# Supplementary Material: Ecological characterization of a Cutaneous Leishmaniasis outbreak through remotely sensed land cover changes

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Table 1: Number of training polygons per class per date (number of pixels in parenthesis). Low vegetation and bare soil are more variable among years, hence the number of samples differ.

| Class | 2014 | 2015 | 2016 |
|---|---|---|---|
| Forest | 160 (4841) | 160 (4841) | 160 (4841) |
| Water | 52 (29007) | 52 (29007) | 52 (29007) |
| Low vegetation | 100 (4686) | 100 (4485) | 78 (3745) |
| Urban | 38 (42590) | 38 (42365) | 38 (42365) |
| Bare soil | 70 (1778) | 56 (1095) | 54 (2156) |

Table 2: Variables derived from satellite image analysis used for modeling the the habitat suitability for CL occurrence in Corrientes (Argentina).

| Variable | Description | Example name |
|---|---|---|
| EVI Average | Average of Enhanced Vegetation Index (EVI) in an area of 50 or 250 m radius. | LC08_20140719_EVI_average_17 |
| EVI Standard Deviation | Standard deviation of Enhanced Vegetation Index (EVI) in an area of 50 or 250 m radius. | LC08_20140719_EVI_sd_17 |
| EVI Contrast | Contrast estimated over EVI in an area of 50 or 250 m radius. | LC08_20140719_EVI_17_Contr |
| EVI Correlation | Correlation estimated over EVI in an area of 50 or 250 m radius. | LC08_20140719_EVI_17_Corr |
| EVI Entropy | Entropy estimated over EVI in an area of 50 or 250 m radius. | LC08_20140719_EVI_17_Entr |
| EVI Variance | Variance estimated over EVI in an area of 50 or 250 m radius. | LC08_20140719_EVI_17_Var |
| LSWI Average | Average of Land Surface Water Index (LSWI) in an area of 50 or 250 m radius. | LC08_20140719_LSWI2_average_17 |
| LSWI Standard Deviation | Standard deviation of Land Surface Water Index (LSWI) in an area of 50 or 250 m radius. | LC08_20140719_LSWI2_sd_17 |
| LSWI Contrast | Contrast estimated over LSWI in an area of 50 or 250 m radius. | LC08_20140719_LSWI2_17_Contr |
| LSWI Correlation | Correlation estimated over LSWI in an area of 50 or 250 m radius. | LC08_20140719_LSWI2_17_Corr |
| LSWI Entropy | Entropy estimated over LSWI in an area of 50 or 250 m radius. | LC08_20140719_LSWI2_17_Entr |
| LSWI Variance | Variance estimated over LSWI in an area of 50 or 250 m radius. | LC08_20140719_LSWI2_17_Var |
| NDBI Average | Average of Normalized Difference Built-up Index (NDBI) in an area of 50 or 250 m radius. | LC08_20140719_NDBI_average_17 |
| NDBI Standard Deviation | Standard deviation of Normalized Difference Built-up Index (NDBI) in an area of 50 or 250 m radius. | LC08_20140719_NDBI_sd_17 |
| NDBI Contrast | Contrast estimated over NDBI in an area of 50 or 250 m radius. | LC08_20140719_NDBI_17_Contr |
| NDBI Correlation | Correlation estimated over NDBI in an area of 50 or 250 m radius. | LC08_20140719_NDBI_17_Corr |
| NDBI Entropy | Entropy estimated over NDBI in an area of 50 or 250 m radius. | LC08_20140719_NDBI_17_Entr |
| NDBI Variance | Variance estimated over NDBI in an area of 50 or 250 m radius. | LC08_20140719_NDBI_17_Var |
| NDVI Average | Average of Normalized Difference Vegetation Index (NDVI) in an area of 50 or 250 m radius. | LC08_20140719_NDVI_average_17 |

Table 2 – *Continued from previous page*

| Variable | Description | Example name |
|---|---|---|
| NDVI Standard Deviation | Standard deviation of Normalized Difference Vegetation Index (NDVI) in an area of 50 or 250 m radius. | LC08_20140719_NDVI_sd_17 |
| NDWI Averge (McFeters) | Average of Normalized Difference Water Index (NDWI) in an area of 50 or 250 m radius. | LC08_20140719_NDWI_MF_average_17 |
| NDWI Standard Deviation (McFeters) | Standard deviation of Normalized Difference Water Index (NDWI) in an area of 50 or 250 m radius. | LC08_20140719_NDWI_MF_sd_17 |
| NDWI Averge (Xu) | Average of Normalized Difference Water Index (NDWI) in an area of 50 or 250 m radius. | LC08_20140719_NDWI_XU_average_17 |
| NDWI Standard Deviation (Xu) | Standard deviation of Normalized Difference Water Index (NDWI) in an area of 50 or 250 m radius. | LC08_20140719_NDWI_XU_sd_17 |
| Land cover | Result of random forest supervised classification. Land cover classes are: water, bare soil, low vegetation, forest and urban | rf_class_20140719 |
| Richness | Number of different land cover classes in an area of 50 or 250 m radius. | richness_20140719_17 |
| Interspertion | Proportion or cells belonging to land cover classes different to that of the central pixel in an area of 50 or 250 m radius. | interspersion_20140719_17 |
| Mode | Most common land cover class in an area of 50 or 250 m radius. | mode_20140719_17 |
| Diversity | Simpson diversity index estimated over land cover classes in an area of 50 or 250 m radius. | diversity_2014_simpson_size_17 |
| Tasselled cap 1 | First component of tasselled cap transformation, also called brightness, in an area of 50 or 250 m radius. | LC08_20140719_tasscap.1_17 |
| Tasselled cap 2 | Second component of tasselled cap transformation, also called greenness, in an area of 50 or 250 m radius. | LC08_20140719_tasscap.2_17 |
| Tasselled cap 3 | Third component of tasselled cap transformation, also called wetness, in an area of 50 or 250 m radius. | LC08_20140719_tasscap.3_17 |
| Tasselled cap 4 | Fourth component of tasselled cap transformation, also called atmospheric haze, in an area of 50 or 250 m radius. | LC08_20140719_tasscap.4_17 |
| CVA angle | Angle of change derived from the Change Vector Analysis (CVA) algorithm applied over brightness and greenness components for the years 2014-2015 and 2015-2016 | LC08_2014_2015_cva_angle |

Table 2 – *Continued from previous page*

| Variable | Description | Example name |
|---|---|---|
| CVA magnitude | Magnitude of change derived from the Change Vector Analysis (CVA) algorithm applied over brightness and greenness components for the years 2014-2015 and 2015-2016 | LC08_2014_2015_cva_magnitude |
| CVA change | Type of change derived from the Change Vector Analysis (CVA) algorithm. Angle and Magnitude layers are combined and classified as 4 different types of change. | LC08_2014_2015_cva_change |
| Distance Change 1 | Distance in m from each cell to the cells classified as change type 1. | LC08_2014_2015_cva_change_dist_1 |
| Distance Change 2 | Distance in m from each cell to the cells classified as change type 2. | LC08_2014_2015_cva_change_dist_2 |
| Distance Change 3 | Distance in m from each cell to the cells classified as change type 3. | LC08_2014_2015_cva_change_dist_3 |
| Distance Change 4 | Distance in m from each cell to the cells classified as change type 4. | LC08_2014_2015_cva_change_dist_4 |
| Mode Change | Most common type of change in an area of 50 or 250 m radius. | LC08_2014_2015_cva_change_mode_17 |

Table 3: Threshold-dependent measures used for assessing the predictive performance of models. References: TP, the number of presence points correctly classified as present; TN, the number of absence points correctly classified as absent; FP, the number of actual absence points classified as present; FN, the number of actual presence points classified as absent; P, the total number of actual presences; N, the total number of actual absences.

| Performance measure | Definition | Formula |
|---|---|---|
| Sensitivity | True presences correctly predicted | TP/P |
| Specificity | True absences correctly predicted | TN/N |
| Omission rate | Proportion of presences wrongly predicted | FN/FN+TN |
| Overall Accuracy | Proportion of presences and absences correctly predicted | TN+TP/(P+N) |

Table 4: Threshold dependent evaluation based on independent data. Models trained with 25 cases were evaluated with 74 and vice-versa. References: Thres, threshold value; AUC, area under the receiver-operator curve; Omiss, omission rate; Sens, sensitivity; Spec, specificity; OA, overall accuracy.

| Model | Criteria | Thres | AUC | Omiss | Sens | Spec | OA |
|---|---|---|---|---|---|---|---|
| *Models trained with n=25 and tested with n=74* | | | | | | | |
| 2014_50m | min.occ.pred | 0.000 | 0.576 | 0.000 | 1.000 | 0.152 | 0.346 |
| | mean.occ.pred | 0.242 | 0.620 | 0.635 | 0.365 | 0.876 | 0.759 |
| | 10.perc.omis | 0.010 | 0.672 | 0.149 | 0.851 | 0.492 | 0.574 |
| | sens=spec | 0.050 | 0.695 | 0.297 | 0.703 | 0.688 | 0.691 |
| | max.sens+spec | 0.040 | 0.702 | 0.257 | 0.743 | 0.660 | 0.679 |
| 2014_250m | min.occ.pred | 0.000 | 0.506 | 0.000 | 1.000 | 0.012 | 0.238 |
| | mean.occ.pred | 0.165 | 0.617 | 0.730 | 0.270 | 0.964 | 0.806 |
| | 10.perc.omis | 0.000 | 0.500 | 0.000 | 1.000 | 0.000 | 0.228 |
| | sens=spec | 0.010 | 0.680 | 0.392 | 0.608 | 0.752 | 0.719 |
| | max.sens+spec | 0.020 | 0.697 | 0.419 | 0.581 | 0.812 | 0.759 |
| 2015_50m | min.occ.pred | 0.000 | 0.662 | 0.000 | 1.000 | 0.324 | 0.478 |
| | mean.occ.pred | 0.377 | 0.678 | 0.568 | 0.432 | 0.924 | 0.812 |
| | 10.perc.omis | 0.010 | 0.749 | 0.081 | 0.919 | 0.580 | 0.657 |
| | sens=spec | 0.080 | 0.746 | 0.257 | 0.743 | 0.748 | 0.747 |
| | max.sens+spec | 0.030 | 0.766 | 0.135 | 0.865 | 0.668 | 0.713 |
| 2015_250m | min.occ.pred | 0.000 | 0.578 | 0.000 | 1.000 | 0.156 | 0.349 |
| | mean.occ.pred | 0.360 | 0.659 | 0.581 | 0.419 | 0.900 | 0.790 |
| | 10.perc.omis | 0.010 | 0.702 | 0.135 | 0.865 | 0.540 | 0.614 |
| | sens=spec | 0.070 | 0.731 | 0.270 | 0.730 | 0.732 | 0.731 |

Table 4 – *Continued from previous page*

| Model | Criteria | Thres | AUC | Omiss | Sens | Spec | OA |
|---|---|---|---|---|---|---|---|
| | max.sens+spec | 0.040 | 0.745 | 0.203 | 0.797 | 0.692 | 0.716 |
| | *Models trained with n=74 and tested with n=25* | | | | | | |
| 2014_50m | min.occ.pred | 0.125 | 0.746 | 0.000 | 1.000 | 0.492 | 0.538 |
| | mean.occ.pred | 0.668 | 0.682 | 0.520 | 0.480 | 0.884 | 0.847 |
| | 10.perc.omis | 0.190 | 0.702 | 0.120 | 0.880 | 0.524 | 0.556 |
| | 10.perc.omis | 0.260 | 0.724 | 0.120 | 0.880 | 0.568 | 0.596 |
| | sens=spec | 0.550 | 0.788 | 0.200 | 0.800 | 0.776 | 0.778 |
| | max.sens+spec | 0.540 | 0.806 | 0.160 | 0.840 | 0.772 | 0.778 |
| 2014_250m | min.occ.pred | 0.039 | 0.716 | 0.000 | 1.000 | 0.432 | 0.484 |
| | mean.occ.pred | 0.764 | 0.782 | 0.360 | 0.640 | 0.924 | 0.898 |
| | 10.perc.omis | 0.380 | 0.834 | 0.120 | 0.880 | 0.788 | 0.796 |
| | 10.perc.omis | 0.390 | 0.838 | 0.120 | 0.880 | 0.796 | 0.804 |
| | sens=spec | 0.480 | 0.840 | 0.160 | 0.840 | 0.840 | 0.840 |
| | max.sens+spec | 0.330 | 0.862 | 0.040 | 0.960 | 0.764 | 0.782 |
| 2015_50m | min.occ.pred | 0.339 | 0.852 | 0.000 | 1.000 | 0.704 | 0.731 |
| | mean.occ.pred | 0.728 | 0.698 | 0.520 | 0.480 | 0.916 | 0.876 |
| | 10.perc.omis | 0.480 | 0.844 | 0.120 | 0.880 | 0.808 | 0.815 |
| | sens=spec | 0.490 | 0.826 | 0.160 | 0.840 | 0.812 | 0.815 |
| | sens=spec | 0.500 | 0.814 | 0.200 | 0.800 | 0.828 | 0.825 |
| | max.sens+spec | 0.450 | 0.866 | 0.040 | 0.960 | 0.772 | 0.789 |
| 2015_250m | min.occ.pred | 0.121 | 0.810 | 0.000 | 1.000 | 0.620 | 0.655 |
| | mean.occ.pred | 0.681 | 0.724 | 0.480 | 0.520 | 0.928 | 0.891 |
| | 10.perc.omis | 0.350 | 0.862 | 0.080 | 0.920 | 0.804 | 0.815 |
| | 10.perc.omis | 0.370 | 0.866 | 0.080 | 0.920 | 0.812 | 0.822 |
| | sens=spec | 0.380 | 0.810 | 0.200 | 0.800 | 0.820 | 0.818 |
| | max.sens+spec | 0.340 | 0.880 | 0.040 | 0.960 | 0.800 | 0.815 |


Figure 1: Natural color Landsat 8 band combinations for years 2014 (A), 2015 (B) and 2016 (C) for Corrientes city and surroundings (RBG 3,2,1).

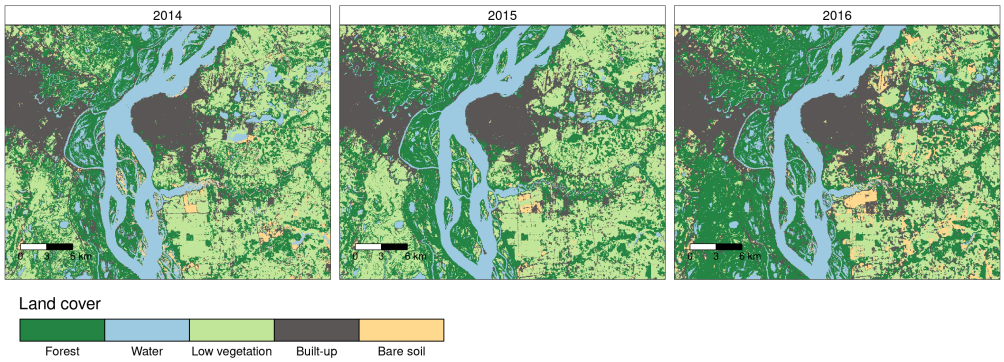


Figure 2: Supervised classification for years 2014, 2015 and 2016 for Corrientes city and surroundings.

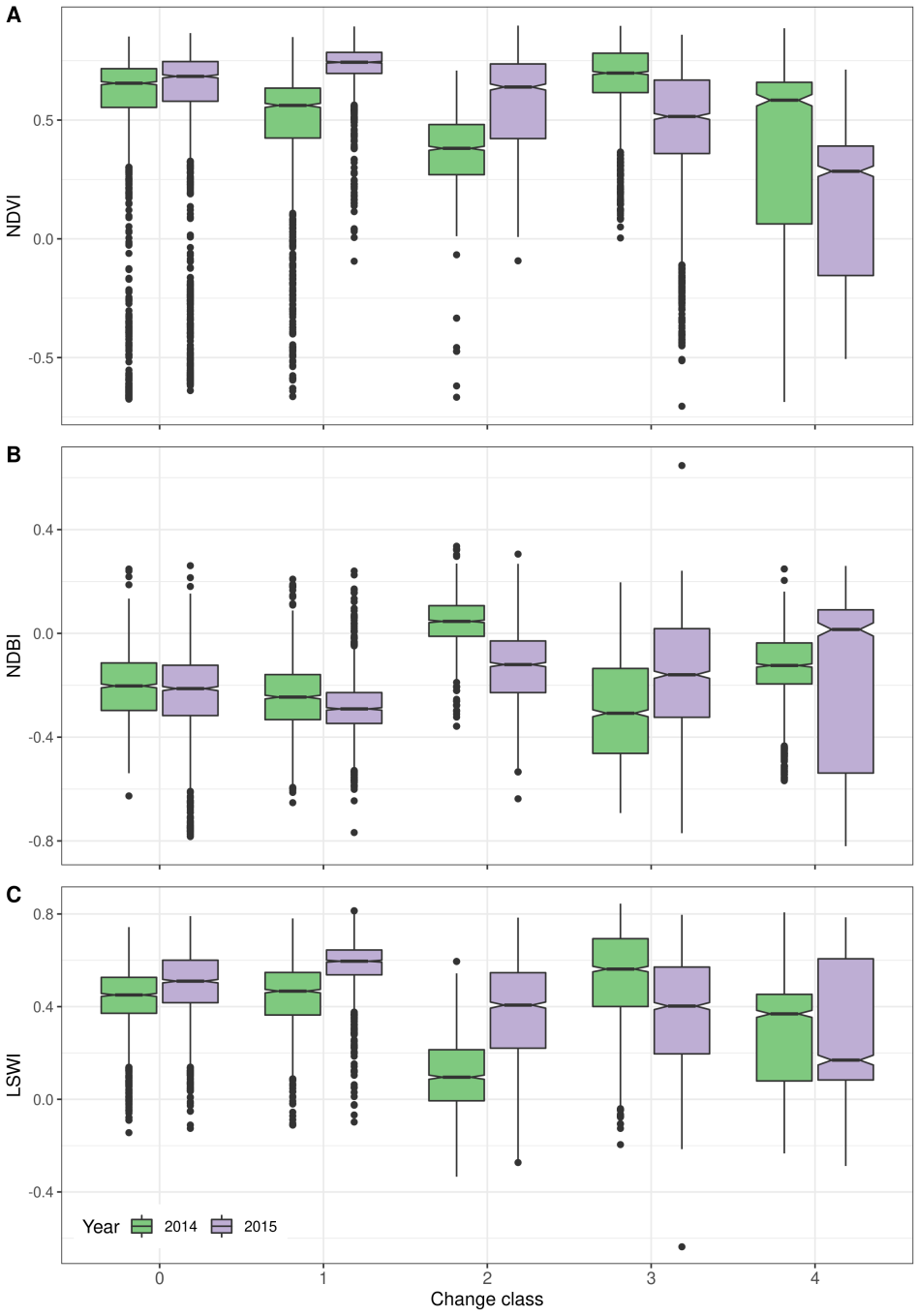


Figure 3: Changes in NDVI, LSWI and NDBI between 2014 and 2015 in a sample of pixels classified as different type of changes through Change Vector Analysis (CVA).

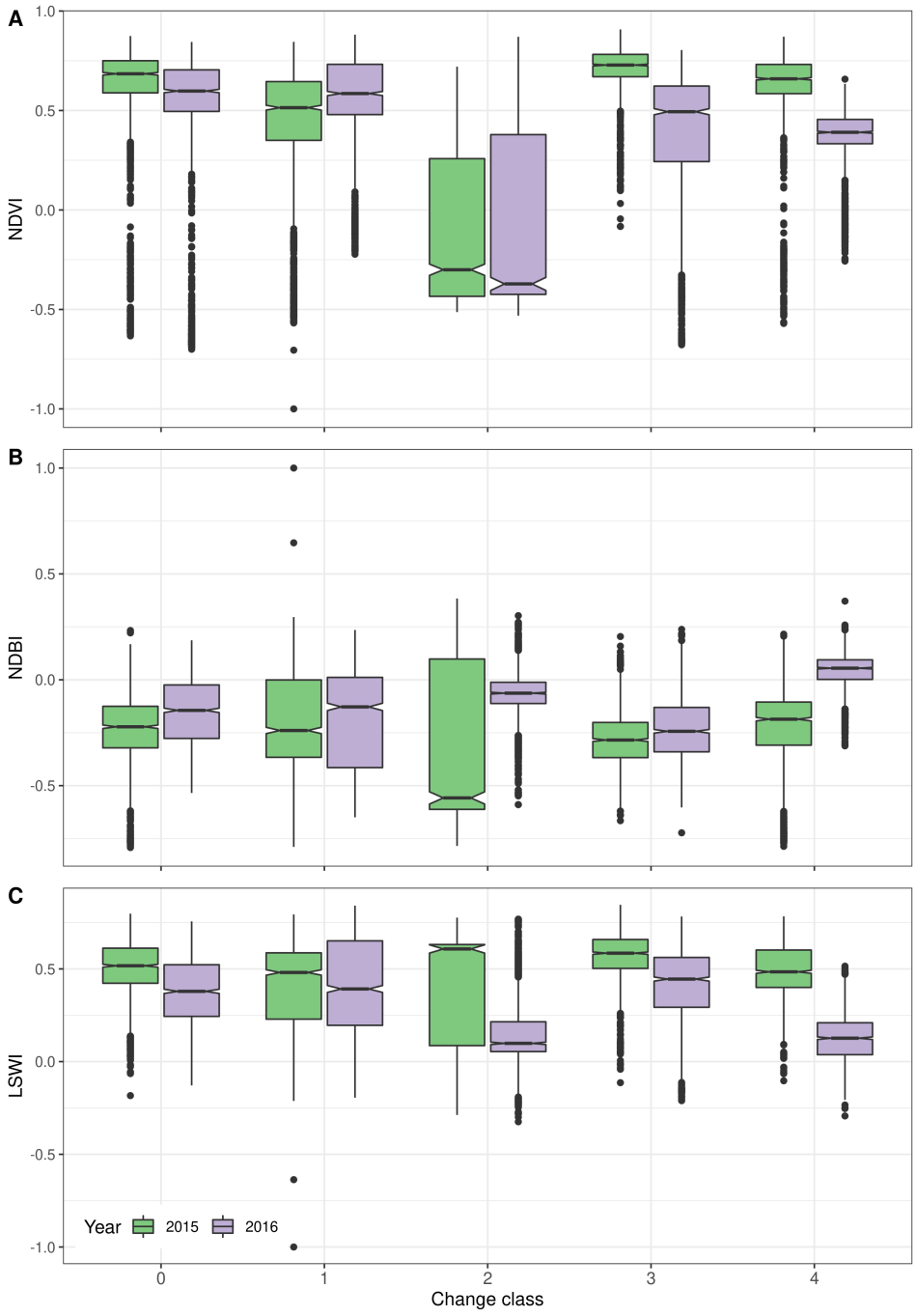


Figure 4: Changes in NDVI, LSWI and NDBI between 2015 and 2016 in a sample of pixels classified as different type of changes through Change Vector Analysis (CVA).

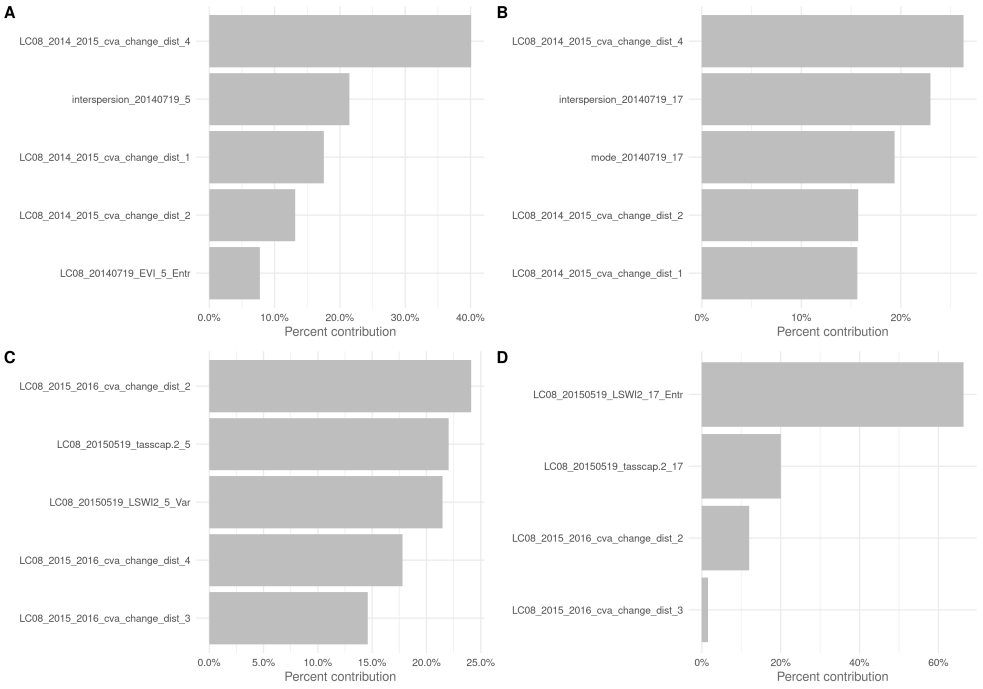


Figure 5: Variable importance for the best models trained with n=25. A) period 2014-2015, variables obtained in a 50 m radius, B) period 2014-2015, variables obtained in a 250 m radius, C) period 2015-2016, variables obtained in a 50 m radius, D) period 2015-2016, variables obtained in a 250 m radius.

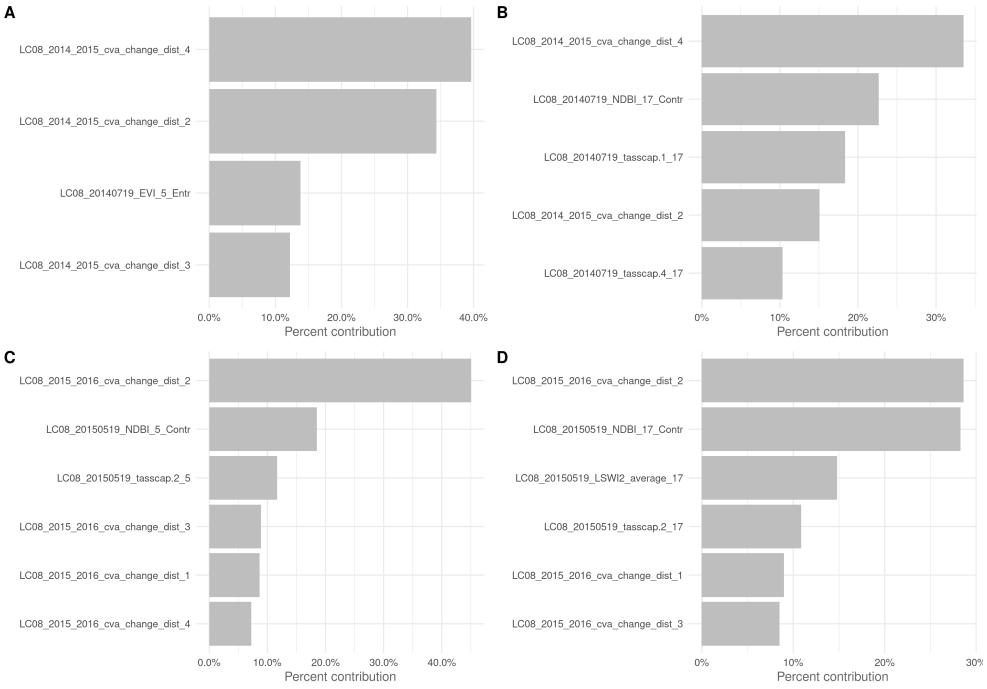


Figure 6: Variable importance for the best models trained with n=74. A) period 2014-2015, variables obtained in a 50 m radius, B) period 2014-2015, variables obtained in a 250 m radius, C) period 2015-2016, variables obtained in a 50 m radius, D) period 2015-2016, variables obtained in a 250 m radius.

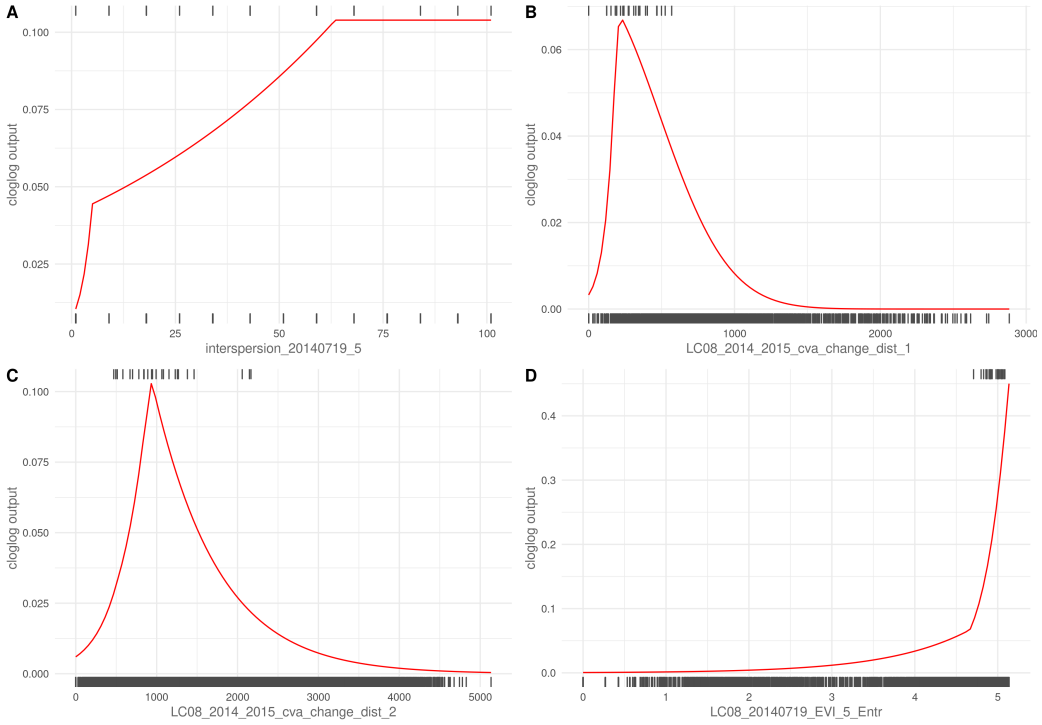


Figure 7: Response curves for 2014_50m model trained with n=25.

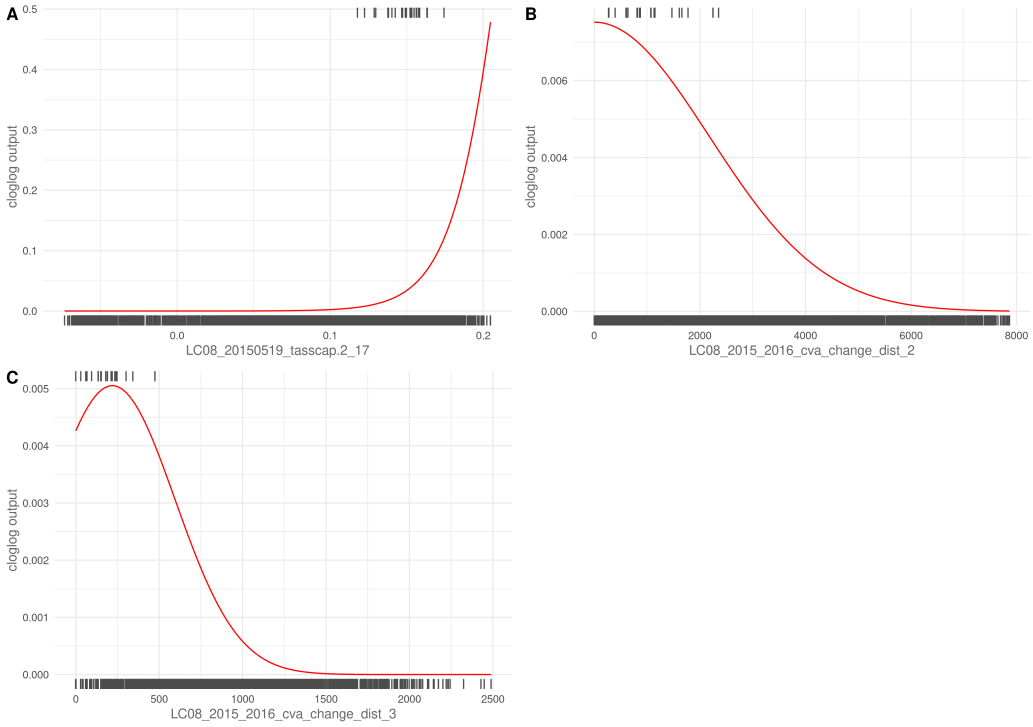


Figure 8: Response curves for 2014_250m model trained with n=25.

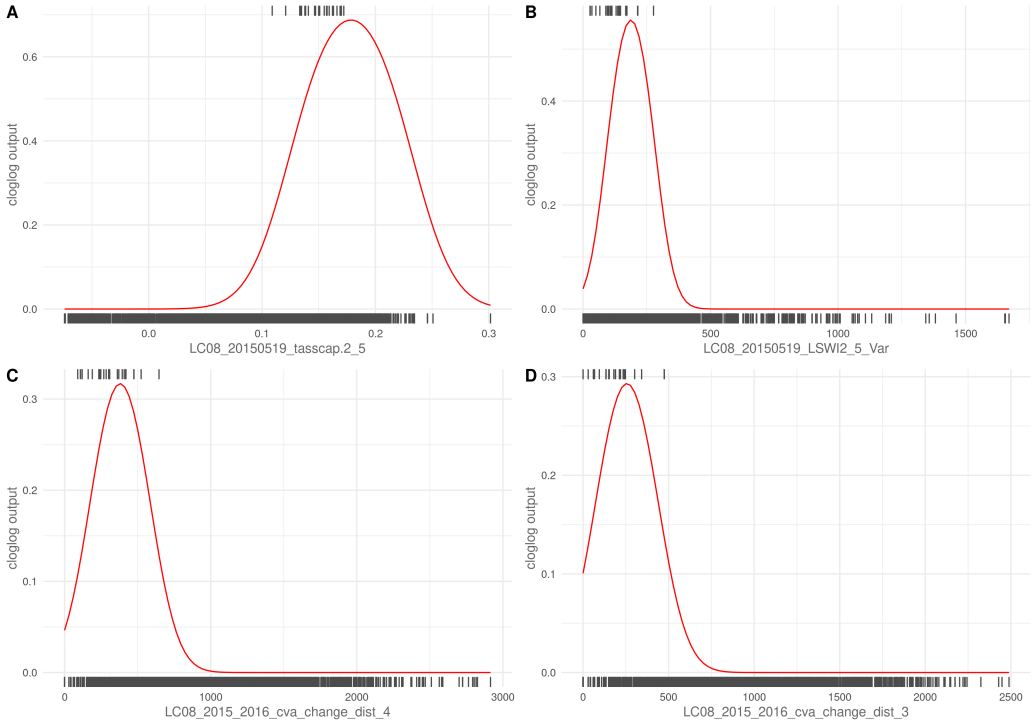


Figure 9: Response curves for 2015_50m model trained with n=25.

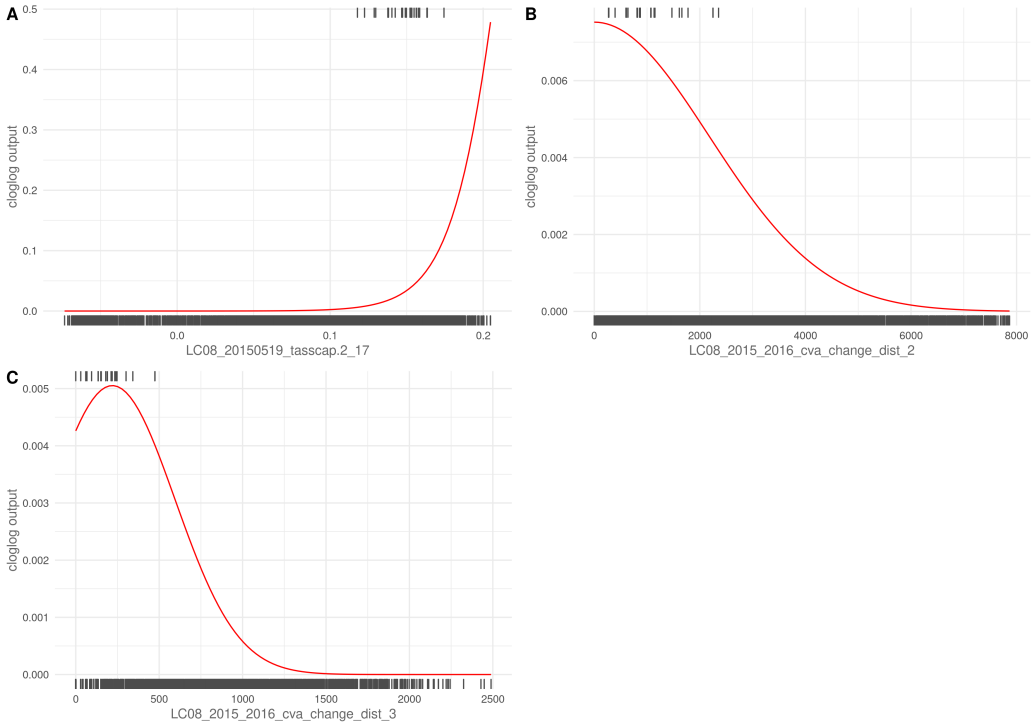


Figure 10: Response curves for 2015_250m model trained with n=25.

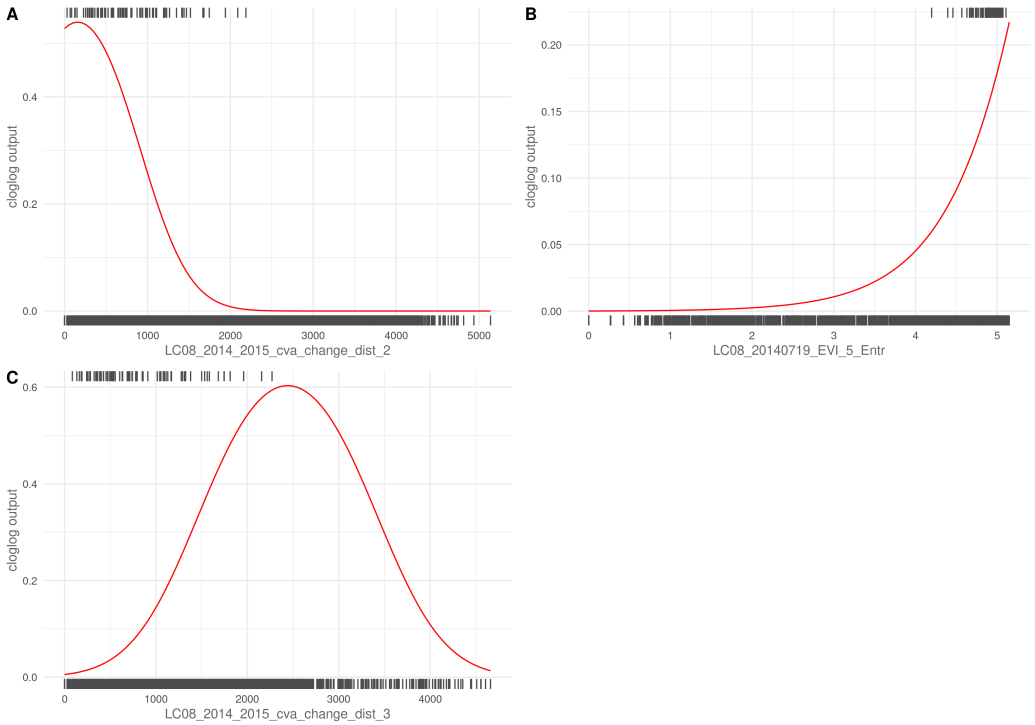


Figure 11: Response curves for 2014_50m model trained with n=74.

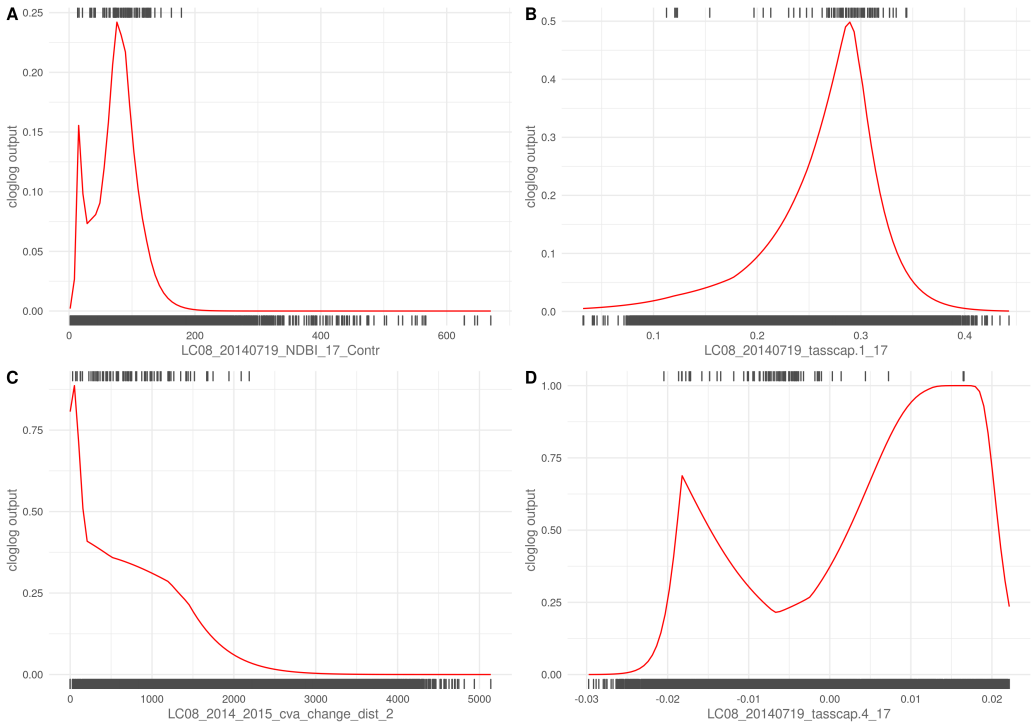


Figure 12: Response curves for 2014_250m model trained with n=74.

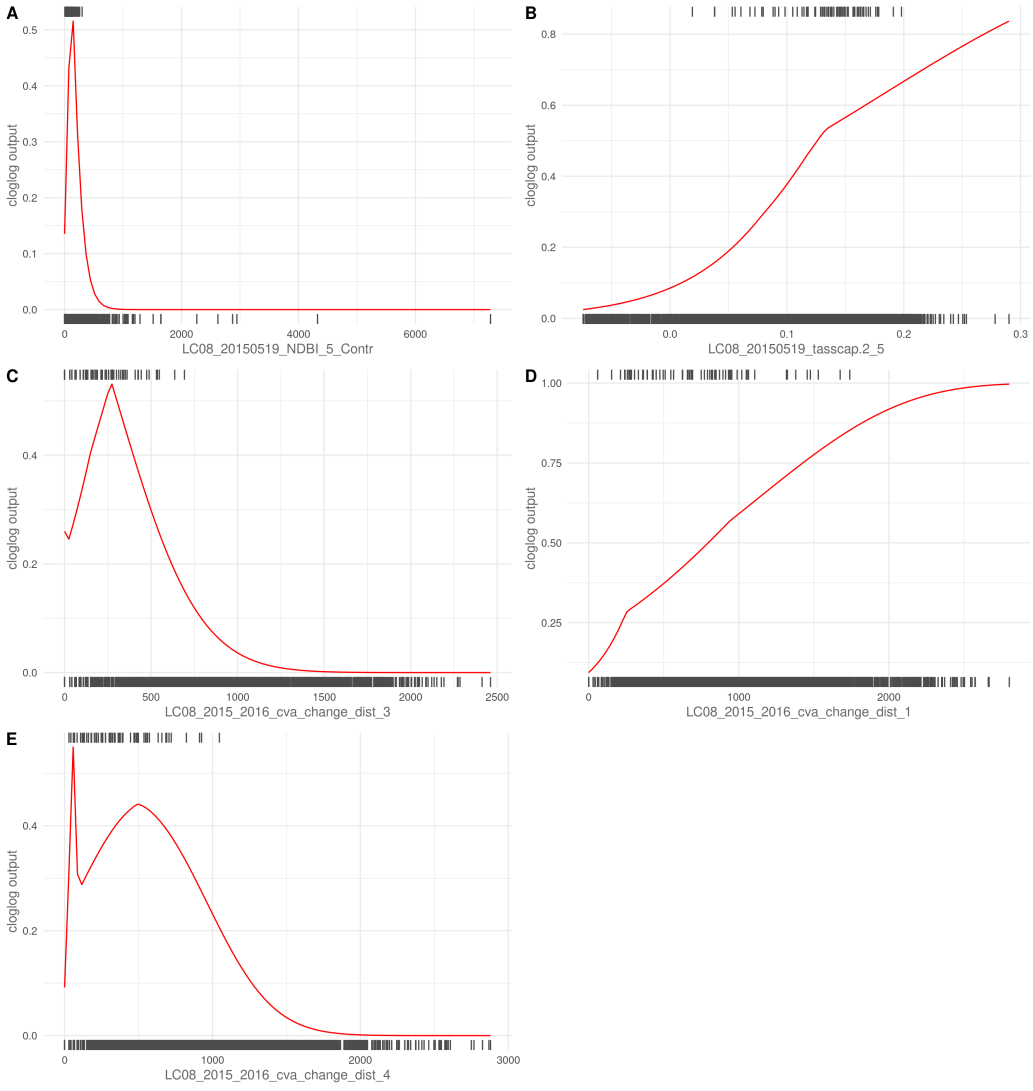


Figure 13: Response curves for 2015_50m model trained with n=74.

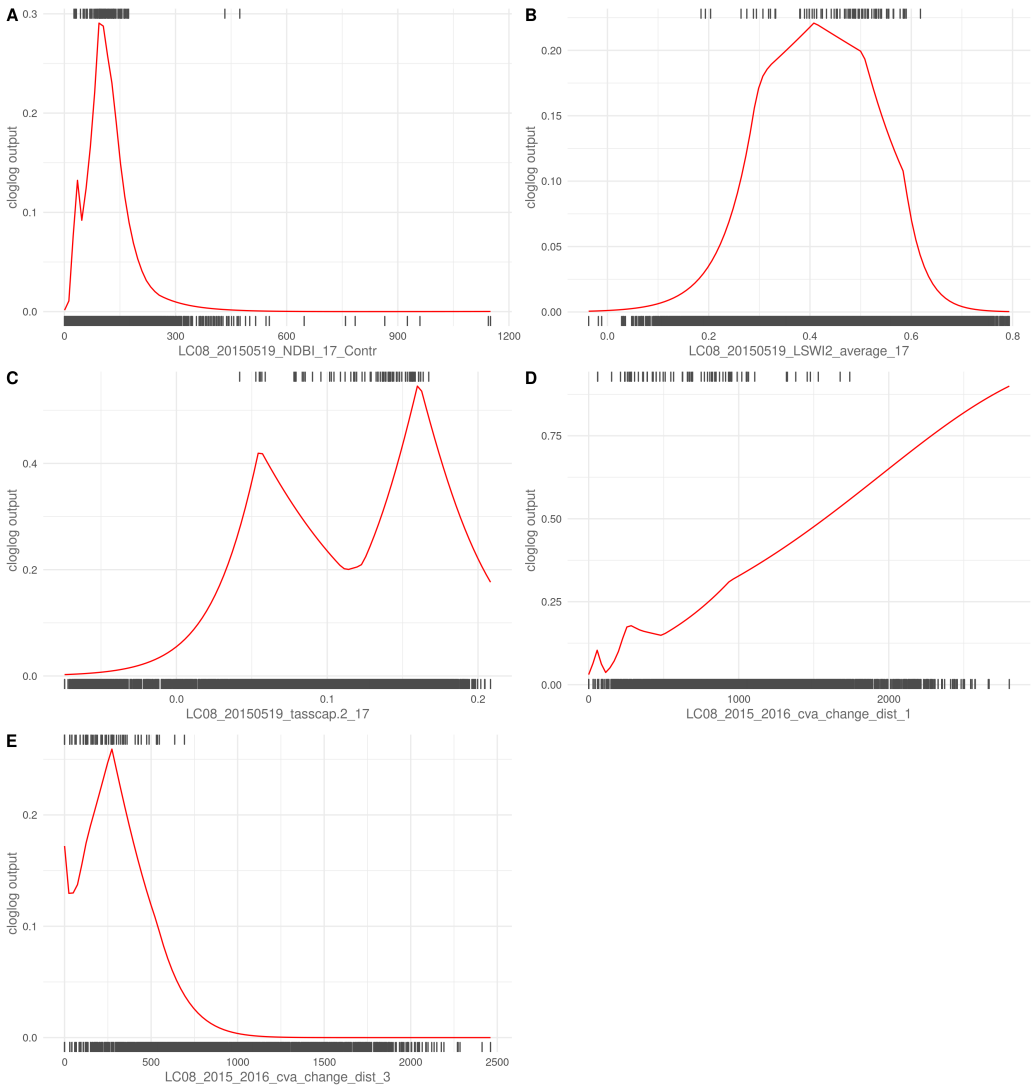


Figure 14: Response curves for 2015_250m model trained with n=74.

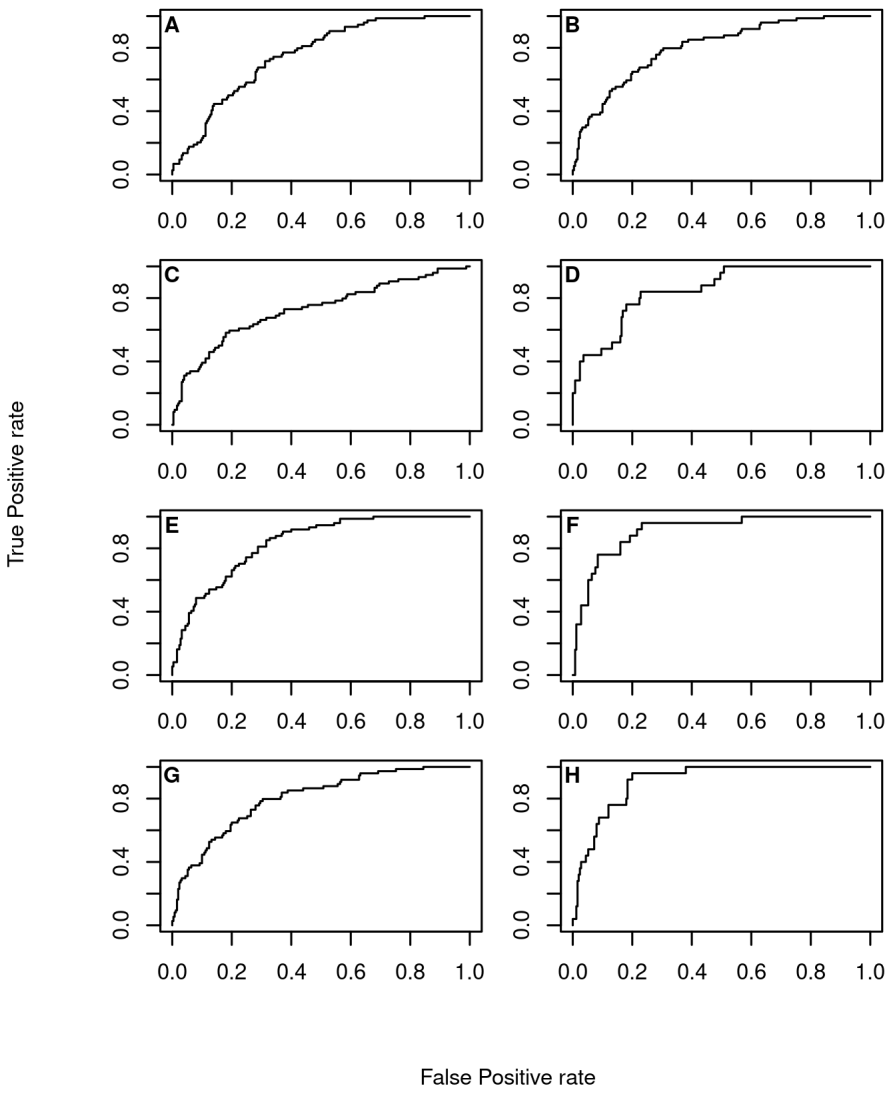


Figure 15: Testing Receiver-Operator Characteristic (ROC) curves.

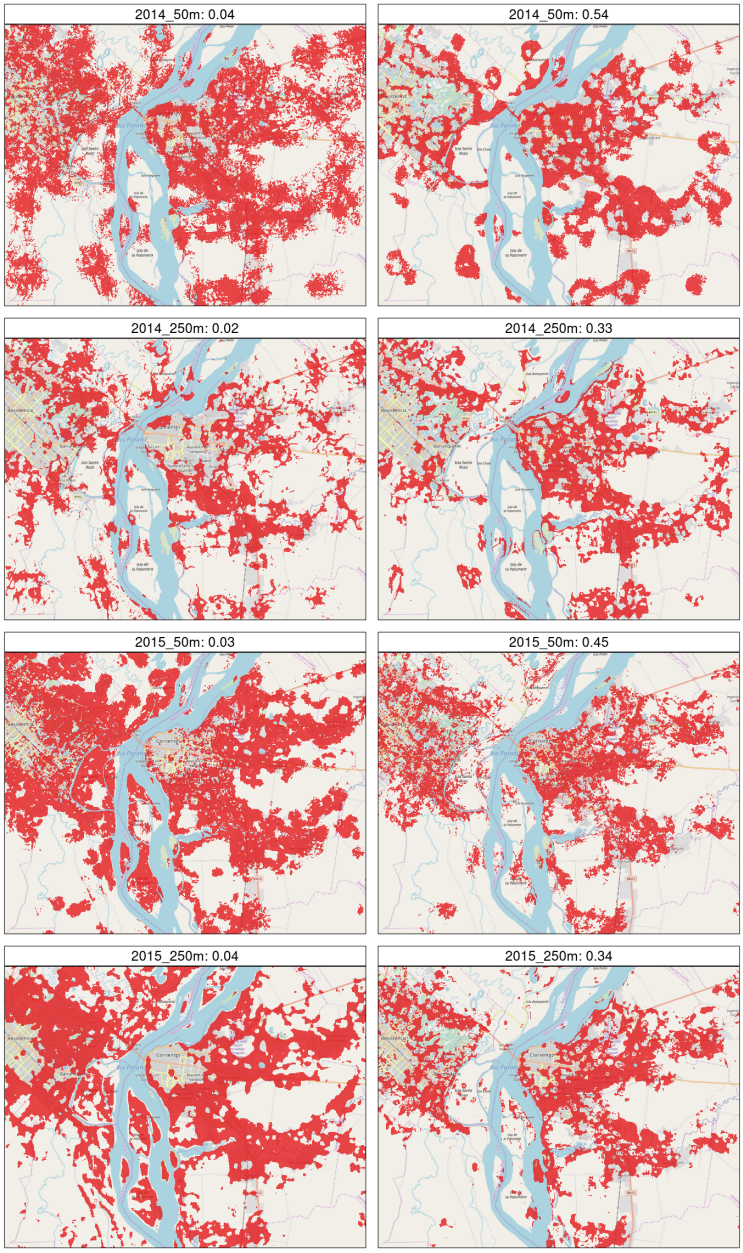


Figure 16: Areas predicted as suitable for CL occurrence according to test thresholds that maximize sensitivity + specificity for models trained with n = 25 (left) and n = 74 (right).

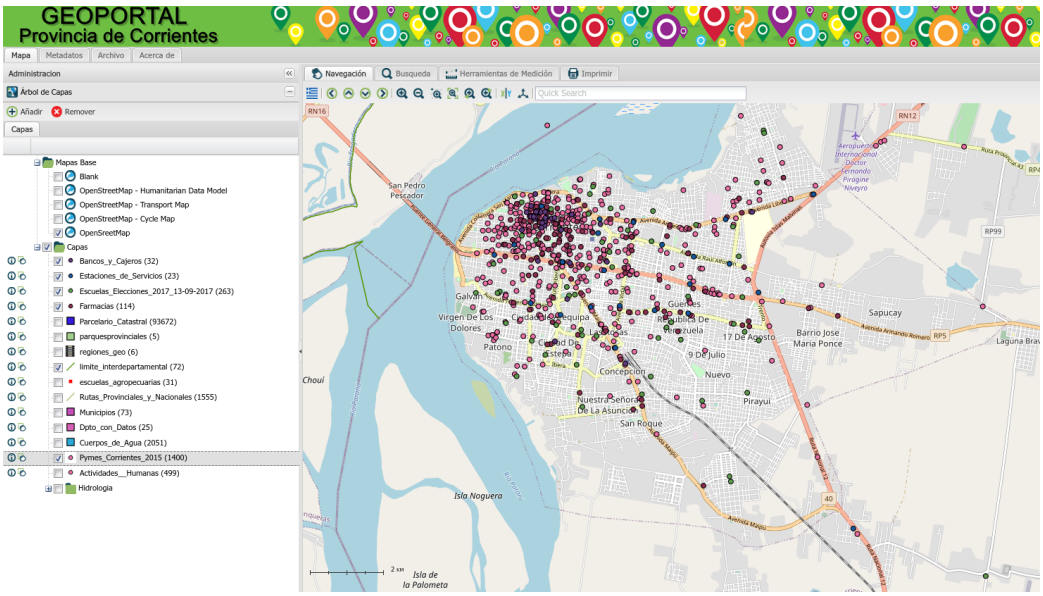


Figure 17: Spatial distribution of pharmacies, banks, shops and schools in Corrientes city (Argentina) denoting the location of the most urbanized area of the city. Source: `https://ide.corrientes.gob.ar/`.