CRI Strata 4:**
  - **CRI_csfi4: conditional simulation**
  - **cri_rkfi4: regression kriging**
  - **cri_var4: RK variance**

- **CRI Extent:**
  - **cri_extcsfi: conditional simulation**
  - **cri_extrkfi: regression kriging**
  - **cri_extvarfi: RK variance**