

# Ovarian Cancer Histotypes: Report of Statistical Findings

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2024-02-12

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# Preface

This report of statistical findings describes the classification of ovarian cancer histotypes using data from NanoString CodeSets.

Marina Pavanello conducted the initial exploratory data analysis, Cathy Tang implemented class imbalance techniques, Derek Chiu conducted the normalization and statistical analysis, and Lauren Tindale and Aline Talhouk are the project leads.

# 1. Introduction

Ovarian cancer has five major histotypes: high-grade serous carcinoma (HGSC), low-grade serous carcinoma (LGSC), endometrioid carcinoma (ENOC), mucinous carcinoma (MUC), and clear cell carcinoma (CCOC). A common problem with classifying these histotypes is that there is a class imbalance issue. HGSC dominates the distribution, commonly accounting for 70% of cases in many patient cohorts, while the other four histotypes are spread over the rest of the cases. Subsampling methods like up-sampling, down-sampling, and SMOTE can be used to mitigate this problem.

The supervised learning is performed under a consensus framework: we consider various classification algorithms and use evaluation metrics like accuracy, F1-score, Kappa, and G-mean to inform the decision of which methods to carry forward for prediction in confirmation and validation sets.



## 2. Methods

We use 5 classification algorithms and 4 subsampling methods across 500 repetitions in the supervised learning framework for the Training Set, CS1 and CS2. The pipeline was run using SLURM batch jobs submitted to a partition on a CentOS 7 server. Implementations of the techniques below were called from the [splendid](#) package.

- Classifiers:
  - Random Forest
  - SVM
  - Adaboost
  - Multinomial Regression Model with Ridge Penalty
  - Multinomial Regression Model with LASSO Penalty
- Subsampling:
  - None
  - Down-sampling
  - Up-sampling
  - SMOTE

## 3. Distributions

### 3.1 Full Data

The histotype distributions on the full data are shown below.

### 3.2 Training Sets

#### 3.2.1 CS1 Training Set Generation

We use the reference method to normalize CS1 to CS3.

- CS1 reference set: duplicate samples from CS1
  - Samples = 16
  - Genes = 72
- CS3 reference set: corresponding samples in CS3 also found in CS1 reference set
  - Samples = 9
  - Genes = 72
- CS1 validation set: remaining CS1 samples with reference set removed
  - Samples = 273
  - Genes = 72

The final CS1 training set has 254 samples on 72 genes after normalization and keeping only the major histotypes of interest.

Table 3.1: All CodeSet Histotype Groups

Histotype Group	CS1	CS2	CS3
HGSC	123	645	1645
non-HGSC	166	220	585

Table 3.2: All CodeSet Major Reviewed Histotypes

Reviewed Histotype	CS1	CS2	CS3	CS1 %	CS2 %	CS3 %
CCOC	48	61	175	17.8	7.4	8.1
ENOC	60	32	232	22.2	3.9	10.7
HGSC	123	645	1645	45.6	78.6	76.1
LGSC	20	21	40	7.4	2.6	1.9
MUC	19	62	69	7.0	7.6	3.2

Table 3.3: All CodeSet Reviewed Histotypes

Reviewed Histotype	CS1	CS2	CS3
CARCINOMA-NOS	0	1	23
CCOC	48	61	175
CTRL	0	12	0
ENOC	60	32	232
HGSC	123	645	1645
LGSC	20	21	40
MBOT	0	19	3
MIXED (ENOC/CCOC)	0	0	1
MIXED (ENOC/LGSC)	0	0	1
MIXED (HGSC/CCOC)	0	0	1
MMMT	0	0	29
MUC	19	62	69
Other/Exclude	0	0	8
SBOT	19	12	2
serous LMP	0	0	1

Table 3.4: CS1 Histotypes

CodeSet	Reviewed Histotype	n
CS1	CCOC	48
CS1	ENOC	60
CS1	HGSC	123
CS1	LGSC	20
CS1	MUC	19
CS1	SBOT	19

Table 3.5: CS2 Histotypes

CodeSet	Reviewed Histotype	n
CS2	CARCINOMA-NOS	1
CS2	CCOC	61
CS2	CTRL	12
CS2	ENOC	32
CS2	HGSC	645
CS2	LGSC	21
CS2	MBOT	19
CS2	MUC	62
CS2	SBOT	12

Table 3.6: CS3 Histotypes

CodeSet	Reviewed Histotype	n
CS3	CARCINOMA-NOS	23
CS3	CCOC	175
CS3	ENOC	232
CS3	HGSC	1645
CS3	LGSC	40
CS3	MBOT	3
CS3	MIXED (ENOC/CCOC)	1
CS3	MIXED (ENOC/LGSC)	1
CS3	MIXED (HGSC/CCOC)	1
CS3	MMMT	29
CS3	MUC	69
CS3	Other/Exclude	8
CS3	SBOT	2
CS3	serous LMP	1

Table 3.7: Common Summary ID CodeSet Histotypes

Reviewed Histotype	CS1	CS2	CS3
CCOC	3	4	9
ENOC	4	4	9
HGSC	57	62	94
LGSC	7	5	8
MUC	7	5	11

Table 3.8: CS1 Training Set Histotypes

Histotype	n	%
CCC	57	18.8%
ENOCa	59	19.4%
HGSC	156	51.3%
LGSC	16	5.3%
MUC	16	5.3%

Table 3.9: CS2 Training Set Histotypes

Histotype	n	%
CCOC	68	7.2%
ENOC	30	3.2%
HGSC	757	80.1%
LGSC	29	3.1%
MUC	61	6.5%

Table 3.10: All Common Samples Histotype Distribution

revHist	CS1	CS2	CS3
CCOC	3	4	3
ENOC	4	4	3
HGSC	55	58	70
LGSC	7	5	4
MUC	7	5	5

### 3.2.2 CS2 Training Set Generation

We use the pool method to normalize CS2 to CS3 so we can be consistent with the PrOType normalization when there are available pools.

- CS2 pools:
  - Samples = 12 (Pool 1 = 4, Pool 2 = 4, Pool 3 = 4)
  - Genes = 365
- CS3 pools:
  - Samples = 22 (Pool 1 = 12, Pool 2 = 5, Pool 3 = 5)
  - Genes = 513
- CS2 validation set: CS2 samples with pools removed
  - Samples = 881
  - Genes = 365

The final CS2 training set has 821 samples on 136 (common) genes after normalization and keeping only the major histotypes of interest.

## 3.3 Common Samples

## 3.4 Histotypes in Classifier Data

Table 3.11: Distinct Common Samples Histotype Distribution

revHist	CS1	CS2	CS3
CCOC	3	3	3
ENOC	3	3	3
HGSC	53	53	53
LGSC	4	4	4
MUC	5	5	5

Table 3.12: Distinct Common CS2 and CS3 Samples Histotype Distribution

revHist	CS2	CS3
CCOC	3	3
ENOC	3	3
HGSC	71	71
LGSC	4	4
MUC	5	5

Table 3.13: Common Samples Across Sites Histotype Distribution

revHist	AOC	USC	Vancouver
CCOC	3	3	3
ENOC	3	3	3
HGSC	13	13	26
LGSC	2	2	2
MUC	3	3	3

Table 3.14: Distinct Common Samples Across Sites Histotype Distribution

revHist	AOC	USC	Vancouver
CCOC	3	3	3
ENOC	3	3	3
HGSC	13	13	13
LGSC	2	2	2
MUC	3	3	3

Table 3.15: CS3/CS4/CS5 Common Samples Histotype Distribution

revHist	CS3	CS4	CS5
HGSC	47	47	47
NA	26	26	26

Table 3.16: CS3/CS4/CS5 Pools Distribution

Pool	CS3	CS4	CS5
Pool1	12	5	4
Pool2	5	5	4
Pool3	5	5	4
Pool4	NA	2	1
Pool5	NA	2	1
Pool6	NA	2	0
Pool7	NA	2	1
Pool8	NA	2	1
Pool9	NA	2	1
Pool10	NA	2	1
Pool11	NA	2	1

Table 3.17: Full Training Set Histotype Distribution by CodeSet

Variable	Levels	CS1	CS2	CS3	Total
Histotype	HGSC	119 (48%)	624 (80%)	475 (94%)	1218 (79%)
	CCOC	44 (18%)	54 (7%)	8 (2%)	106 (7%)
	ENOC	55 (22%)	27 (3%)	8 (2%)	90 (6%)
	MUC	15 (6%)	59 (8%)	9 (2%)	83 (5%)
	LGSC	14 (6%)	19 (2%)	6 (1%)	39 (3%)
Total	N (%)	247 (16%)	783 (51%)	506 (33%)	1536 (100%)

Table 3.18: Histotype Distribution by CodeSet/Datasets

Variable	Levels	CS1 All	CS2 All	Confirmation	Validation
Histotype	HGSC	122 (46%)	644 (79%)	422 (66%)	676 (74%)
	CCOC	47 (18%)	60 (7%)	75 (12%)	81 (9%)
	ENOC	58 (22%)	30 (4%)	106 (16%)	108 (12%)
	MUC	18 (7%)	61 (7%)	27 (4%)	26 (3%)
	LGSC	18 (7%)	20 (2%)	13 (2%)	18 (2%)
Total	N (%)	263 (10%)	815 (31%)	643 (24%)	909 (35%)

## 4. Results

We show internal validation summaries for the combined classifier training set, as well as the CS1 and CS2 sets with duplicates included. The F1-scores, kappa, and G-mean are the measures of interest. Algorithms are sorted by descending value based on the overall accuracy of the training set. The point ranges show the median, 5th and 95th percentiles, coloured by subsampling methods.

### 4.1 Training Set

#### 4.1.1 Accuracy

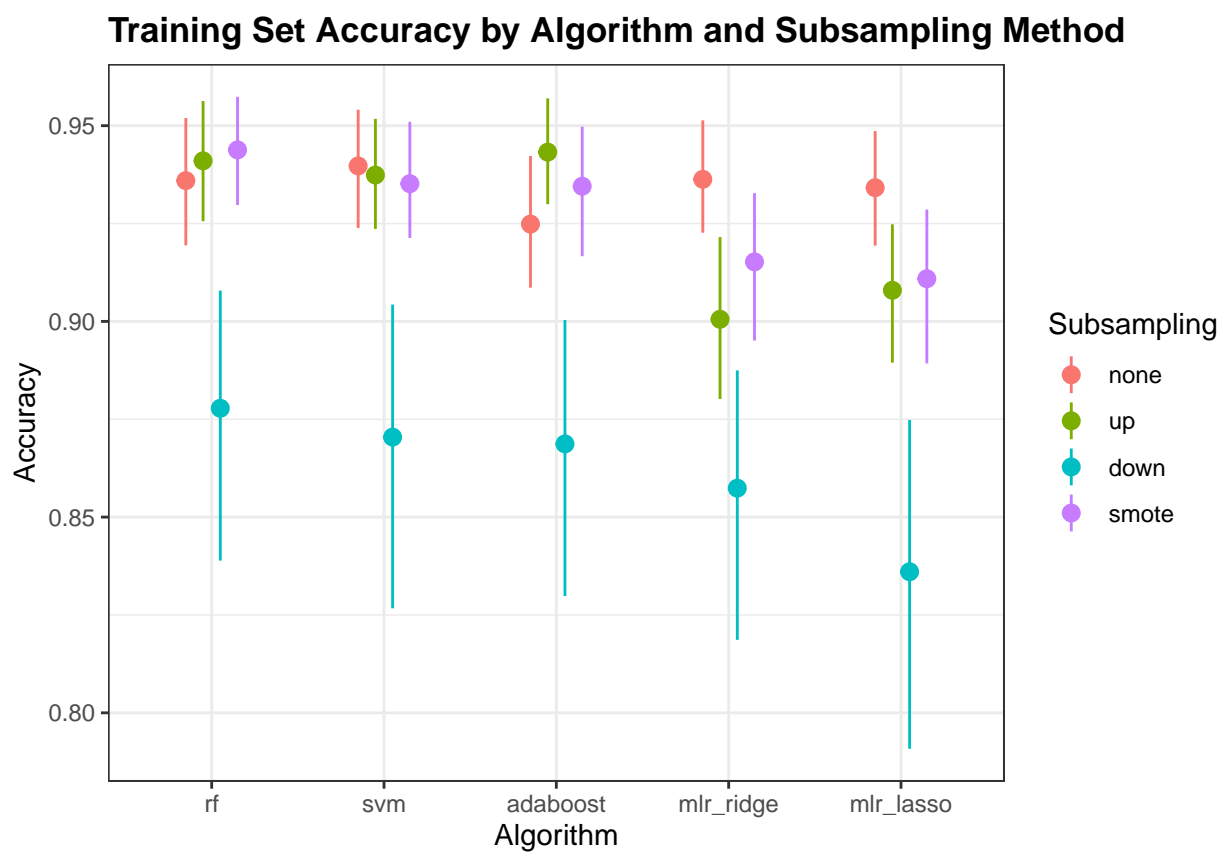


Figure 4.1: Training Set Accuracy



Table 4.1: Training Set Accuracy by Algorithm and Subsampling Method

sampling	rf	svm	adaboost	mlr_ridge	mlr_lasso
none	0.936	0.94	0.925	0.936	0.934
up	0.941	0.937	0.943	0.901	0.908
down	0.878	0.87	0.869	0.857	0.836
smote	<b>0.944</b>	0.935	0.935	0.915	0.911

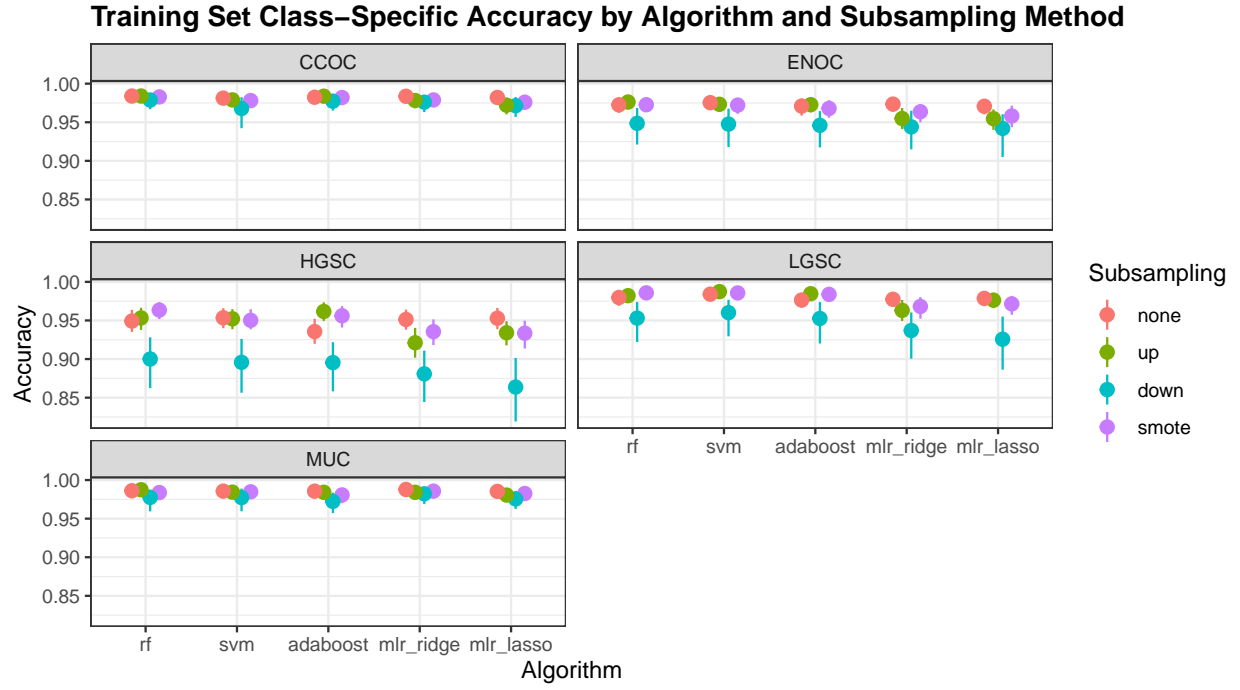


Figure 4.2: Training Set Class-Specific Accuracy

Table 4.2: Training Set Class-Specific Accuracy by Algorithm and Subsampling Method

sampling	histotype	rf	svm	adaboost	mlr_ridge	mlr_lasso
none	CCOC	0.984	0.981	0.982	0.984	0.982
none	ENOC	0.973	0.975	0.971	0.973	0.971
none	HGSC	0.949	0.953	0.936	0.951	0.953
none	LGSC	0.98	0.984	0.976	0.977	0.979
none	MUC	0.986	0.986	0.986	<b>0.988</b>	0.985
up	CCOC	0.984	0.979	0.984	0.978	0.972
up	ENOC	0.976	0.973	0.973	0.955	0.955
up	HGSC	0.953	0.952	0.962	0.921	0.934
up	LGSC	0.982	0.987	0.985	0.963	0.976
up	MUC	0.987	0.984	0.984	0.984	0.981
down	CCOC	0.979	0.968	0.977	0.976	0.971
down	ENOC	0.949	0.948	0.946	0.944	0.942
down	HGSC	0.9	0.896	0.895	0.881	0.864
down	LGSC	0.953	0.96	0.953	0.937	0.926
down	MUC	0.977	0.977	0.972	0.982	0.976
smote	CCOC	0.983	0.978	0.982	0.979	0.976
smote	ENOC	0.973	0.972	0.968	0.964	0.958
smote	HGSC	0.963	0.95	0.956	0.935	0.934
smote	LGSC	0.986	0.986	0.984	0.968	0.971
smote	MUC	0.984	0.985	0.981	0.986	0.983

Table 4.3: Training Set Macro-Averaged F1-Score by Algorithm and Subsampling Method

sampling	rf	svm	adaboost	mlr_ridge	mlr_lasso
none	0.762	0.823	0.728	0.769	0.781
up	0.802	0.823	0.826	0.775	0.767
down	0.742	0.73	0.725	0.727	0.694
smote	<b>0.835</b>	0.823	0.818	0.791	0.779

#### 4.1.2 F1-Score

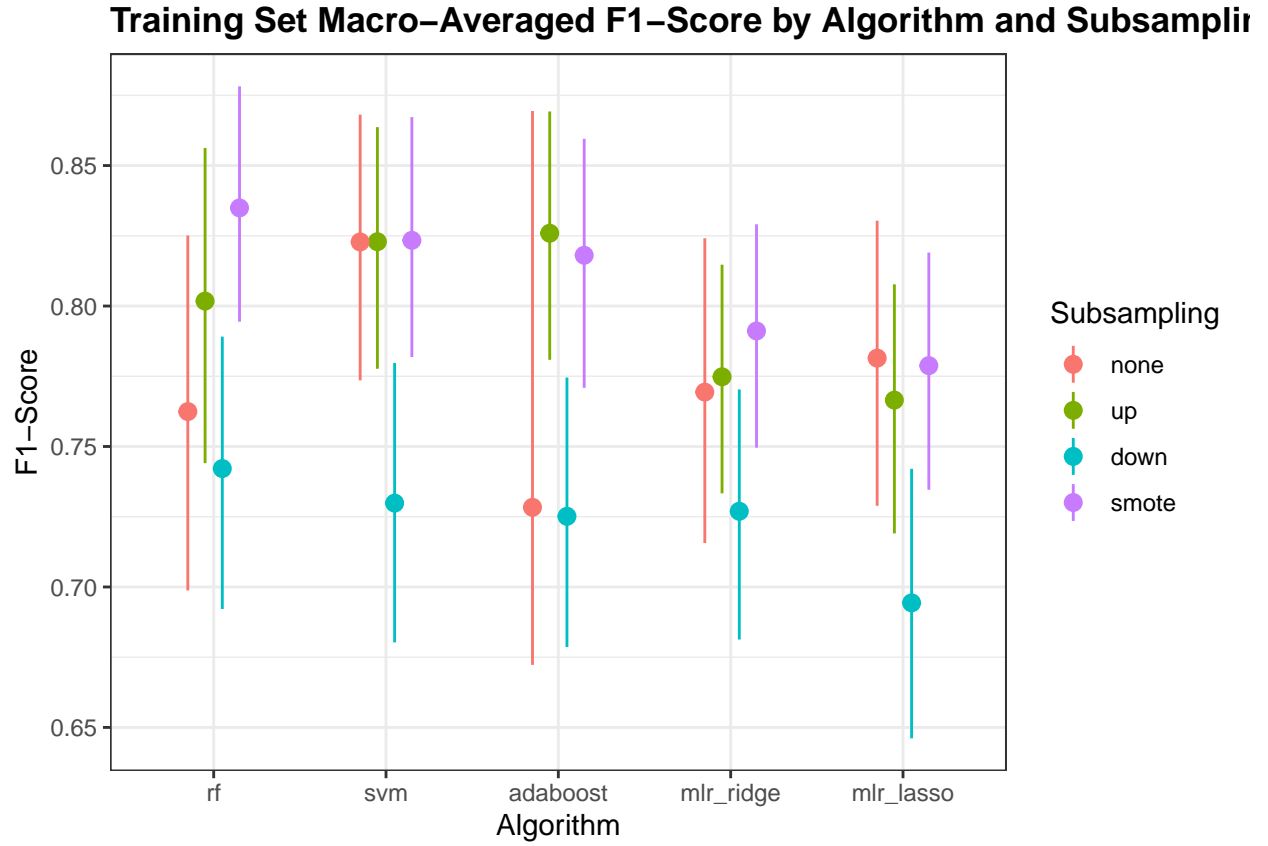


Figure 4.3: Training Set F1-Score

Table 4.4: Training Set Class-Specific F1-Score by Algorithm and Subsampling Method

sampling	histotype	rf	svm	adaboost	mlr_ridge	mlr_lasso
none	CCOC	0.875	0.857	0.862	0.871	0.865
none	ENOC	0.733	0.776	0.702	0.758	0.734
none	HGSC	0.969	0.971	0.961	0.97	0.971
none	LGSC	0.375	0.667	0.167	0.37	0.483
none	MUC	0.873	0.857	0.857	0.885	0.862
up	CCOC	0.873	0.836	0.873	0.846	0.8
up	ENOC	0.776	0.754	0.765	0.675	0.646
up	HGSC	0.971	0.971	0.976	0.948	0.958
up	LGSC	0.526	0.72	0.667	0.545	0.615
up	MUC	0.877	0.846	0.857	0.862	0.821
down	CCOC	0.849	0.781	0.837	0.829	0.805
down	ENOC	0.645	0.639	0.617	0.625	0.602
down	HGSC	0.934	0.931	0.929	0.92	0.907
down	LGSC	0.481	0.519	0.473	0.418	0.377
down	MUC	0.8	0.8	0.771	0.841	0.785
smote	CCOC	0.873	0.831	0.865	0.85	0.83
smote	ENOC	0.769	0.762	0.732	0.716	0.676
smote	HGSC	<b>0.977</b>	0.969	0.972	0.959	0.957
smote	LGSC	0.714	0.71	0.692	0.571	0.588
smote	MUC	0.849	0.851	0.833	0.868	0.847

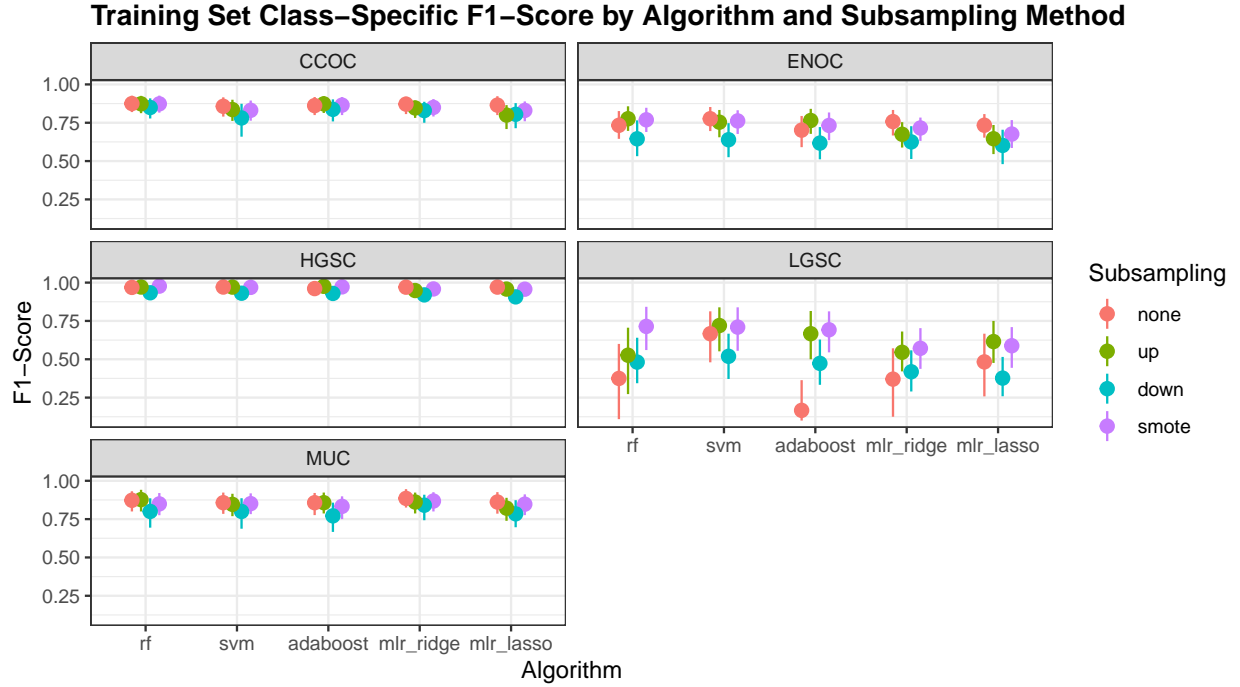


Figure 4.4: Training Set Class-Specific F1-Score

Table 4.5: Training Set Kappa by Algorithm and Subsampling Method

sampling	rf	svm	adaboost	mlr_ridge	mlr_lasso
none	0.804	0.824	0.76	0.81	0.81
up	0.821	0.814	0.838	0.754	0.757
down	0.71	0.694	0.691	0.677	0.638
smote	<b>0.843</b>	0.816	0.821	0.782	0.769

### 4.1.3 Kappa

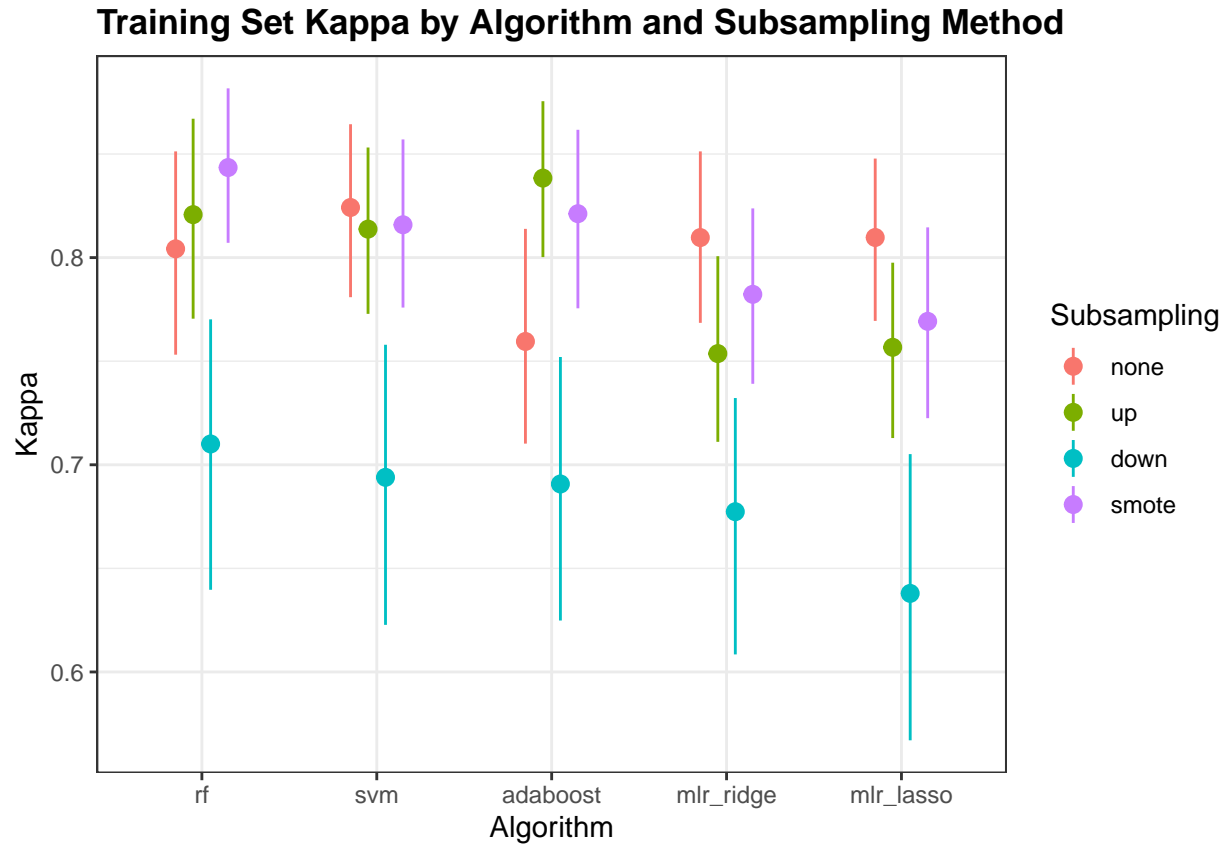


Figure 4.5: Training Set Kappa

Table 4.6: Training Set Class-Specific Kappa by Algorithm and Subsampling Method

sampling	histotype	rf	svm	adaboost	mlr_ridge	mlr_lasso
none	CCOC	0.868	0.846	0.853	0.862	0.855
none	ENOC	0.719	0.763	0.686	0.743	0.718
none	HGSC	0.832	0.854	0.781	0.843	0.853
none	LGSC	0.368	0.659	0.122	0.357	0.469
none	MUC	0.866	0.849	0.849	0.879	0.853
up	CCOC	0.865	0.824	0.864	0.835	0.784
up	ENOC	0.764	0.738	0.75	0.649	0.623
up	HGSC	0.846	0.845	0.881	0.784	0.806
up	LGSC	0.518	0.713	0.66	0.529	0.602
up	MUC	0.871	0.839	0.849	0.853	0.812
down	CCOC	0.838	0.763	0.824	0.817	0.79
down	ENOC	0.617	0.614	0.589	0.598	0.571
down	HGSC	0.734	0.723	0.724	0.695	0.659
down	LGSC	0.46	0.502	0.452	0.394	0.35
down	MUC	0.787	0.79	0.756	0.83	0.772
smote	CCOC	0.865	0.82	0.855	0.838	0.817
smote	ENOC	0.756	0.746	0.714	0.695	0.655
smote	HGSC	<b>0.89</b>	0.846	0.867	0.818	0.81
smote	LGSC	0.707	0.702	0.685	0.558	0.576
smote	MUC	0.839	0.844	0.822	0.861	0.839

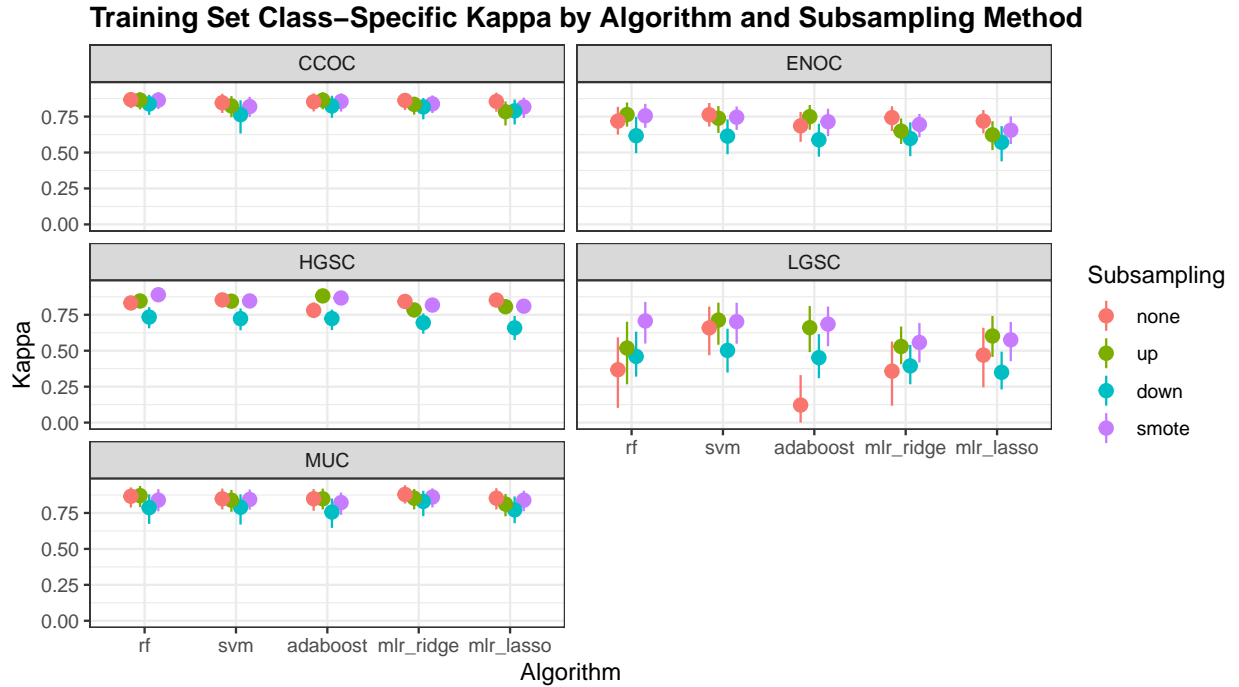


Figure 4.6: Training Set Class-Specific Kappa

Table 4.7: Training Set G-mean by Algorithm and Subsampling Method

sampling	rf	svm	adaboost	mlr_ridge	mlr_lasso
none	0.638	0.785	0.474	0.667	0.721
up	0.714	0.77	0.802	<b>0.87</b>	0.803
down	0.859	0.848	0.845	0.861	0.837
smote	0.838	0.803	0.835	0.864	0.839

#### 4.1.4 G-mean

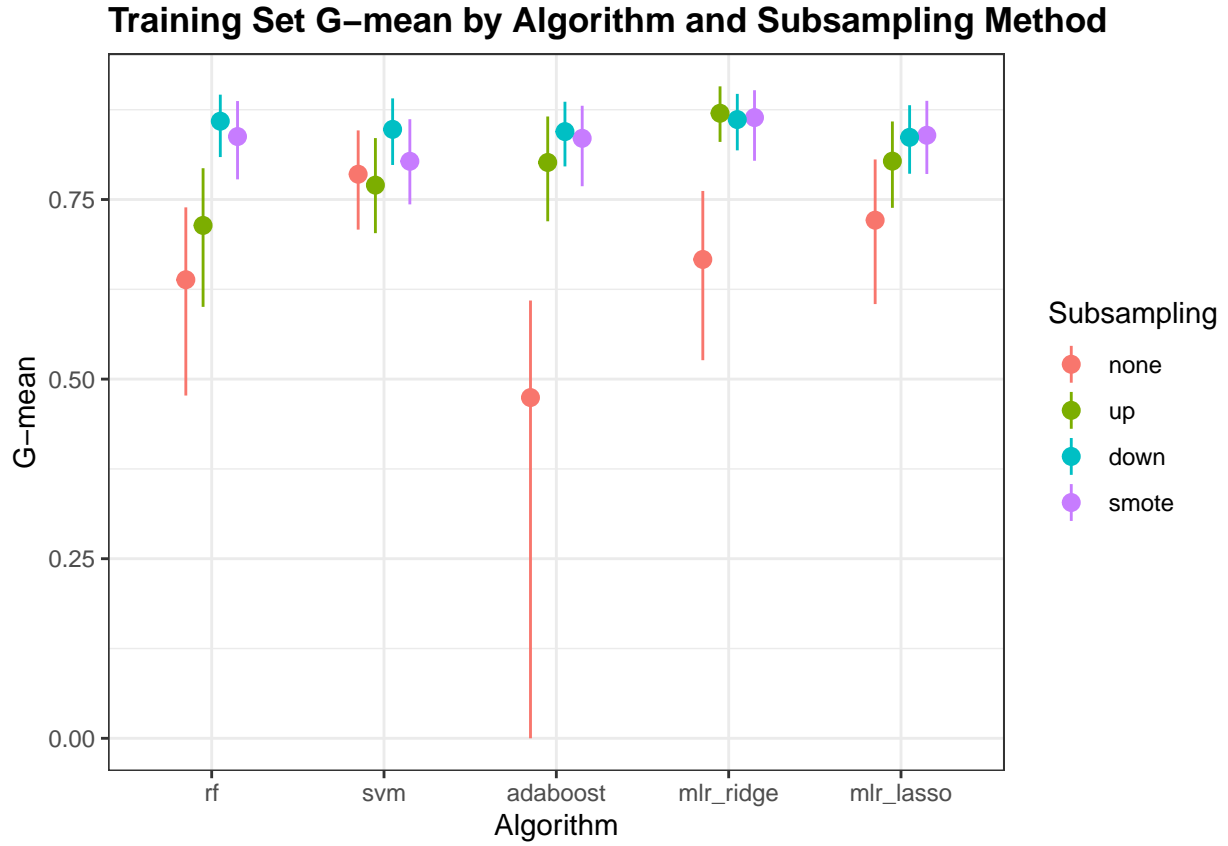


Figure 4.7: Training Set G-mean

Table 4.8: Training Set Class-Specific G-mean by Algorithm and Subsampling Method

sampling	histotype	rf	svm	adaboost	mlr_ridge	mlr_lasso
none	CCOC	0.909	0.9	0.893	0.906	0.914
none	ENOC	0.804	0.853	0.763	0.839	0.829
none	HGSC	0.877	0.907	0.835	0.894	0.908
none	LGSC	0.485	0.794	0.258	0.516	0.639
none	MUC	0.924	0.901	0.899	0.931	0.921
up	CCOC	0.903	0.875	0.913	0.928	0.895
up	ENOC	0.834	0.832	0.866	0.878	0.83
up	HGSC	0.889	0.893	0.932	0.935	0.921
up	LGSC	0.623	0.814	0.78	0.935	0.865
up	MUC	0.923	0.886	0.932	0.94	0.905
down	CCOC	0.927	0.91	0.921	0.921	0.917
down	ENOC	0.878	0.877	0.858	0.877	0.858
down	HGSC	0.922	0.916	0.917	0.91	0.899
down	LGSC	0.915	0.92	0.912	0.931	0.912
down	MUC	0.926	0.916	0.926	0.932	0.913
smote	CCOC	0.929	0.891	0.921	0.927	0.921
smote	ENOC	0.875	0.867	0.861	0.874	0.857
smote	HGSC	<b>0.947</b>	0.912	0.943	0.939	0.933
smote	LGSC	0.847	0.848	0.864	0.922	0.895
smote	MUC	0.93	0.9	0.93	0.935	0.925

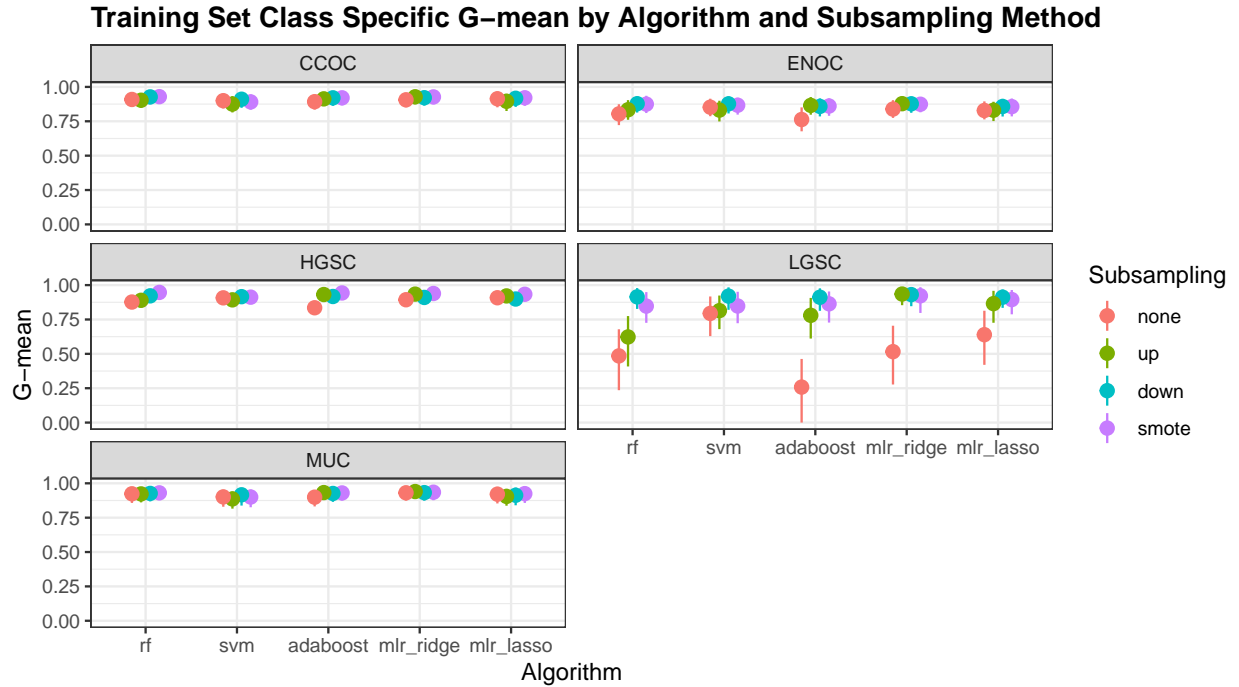


Figure 4.8: Training Set Class-Specific G-mean



## 4.2 Two-Step Training Set

### 4.2.1 Accuracy

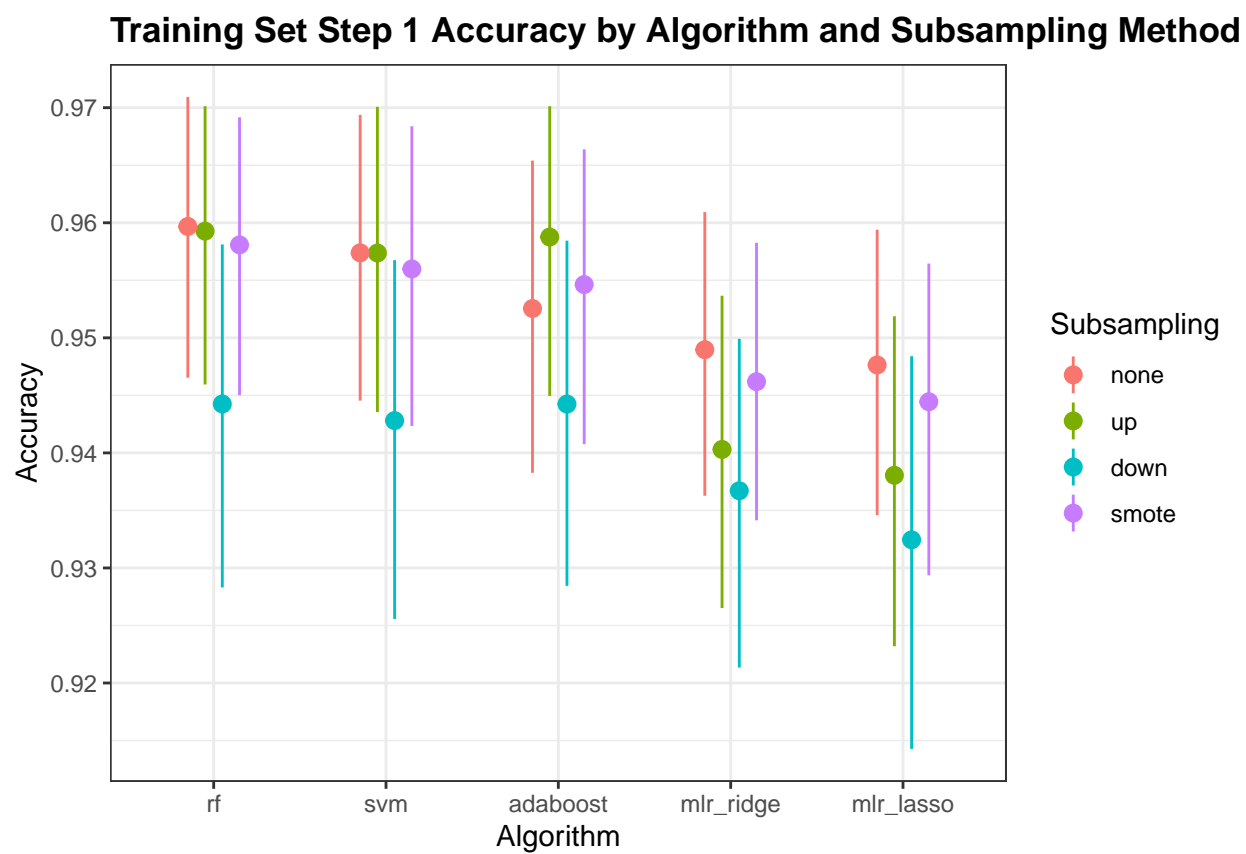


Figure 4.9: Training Set Step 1 Accuracy

Table 4.9: Training Set Step 1 Accuracy by Algorithm and Subsampling Method

sampling	rf	svm	adaboost	mlr_ridge	mlr_lasso
none	<b>0.96</b>	0.957	0.953	0.949	0.948
up	0.959	0.957	0.959	0.94	0.938
down	0.944	0.943	0.944	0.937	0.932
smote	0.958	0.956	0.955	0.946	0.944

Table 4.10: Training Set Step 2 Accuracy by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.884	0.882	0.881	0.876	0.872
up	<b>0.886</b>	0.881	0.878	0.874	0.87
down	0.868	0.868	0.868	0.861	0.854
smote	0.88	0.877	0.875	0.871	0.87

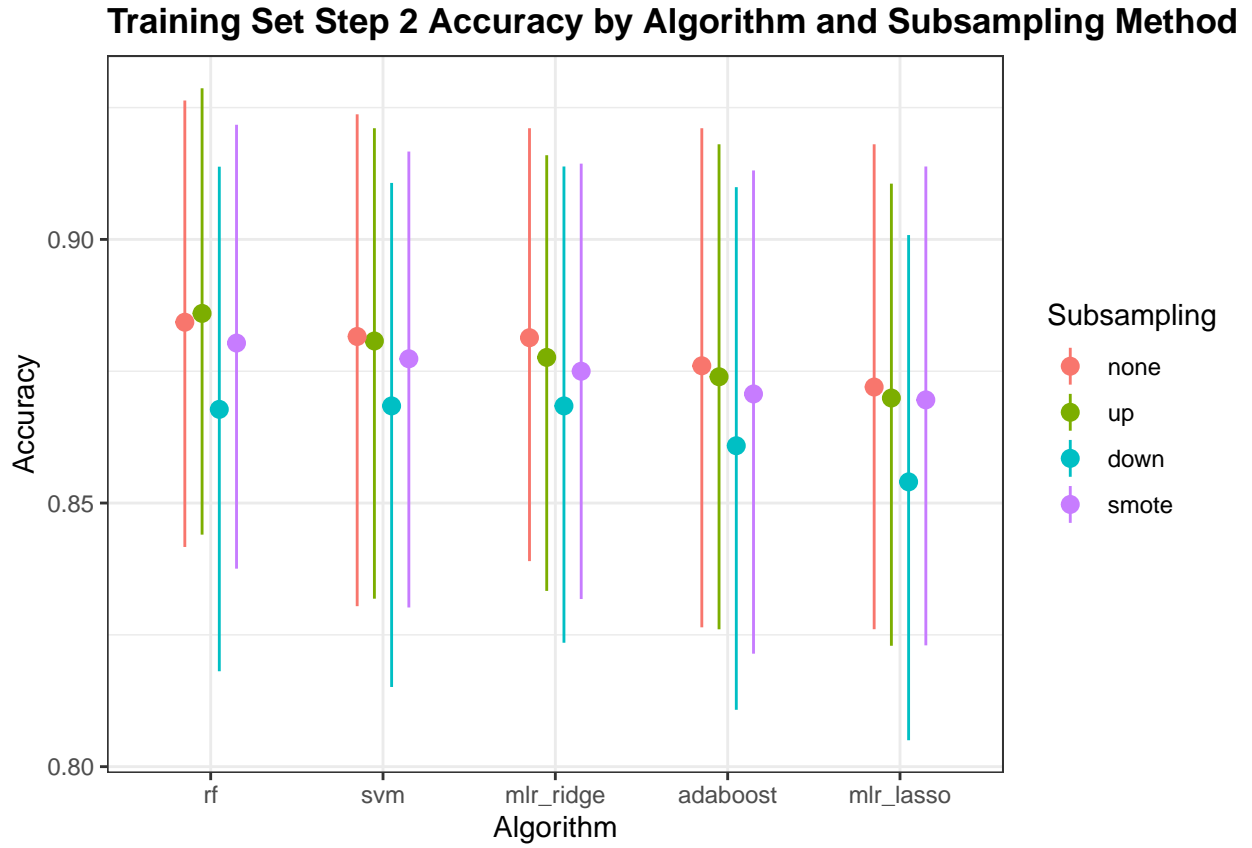


Figure 4.10: Training Set Step 2 Accuracy

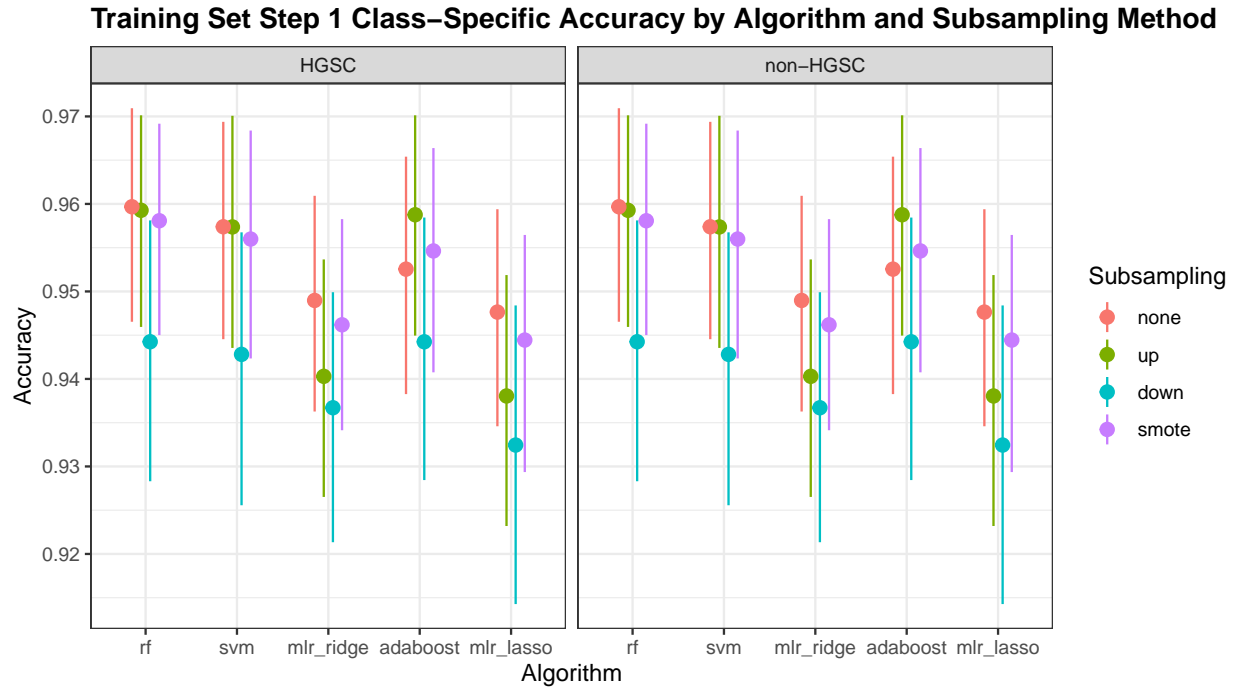


Figure 4.11: Training Set Step 1 Class-Specific Accuracy

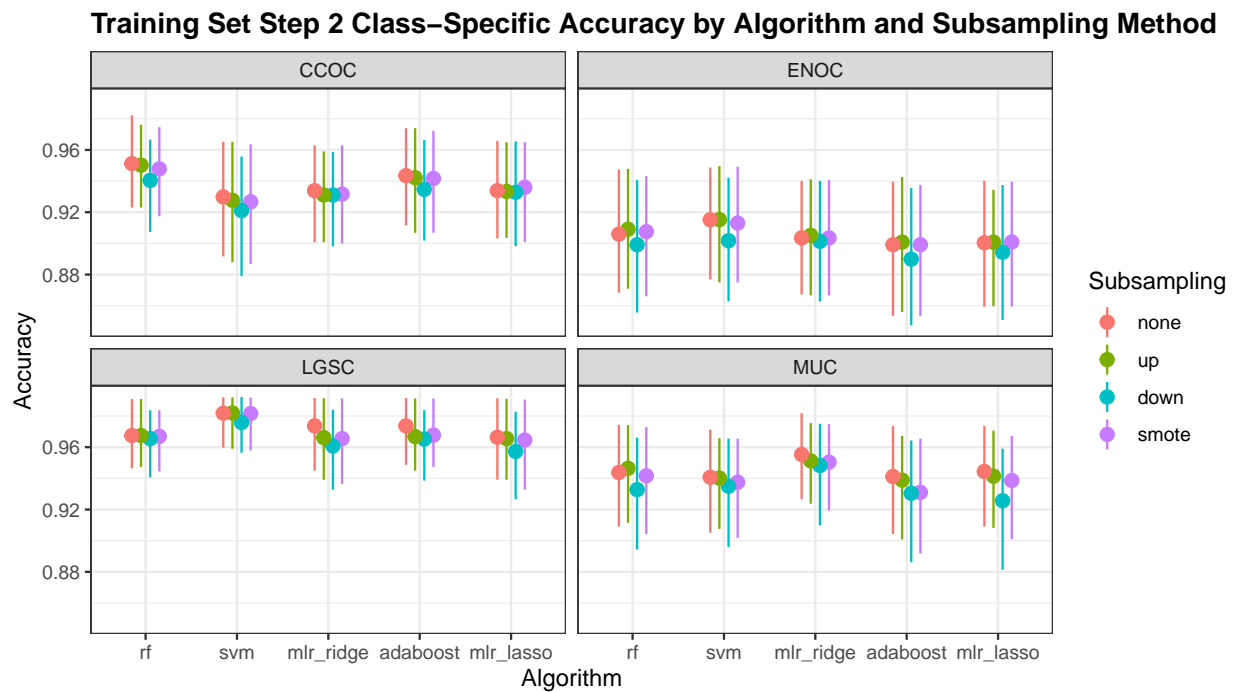


Figure 4.12: Training Set Step 2 Class-Specific Accuracy

Table 4.11: Training Set Step 1 Class-Specific Accuracy by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	HGSC	<b>0.96</b>	0.957	0.949	0.953	0.948
none	non-HGSC	<b>0.96</b>	0.957	0.949	0.953	0.948
up	HGSC	0.959	0.957	0.94	0.959	0.938
up	non-HGSC	0.959	0.957	0.94	0.959	0.938
down	HGSC	0.944	0.943	0.937	0.944	0.932
down	non-HGSC	0.944	0.943	0.937	0.944	0.932
smote	HGSC	0.958	0.956	0.946	0.955	0.944
smote	non-HGSC	0.958	0.956	0.946	0.955	0.944

Table 4.12: Training Set Step 2 Class-Specific Accuracy by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.951	0.93	0.934	0.943	0.934
none	ENOC	0.906	0.915	0.904	0.899	0.9
none	LGSC	0.967	<b>0.982</b>	0.974	0.974	0.966
none	MUC	0.944	0.941	0.955	0.941	0.944
up	CCOC	0.95	0.928	0.931	0.942	0.933
up	ENOC	0.909	0.915	0.905	0.901	0.901
up	LGSC	0.967	<b>0.982</b>	0.966	0.967	0.966
up	MUC	0.946	0.94	0.951	0.939	0.941
down	CCOC	0.94	0.921	0.931	0.935	0.933
down	ENOC	0.899	0.902	0.901	0.89	0.894
down	LGSC	0.966	0.976	0.961	0.965	0.957
down	MUC	0.933	0.935	0.948	0.93	0.926
smote	CCOC	0.948	0.927	0.932	0.942	0.936
smote	ENOC	0.908	0.913	0.904	0.899	0.901
smote	LGSC	0.967	<b>0.982</b>	0.966	0.968	0.965
smote	MUC	0.942	0.938	0.95	0.931	0.939

### 4.2.2 F1-Score

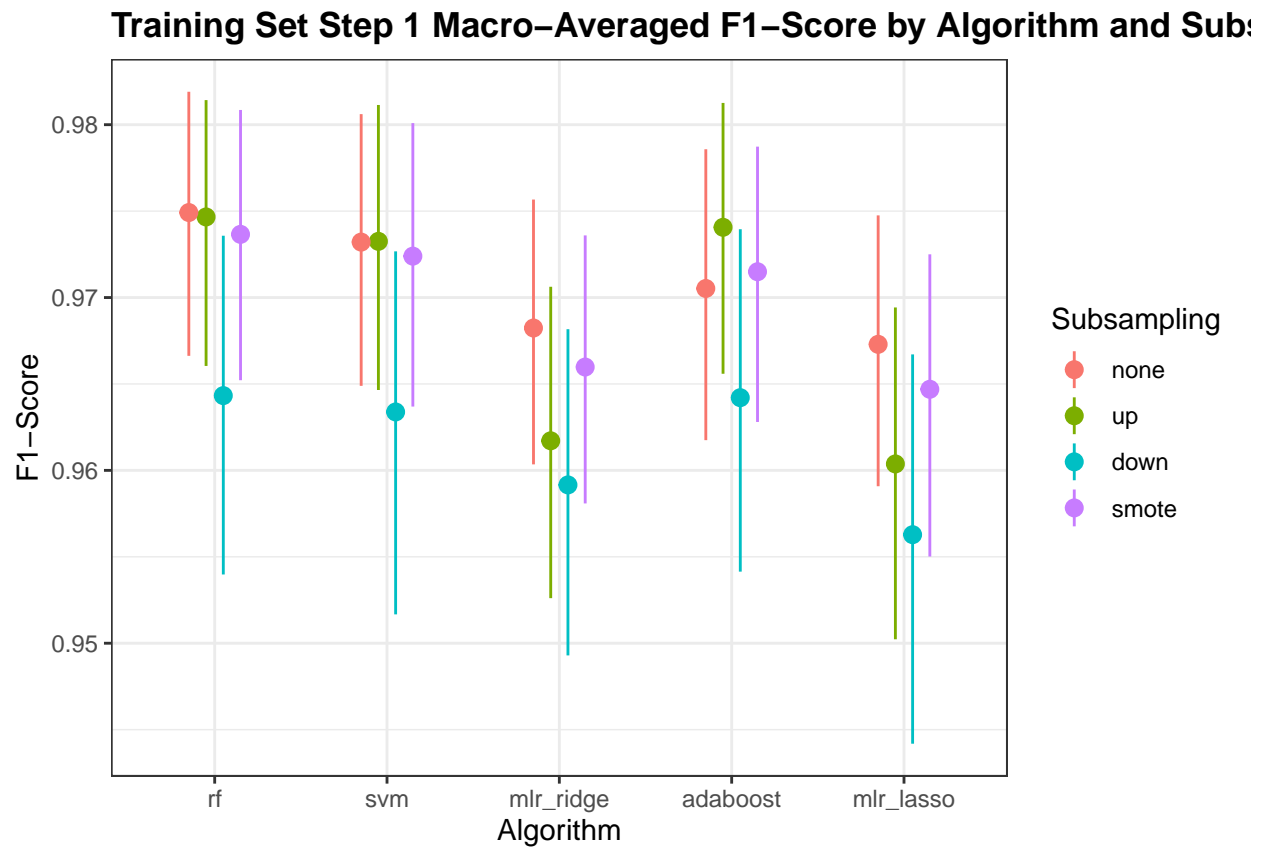


Figure 4.13: Training Set Step 1 F1-Score

Table 4.13: Training Set Step 1 Macro-Averaged F1-Score by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	<b>0.975</b>	0.973	0.968	0.971	0.967
up	<b>0.975</b>	0.973	0.962	0.974	0.96
down	0.964	0.963	0.959	0.964	0.956
smote	0.974	0.972	0.966	0.971	0.965

Table 4.14: Training Set Step 2 Macro-Averaged F1-Score by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.882	<b>0.885</b>	0.88	0.877	0.87
up	0.883	0.884	0.876	0.873	0.868
down	0.866	0.873	0.866	0.859	0.85
smote	0.879	0.881	0.874	0.869	0.866

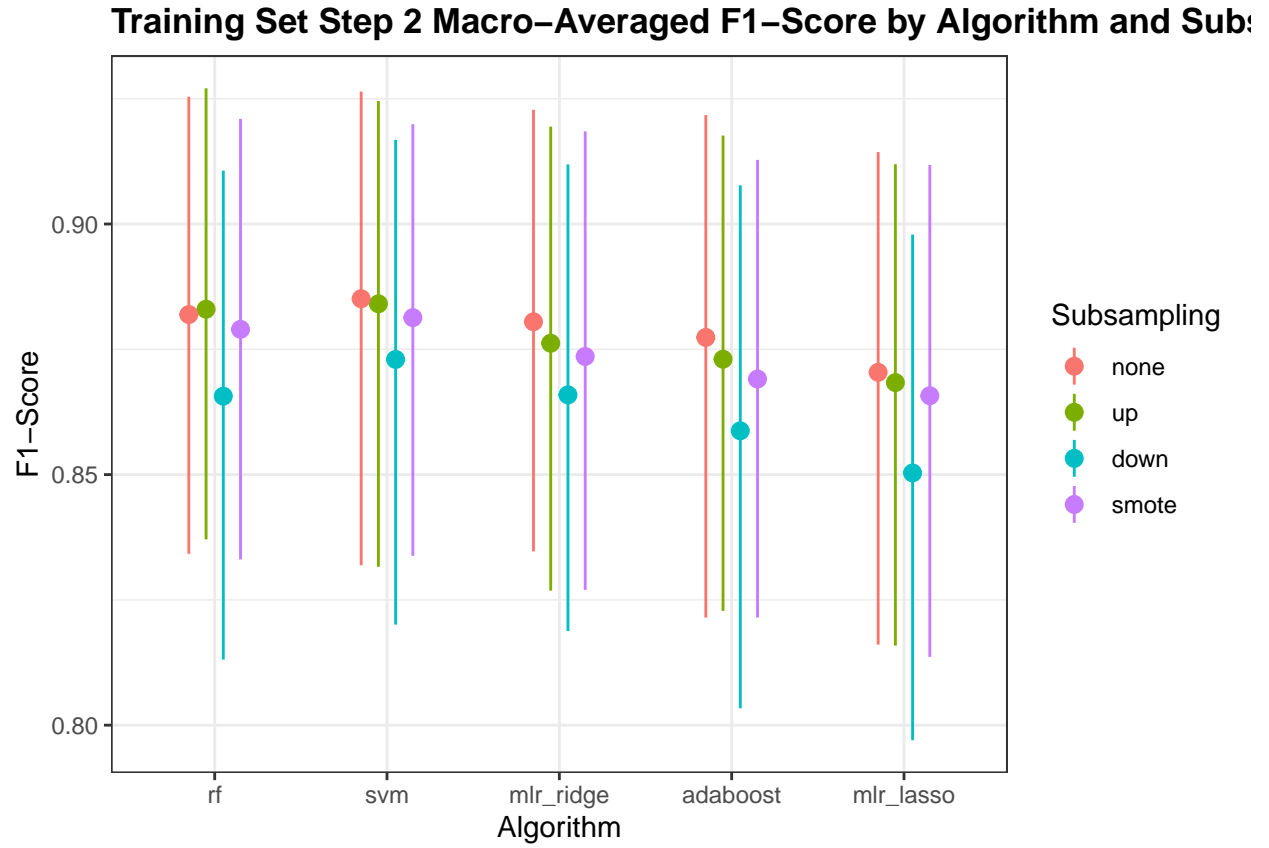


Figure 4.14: Training Set Step 2 F1-Score

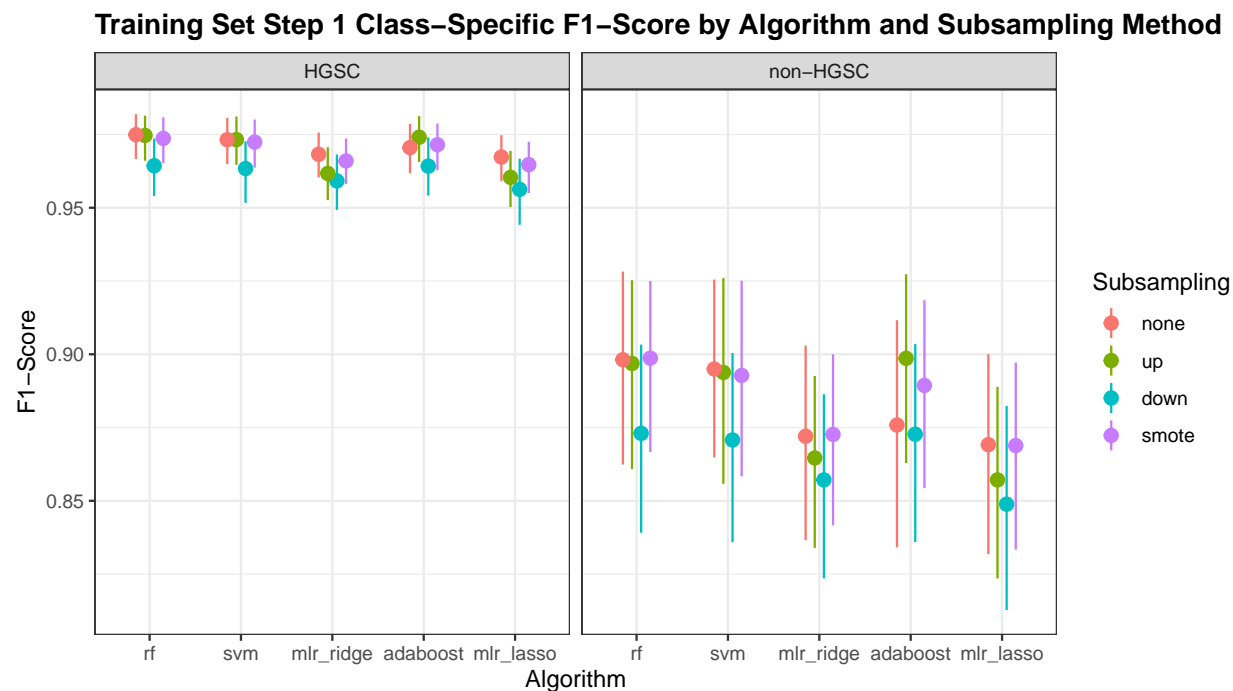


Figure 4.15: Training Set Step 1 Class-Specific F1-Score

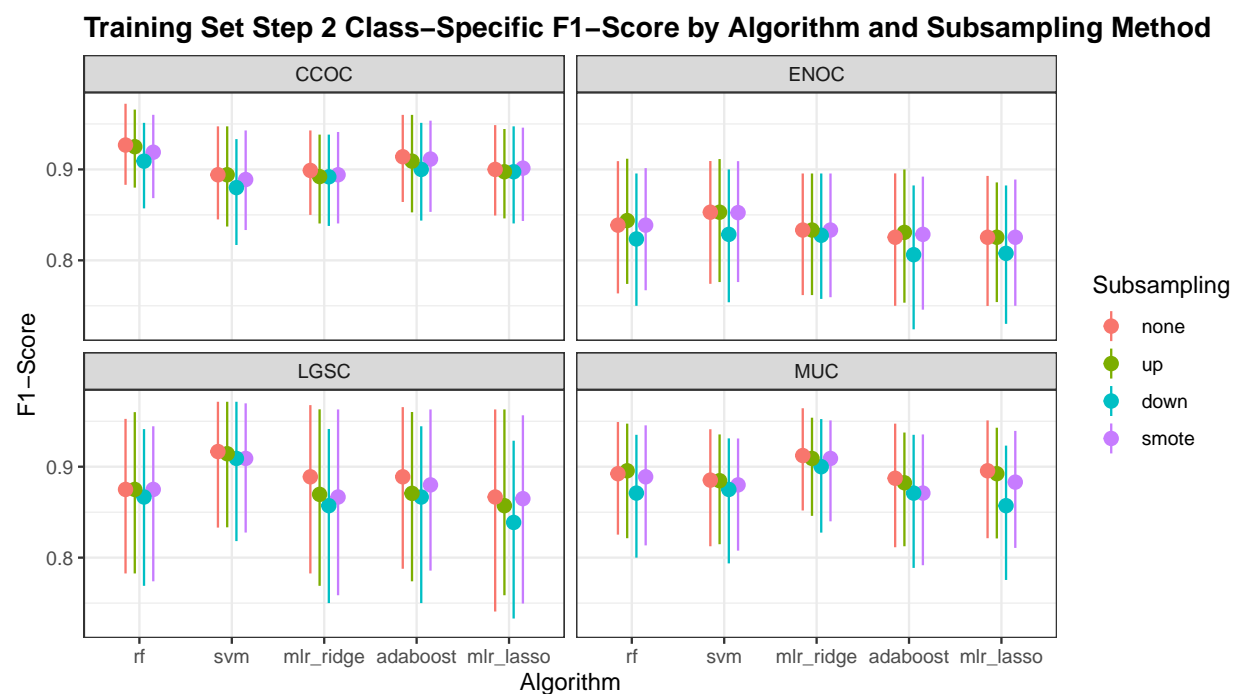


Figure 4.16: Training Set Step 2 Class-Specific F1-Score

Show  entries

Search:

Training Set Step 1 Class-Specific F1-Score by Algorithm and Subsampling Method

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<input type="text" value="All"/>	<input type="text" value="All"/>	<input type="text" value="All"/>	<input type="text" value="All"/>	<input type="text" value="All"/>	<input type="text" value="All"/>	<input type="text" value="All"/>
none	HGSC	$\text{0.975}$	0.973	0.968	0.971	0.967
none	non-HGSC	0.898	0.895	0.872	0.876	0.869
up	HGSC	$\text{0.975}$	0.973	0.962	0.974	0.96
up	non-HGSC	0.897	0.894	0.865	0.899	0.857
down	HGSC	0.964	0.963	0.959	0.964	0.956
down	non-HGSC	0.873	0.871	0.857	0.873	0.849
smote	HGSC	0.974	0.972	0.966	0.971	0.965
smote	non-HGSC	0.899	0.893	0.873	0.889	0.869

Showing 1 to 8 of 8 entries

Previous  Next



Show  entries

Search:

Training Set Step 2 Class-Specific F1-Score by Algorithm and Subsampling Method

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none	CCOC	$\text{0.927}$	0.894	0.899	0.914	0.9
none	ENOC	0.839	0.853	0.833	0.825	0.825
none	LGSC	0.875	0.917	0.889	0.889	0.867
none	MUC	0.892	0.885	0.912	0.887	0.896
up	CCOC	0.925	0.894	0.892	0.909	0.897
up	ENOC	0.844	0.853	0.833	0.831	0.825
up	LGSC	0.875	0.914	0.87	0.871	0.857
up	MUC	0.896	0.885	0.909	0.882	0.892
down	CCOC	0.909	0.88	0.892	0.9	0.897
down	ENOC	0.824	0.829	0.828	0.806	0.808
down	LGSC	0.867	0.909	0.857	0.867	0.839
down	MUC	0.871	0.875	0.9	0.871	0.857
smote	CCOC	0.919	0.889	0.894	0.911	0.901
smote	ENOC	0.839	0.852	0.833	0.829	0.825
smote	LGSC	0.875	0.909	0.867	0.88	0.865
smote	MUC	0.889	0.88	0.909	0.871	0.883

Showing 1 to 16 of 16 entries

Previous  Next

### 4.2.3 Kappa

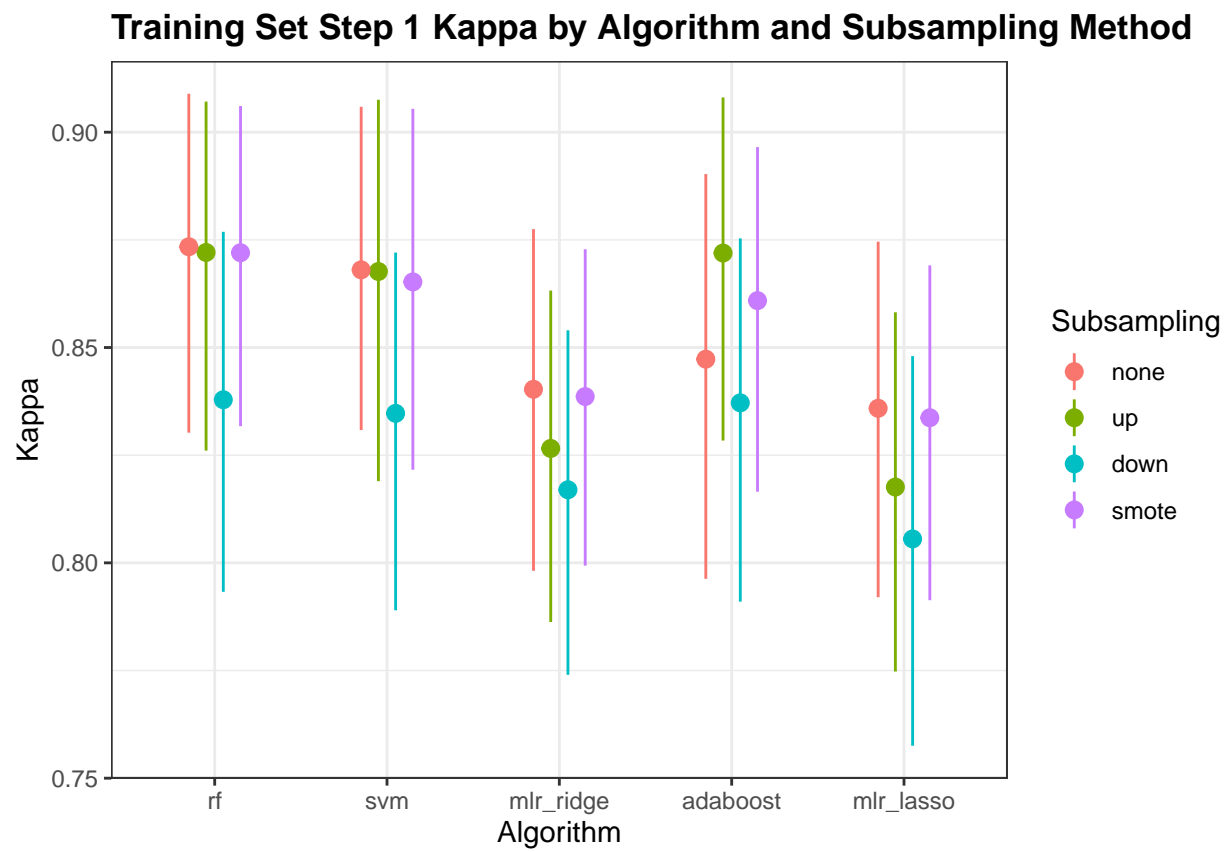


Figure 4.17: Training Set Step 1 Kappa

Table 4.15: Training Set Step 1 Kappa by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	<b>0.873</b>	0.868	0.84	0.847	0.836
up	0.872	0.868	0.827	0.872	0.818
down	0.838	0.835	0.817	0.837	0.806
smote	0.872	0.865	0.839	0.861	0.834

Table 4.16: Training Set Step 2 Kappa by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.841	0.836	0.836	0.829	0.824
up	<b>0.842</b>	0.836	0.832	0.827	0.821
down	0.818	0.819	0.82	0.808	0.801
smote	0.835	0.831	0.827	0.822	0.82

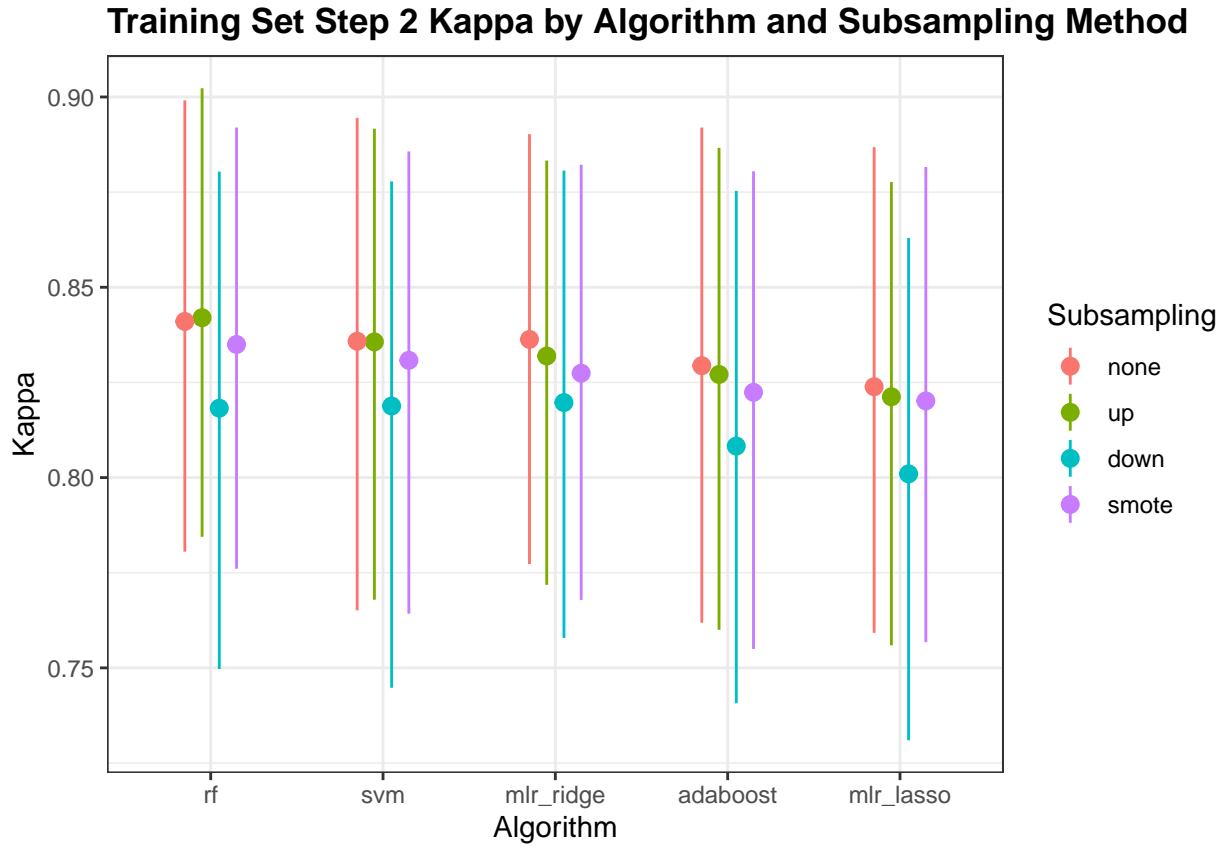


Figure 4.18: Training Set Step 2 Kappa

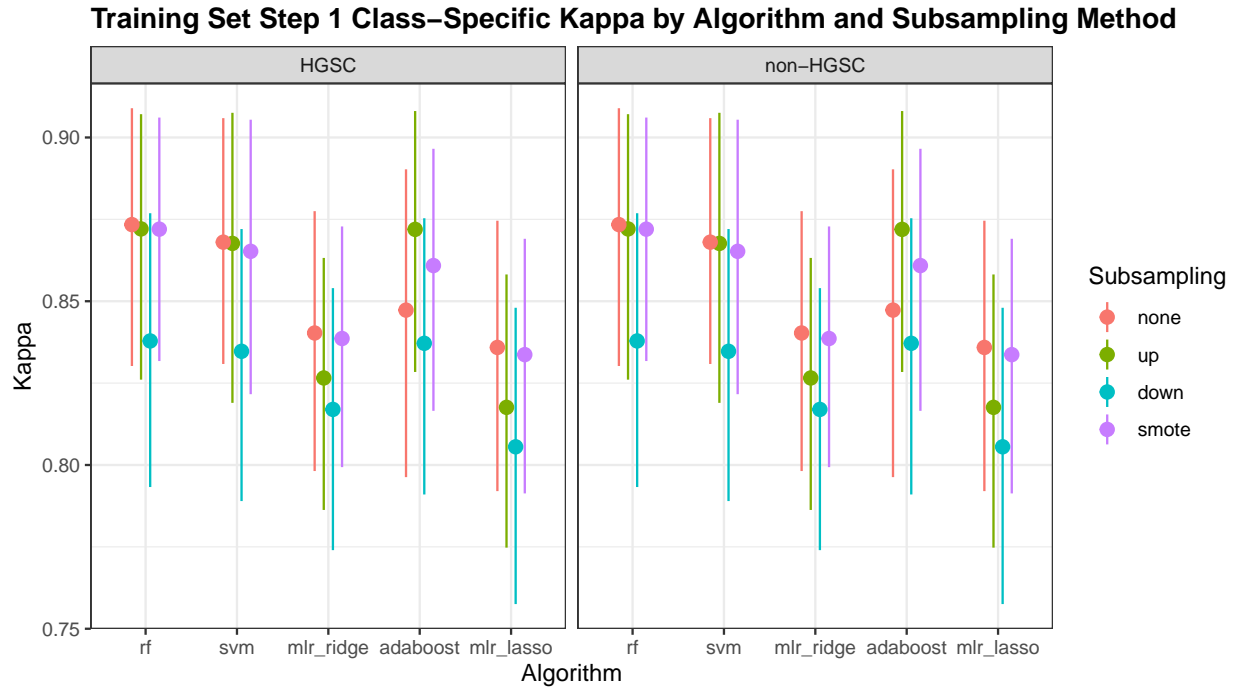


Figure 4.19: Training Set Step 1 Class-Specific Kappa

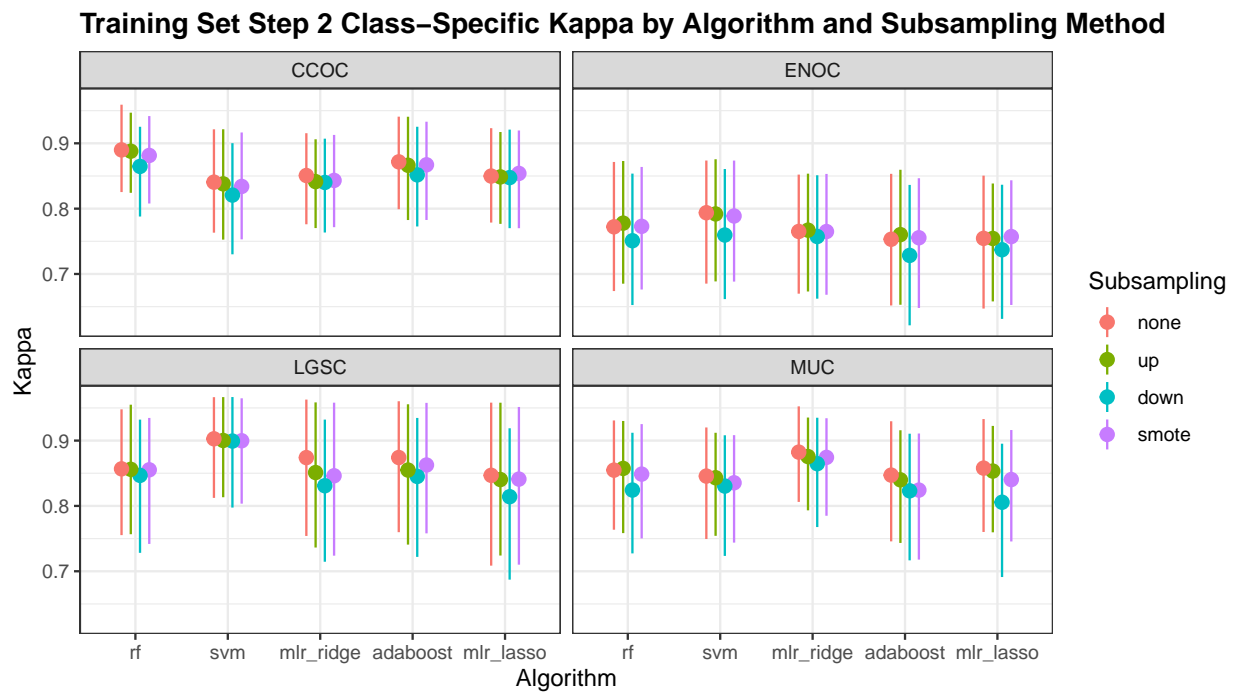


Figure 4.20: Training Set Step 2 Class-Specific Kappa

Table 4.17: Training Set Step 1 Class-Specific Kappa by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	HGSC	<b>0.873</b>	0.868	0.84	0.847	0.836
none	non-HGSC	<b>0.873</b>	0.868	0.84	0.847	0.836
up	HGSC	0.872	0.868	0.827	0.872	0.818
up	non-HGSC	0.872	0.868	0.827	0.872	0.818
down	HGSC	0.838	0.835	0.817	0.837	0.806
down	non-HGSC	0.838	0.835	0.817	0.837	0.806
smote	HGSC	0.872	0.865	0.839	0.861	0.834
smote	non-HGSC	0.872	0.865	0.839	0.861	0.834

Table 4.18: Training Set Step 2 Class-Specific Kappa by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.89	0.841	0.851	0.872	0.85
none	ENOC	0.772	0.794	0.765	0.753	0.755
none	LGSC	0.857	<b>0.903</b>	0.874	0.874	0.847
none	MUC	0.855	0.846	0.882	0.847	0.858
up	CCOC	0.888	0.838	0.841	0.866	0.849
up	ENOC	0.778	0.792	0.767	0.76	0.754
up	LGSC	0.856	0.9	0.851	0.855	0.84
up	MUC	0.857	0.843	0.876	0.84	0.853
down	CCOC	0.865	0.821	0.84	0.852	0.848
down	ENOC	0.751	0.76	0.757	0.728	0.737
down	LGSC	0.847	0.899	0.831	0.845	0.814
down	MUC	0.824	0.83	0.865	0.823	0.806
smote	CCOC	0.881	0.834	0.843	0.867	0.854
smote	ENOC	0.773	0.789	0.765	0.755	0.757
smote	LGSC	0.855	0.9	0.846	0.863	0.841
smote	MUC	0.849	0.835	0.874	0.824	0.84

#### 4.2.4 G-mean

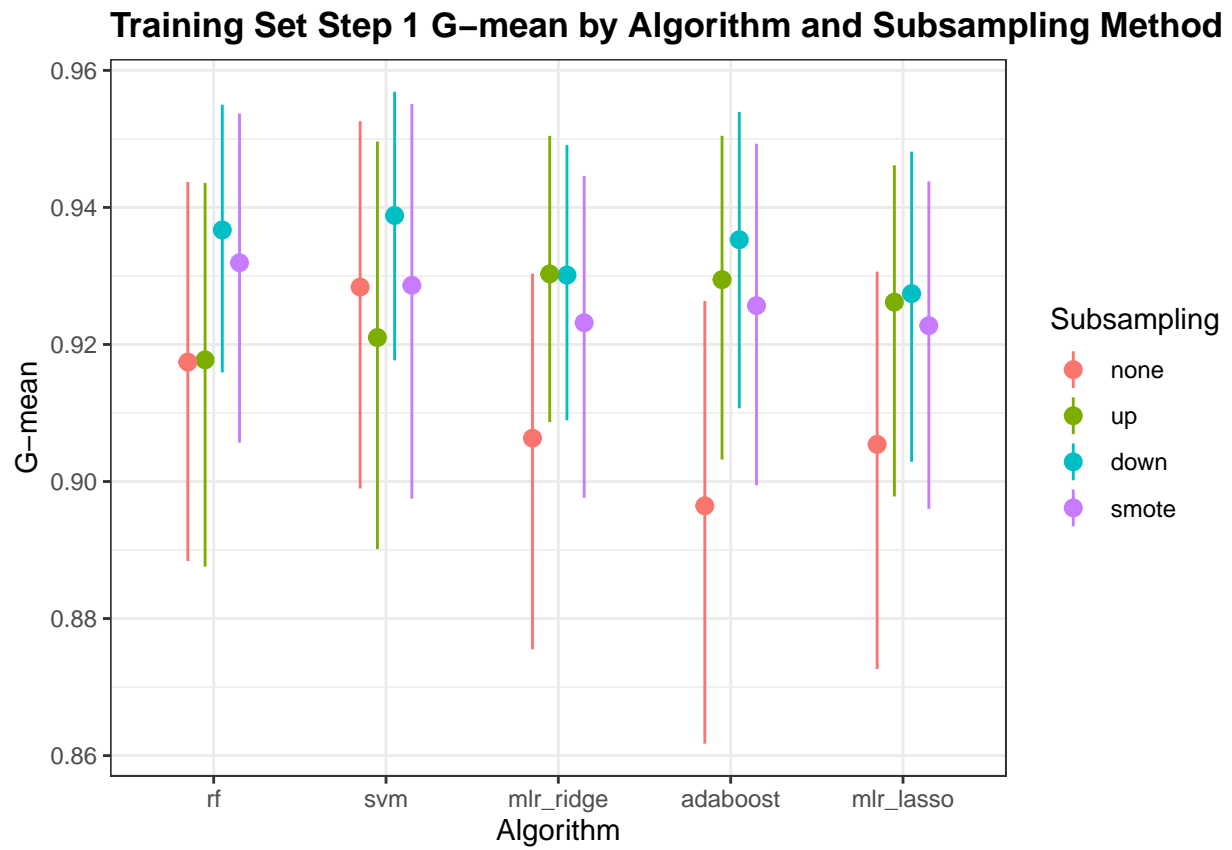


Figure 4.21: Training Set Step 1 G-mean

Table 4.19: Training Set Step 1 G-mean by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.917	0.928	0.906	0.896	0.905
up	0.918	0.921	0.93	0.929	0.926
down	0.937	<b>0.939</b>	0.93	0.935	0.927
smote	0.932	0.929	0.923	0.926	0.923

Table 4.20: Training Set Step 2 G-mean by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.885	0.882	0.883	0.877	0.869
up	<b>0.887</b>	0.881	0.882	0.878	0.874
down	0.874	0.874	0.877	0.865	0.859
smote	0.885	0.88	0.881	0.875	0.871

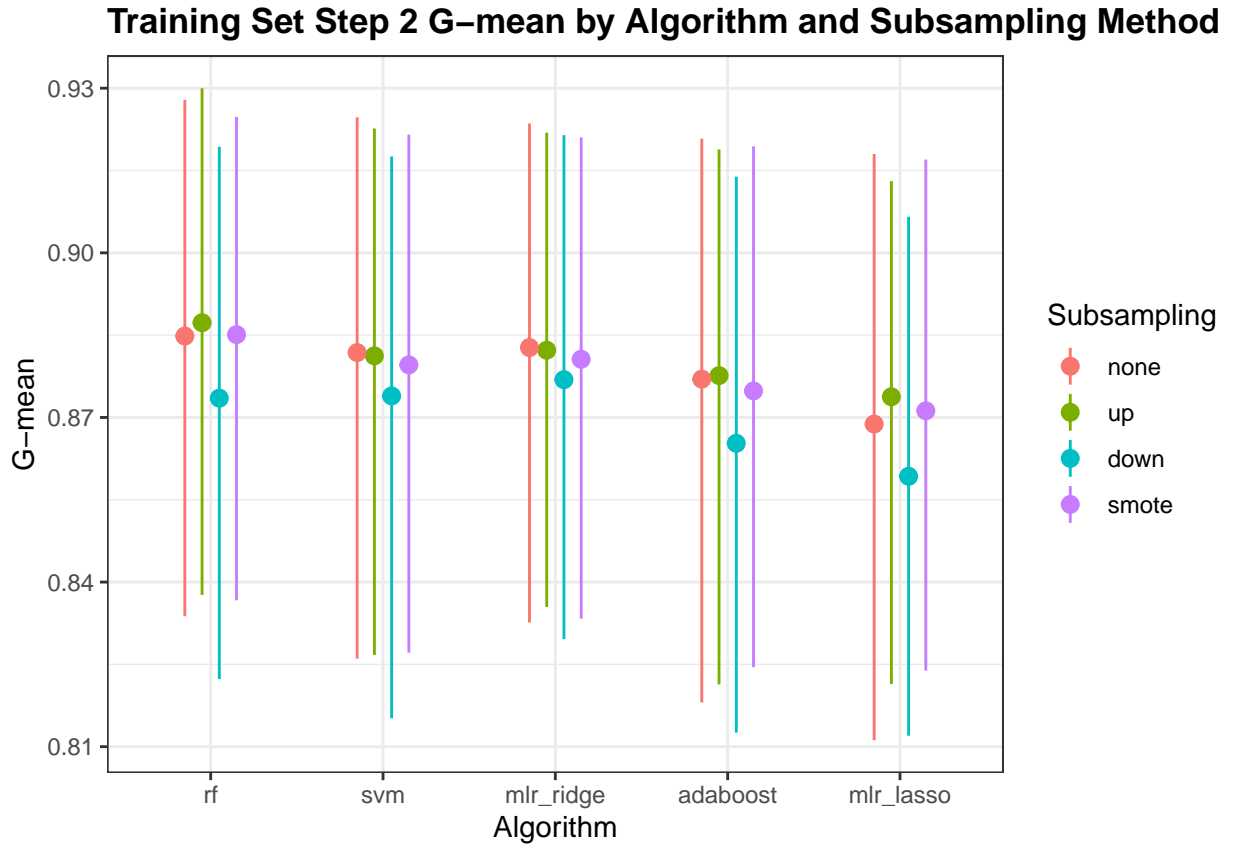


Figure 4.22: Training Set Step 2 G-mean

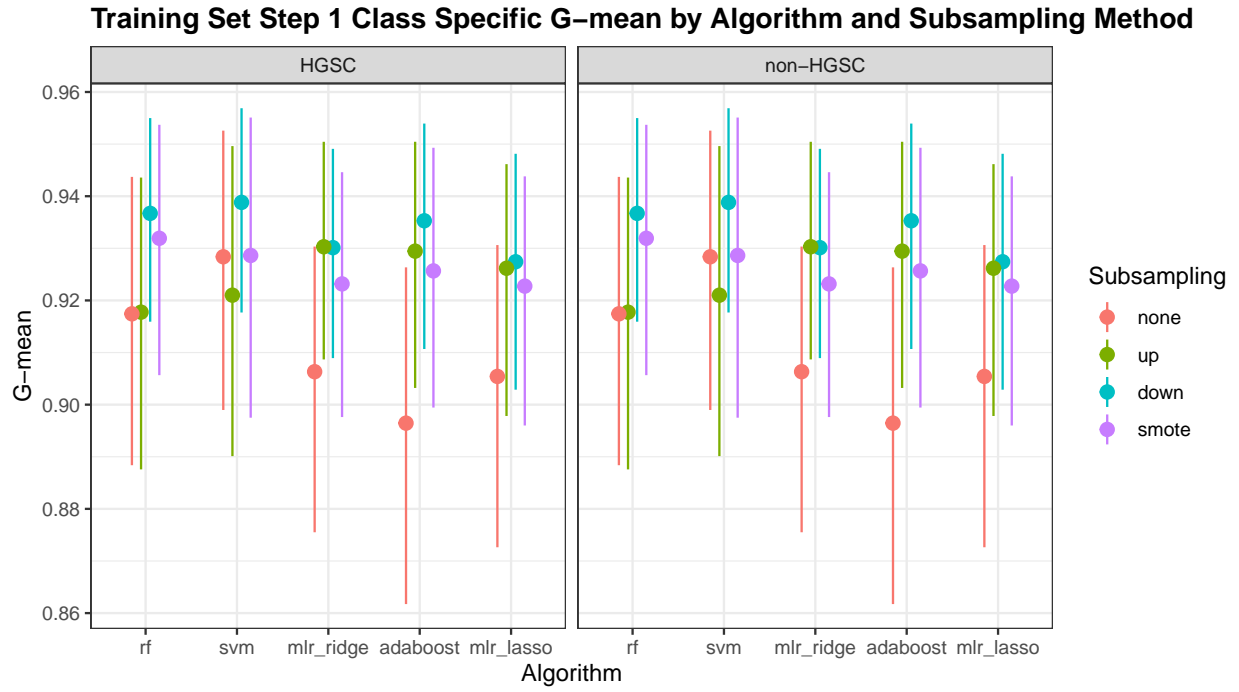


Figure 4.23: Training Set Step 1 Class-Specific G-mean

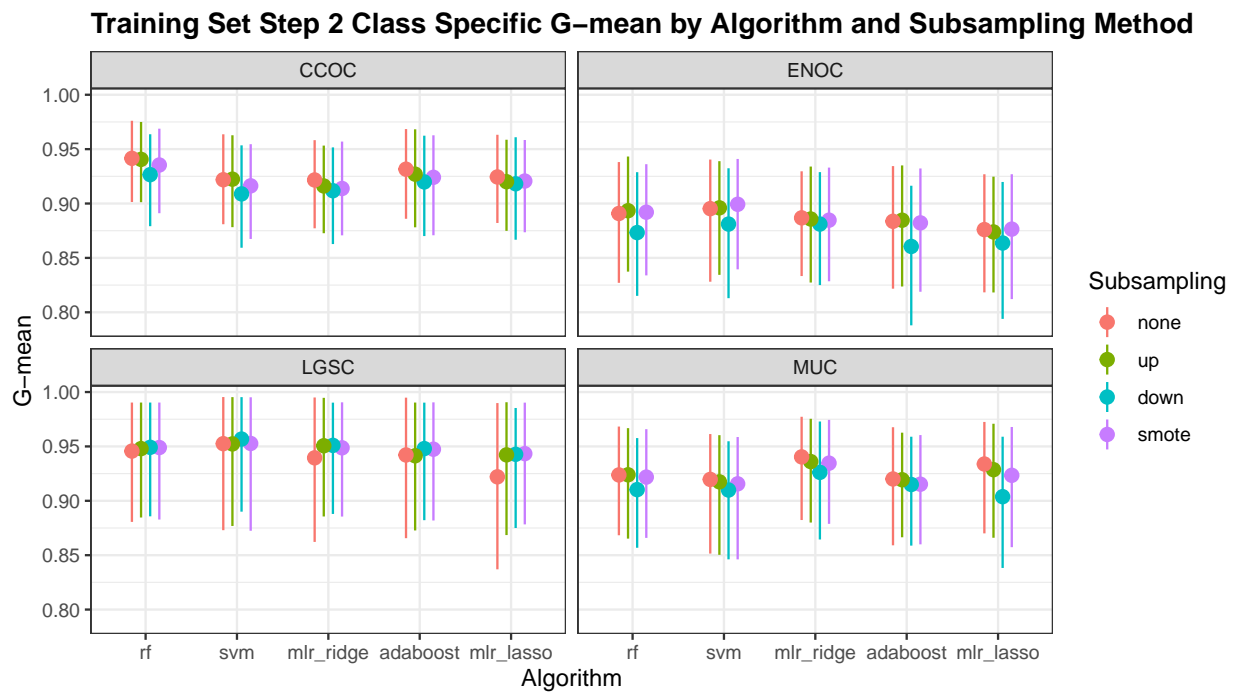


Figure 4.24: Training Set Step 2 Class-Specific G-mean



Table 4.21: Training Set Step 1 Class-Specific G-mean by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	HGSC	0.917	0.928	0.906	0.896	0.905
none	non-HGSC	0.917	0.928	0.906	0.896	0.905
up	HGSC	0.918	0.921	0.93	0.929	0.926
up	non-HGSC	0.918	0.921	0.93	0.929	0.926
down	HGSC	0.937	<b>0.939</b>	0.93	0.935	0.927
down	non-HGSC	0.937	<b>0.939</b>	0.93	0.935	0.927
smote	HGSC	0.932	0.929	0.923	0.926	0.923
smote	non-HGSC	0.932	0.929	0.923	0.926	0.923

Table 4.22: Training Set Step 2 Class-Specific G-mean by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.942	0.922	0.922	0.932	0.924
none	ENOC	0.891	0.895	0.887	0.884	0.876
none	LGSC	0.946	0.953	0.94	0.942	0.922
none	MUC	0.924	0.92	0.94	0.92	0.934
up	CCOC	0.941	0.922	0.916	0.927	0.92
up	ENOC	0.893	0.896	0.886	0.885	0.874
up	LGSC	0.948	0.952	0.951	0.941	0.942
up	MUC	0.924	0.917	0.936	0.919	0.929
down	CCOC	0.927	0.909	0.912	0.92	0.918
down	ENOC	0.873	0.881	0.881	0.861	0.864
down	LGSC	0.949	<b>0.957</b>	0.951	0.948	0.943
down	MUC	0.91	0.91	0.926	0.915	0.904
smote	CCOC	0.935	0.916	0.914	0.924	0.921
smote	ENOC	0.892	0.899	0.885	0.882	0.876
smote	LGSC	0.949	0.953	0.949	0.947	0.943
smote	MUC	0.922	0.916	0.935	0.915	0.923

Table 4.23: CS1 Set Accuracy by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.828	<b>0.849</b>	0.841	0.808	0.831
up	0.847	0.841	0.842	0.835	0.824
down	0.802	0.811	0.788	0.781	0.766
smote	0.846	0.841	0.837	0.839	0.823

## 4.3 CS1 Set

### 4.3.1 Accuracy

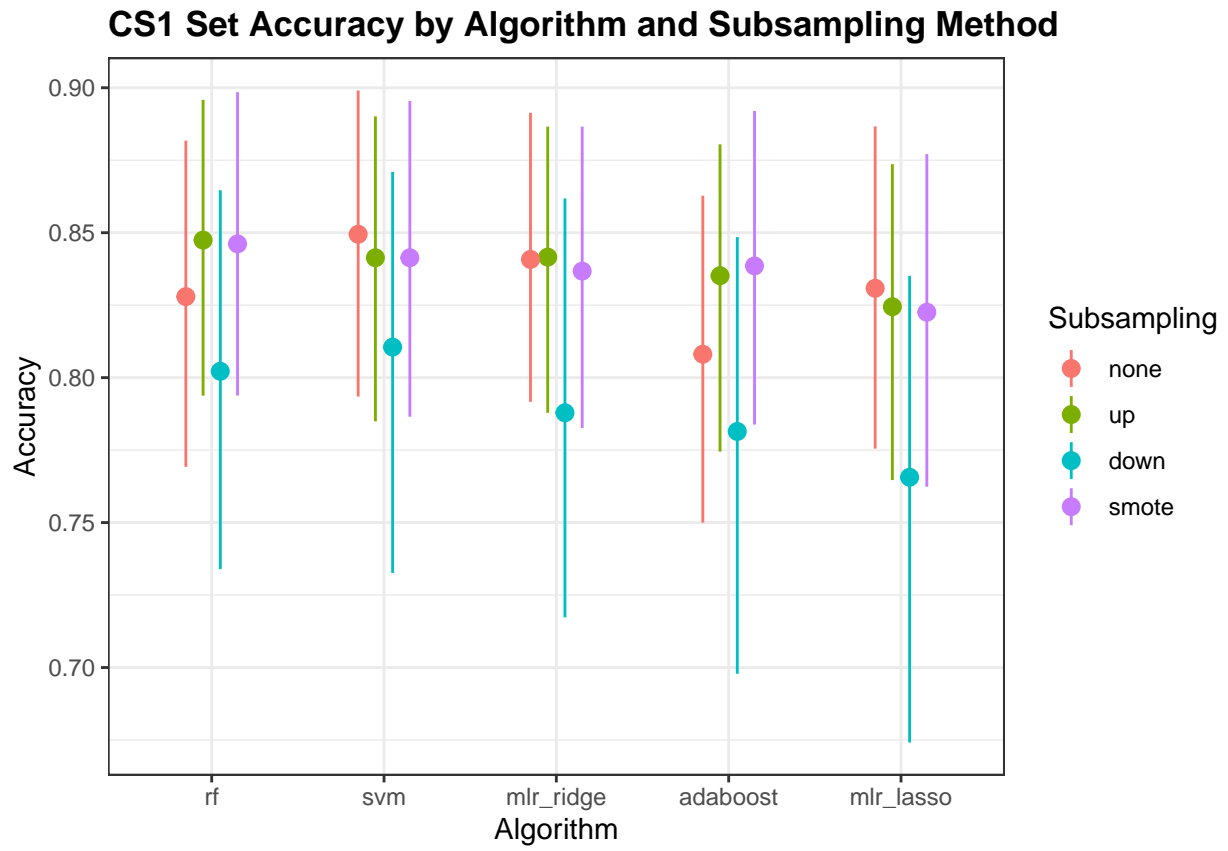


Figure 4.25: CS1 Set Accuracy

Table 4.24: CS1 Set Class-Specific Accuracy by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.942	0.944	0.938	0.941	0.937
none	ENOC	0.891	0.912	0.898	0.887	0.897
none	HGSC	0.902	0.903	0.912	0.882	0.904
none	LGSC	0.956	0.972	0.968	0.947	0.957
none	MUC	0.969	0.969	0.977	0.967	0.97
up	CCOC	0.945	0.937	0.933	0.941	0.922
up	ENOC	0.901	0.904	0.896	0.892	0.884
up	HGSC	0.918	0.899	0.916	0.906	0.911
up	LGSC	0.968	<b>0.978</b>	0.967	0.965	0.961
up	MUC	0.971	0.969	0.971	0.969	0.977
down	CCOC	0.939	0.936	0.941	0.933	0.926
down	ENOC	0.881	0.888	0.888	0.87	0.873
down	HGSC	0.888	0.882	0.868	0.871	0.856
down	LGSC	0.941	0.958	0.922	0.935	0.92
down	MUC	0.967	0.96	0.967	0.96	0.959
smote	CCOC	0.944	0.941	0.933	0.939	0.931
smote	ENOC	0.896	0.9	0.894	0.89	0.887
smote	HGSC	0.92	0.901	0.911	0.913	0.901
smote	LGSC	0.968	0.976	0.962	0.968	0.957
smote	MUC	0.97	0.969	0.977	0.969	<b>0.978</b>

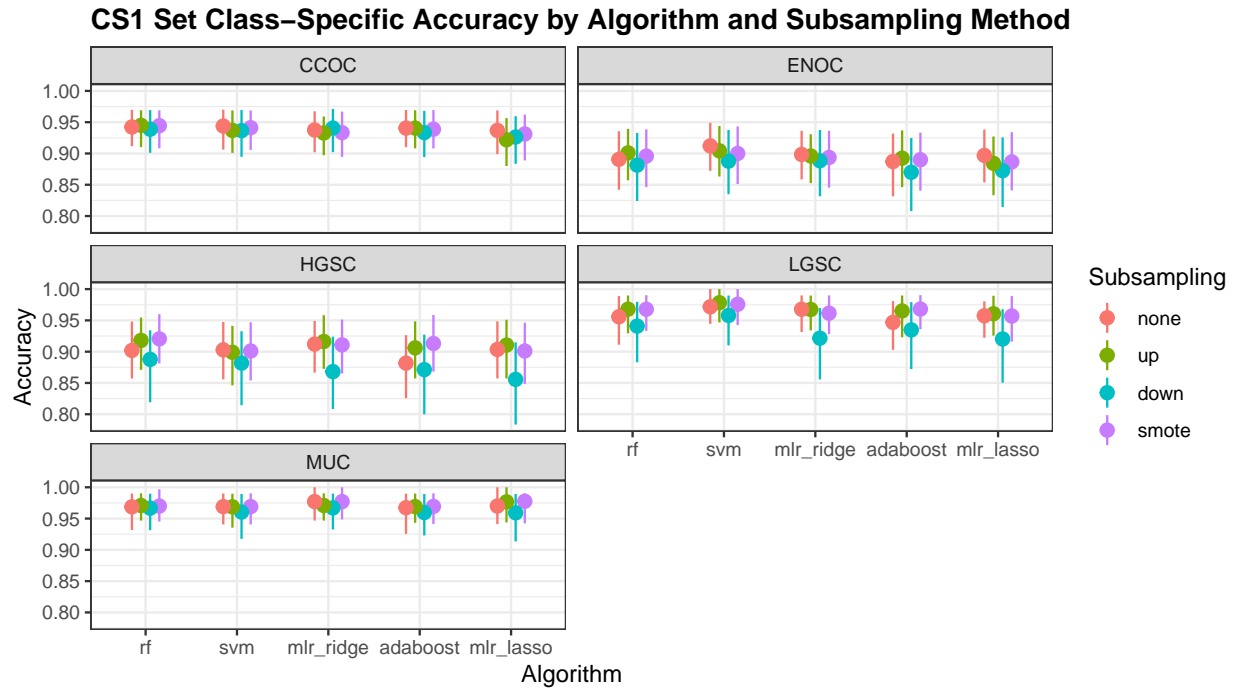


Figure 4.26: CS1 Set Class-Specific Accuracy

Table 4.25: CS1 Set Macro-Averaged F1-Score by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.748	0.805	0.794	0.718	0.771
up	0.792	0.793	<b>0.806</b>	0.772	0.787
down	0.76	0.771	0.751	0.733	0.723
smote	0.804	0.797	0.803	0.797	0.784

### 4.3.2 F1-Score

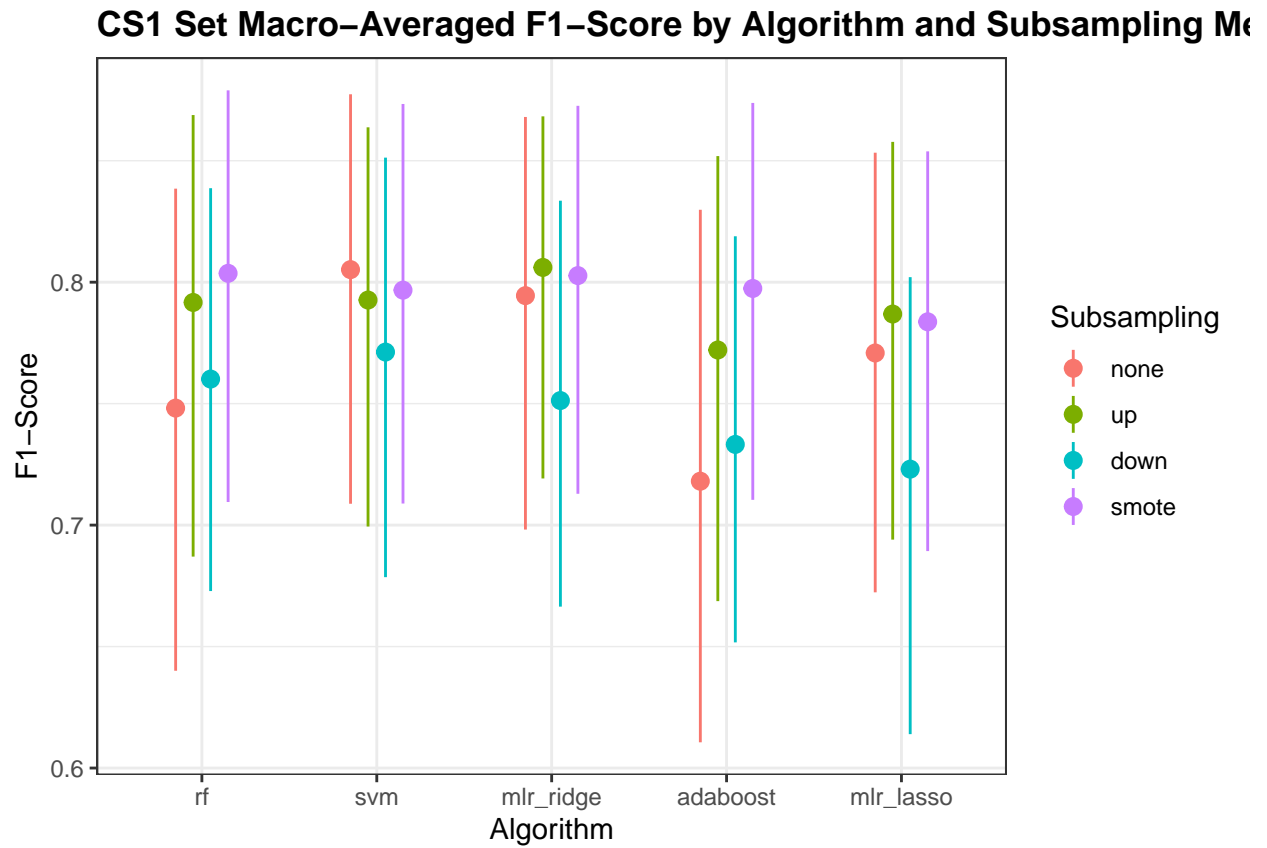


Figure 4.27: CS1 Set F1-Score

Table 4.26: CS1 Set Class-Specific F1-Score by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.829	0.833	0.824	0.828	0.813
none	ENOC	0.764	0.8	0.769	0.739	0.769
none	HGSC	0.9	0.9	0.909	0.884	0.9
none	LGSC	0.545	0.769	0.714	0.444	0.625
none	MUC	0.727	0.727	0.8	0.667	0.769
up	CCOC	0.839	0.813	0.812	0.828	0.784
up	ENOC	0.78	0.782	0.766	0.765	0.743
up	HGSC	<b>0.915</b>	0.898	0.909	0.903	0.902
up	LGSC	0.667	0.8	0.769	0.667	0.727
up	MUC	0.769	0.71	0.8	0.75	0.778
down	CCOC	0.828	0.824	0.833	0.812	0.8
down	ENOC	0.743	0.764	0.756	0.711	0.723
down	HGSC	0.871	0.865	0.843	0.85	0.83
down	LGSC	0.667	0.714	0.6	0.632	0.571
down	MUC	0.727	0.727	0.732	0.714	0.706
smote	CCOC	0.839	0.833	0.821	0.833	0.811
smote	ENOC	0.779	0.785	0.769	0.766	0.757
smote	HGSC	<b>0.915</b>	0.898	0.901	0.907	0.889
smote	LGSC	0.75	0.769	0.75	0.75	0.706
smote	MUC	0.769	0.727	0.8	0.766	0.8

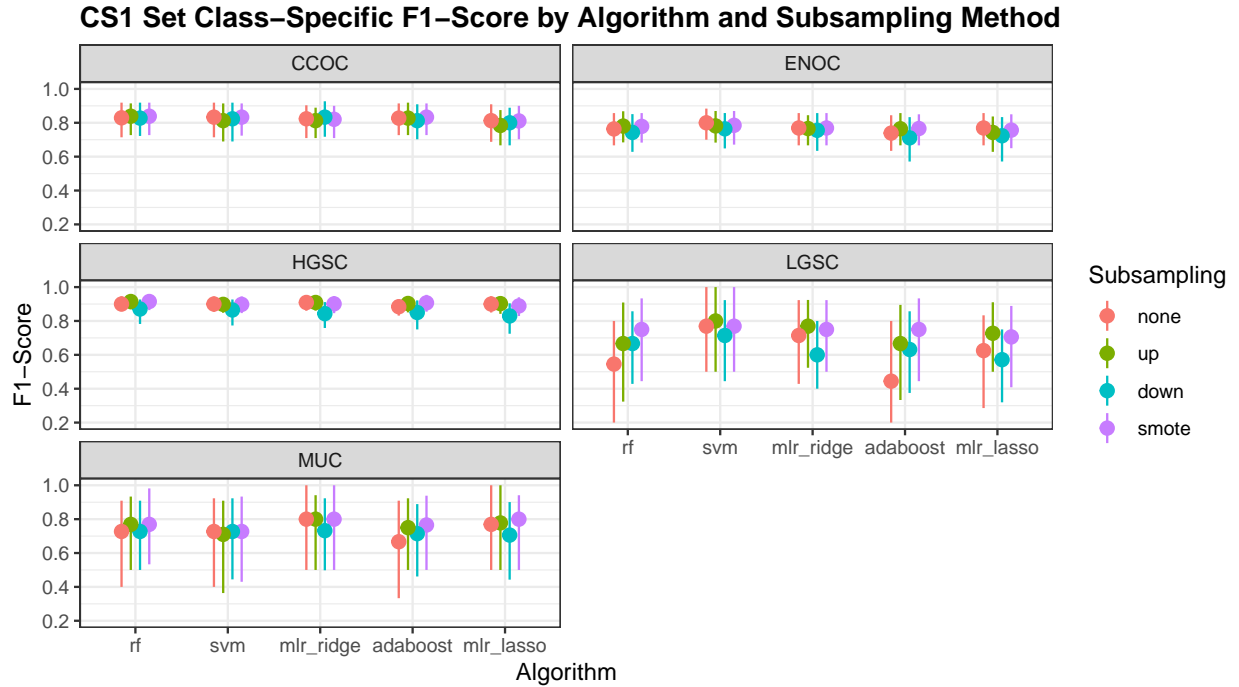


Figure 4.28: CS1 Set Class-Specific F1-Score

Table 4.27: CS1 Set Kappa by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.743	0.776	0.765	0.706	0.752
up	0.775	0.763	0.771	0.755	0.747
down	0.723	0.733	0.707	0.694	0.675
smote	<b>0.777</b>	0.768	0.767	0.766	0.746

### 4.3.3 Kappa

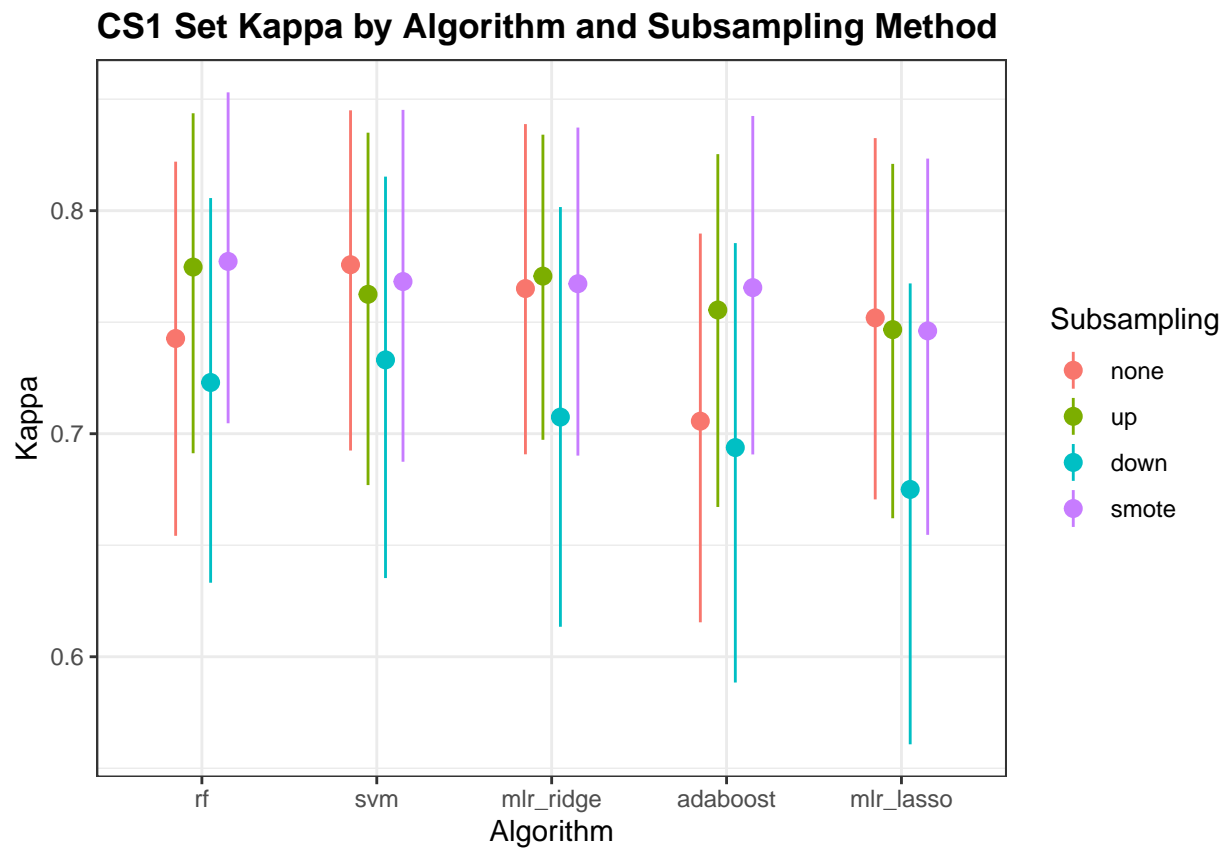


Figure 4.29: CS1 Set Kappa

Table 4.28: CS1 Set Class-Specific Kappa by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.795	0.797	0.784	0.792	0.777
none	ENOC	0.691	0.744	0.704	0.666	0.7
none	HGSC	0.803	0.806	0.824	0.764	0.807
none	LGSC	0.49	0.754	0.692	0.342	0.593
none	MUC	0.709	0.712	0.784	0.652	0.753
up	CCOC	0.804	0.776	0.773	0.792	0.734
up	ENOC	0.713	0.722	0.697	0.696	0.664
up	HGSC	0.836	0.799	0.83	0.811	0.82
up	LGSC	0.652	0.784	0.753	0.646	0.711
up	MUC	0.753	0.678	0.782	0.73	0.757
down	CCOC	0.789	0.784	0.797	0.774	0.755
down	ENOC	0.664	0.691	0.679	0.624	0.643
down	HGSC	0.772	0.76	0.731	0.738	0.706
down	LGSC	0.632	0.691	0.558	0.594	0.523
down	MUC	0.708	0.709	0.712	0.687	0.682
smote	CCOC	0.804	0.796	0.776	0.794	0.767
smote	ENOC	0.709	0.717	0.699	0.693	0.683
smote	HGSC	<b>0.84</b>	0.802	0.819	0.825	0.799
smote	LGSC	0.727	0.754	0.728	0.739	0.677
smote	MUC	0.753	0.711	0.789	0.745	0.788

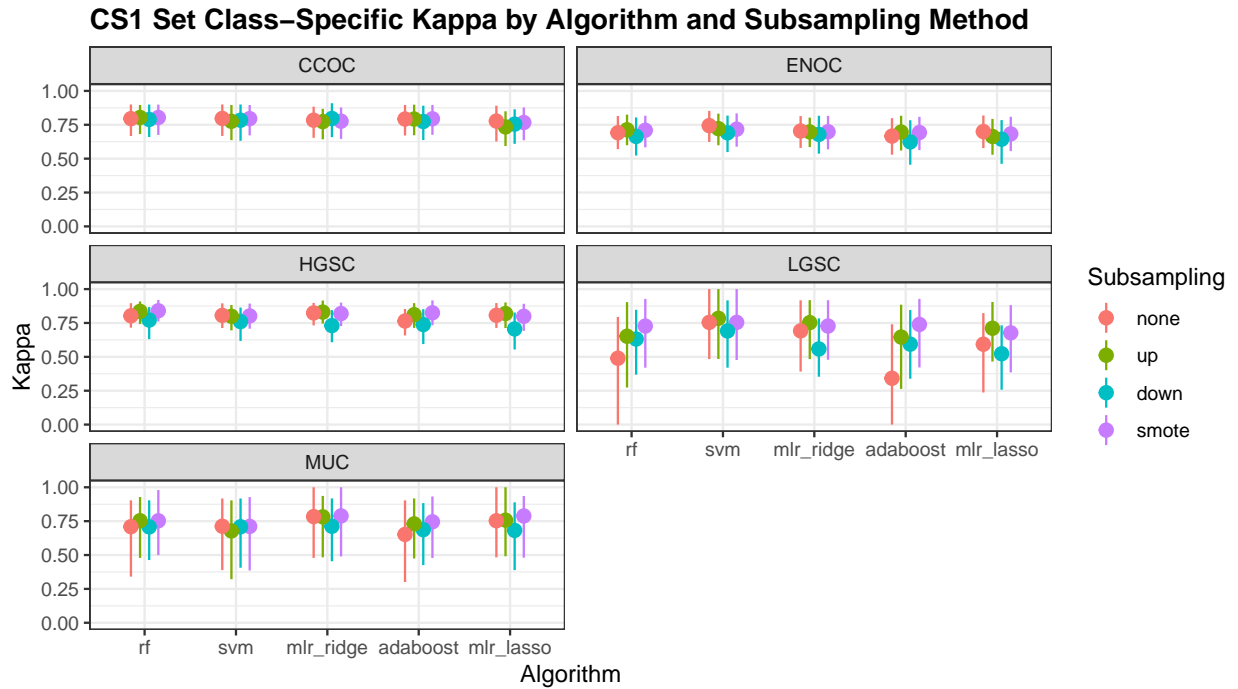


Figure 4.30: CS1 Set Class-Specific Kappa

Table 4.29: CS1 Set G-mean by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.658	0.757	0.75	0.571	0.727
up	0.734	0.734	<b>0.812</b>	0.716	0.787
down	0.791	0.793	0.795	0.774	0.756
smote	0.786	0.752	0.81	0.781	0.793

#### 4.3.4 G-mean

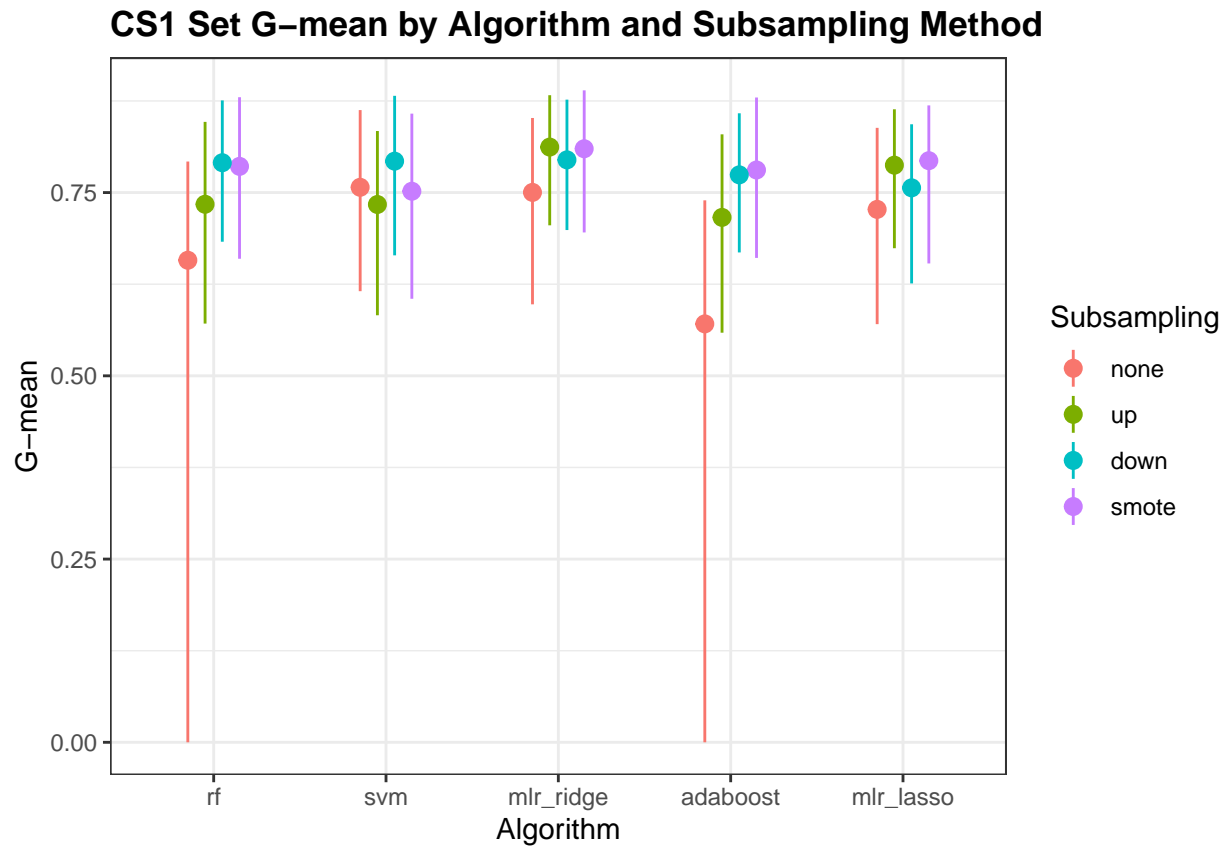


Figure 4.31: CS1 Set G-mean



Table 4.30: CS1 Set Class-Specific G-mean by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.888	0.891	0.889	0.885	0.885
none	ENOC	0.854	0.867	0.848	0.827	0.848
none	HGSC	0.904	0.905	0.913	0.883	0.905
none	LGSC	0.606	0.816	0.775	0.471	0.707
none	MUC	0.775	0.812	0.845	0.745	0.84
up	CCOC	0.893	0.883	0.891	0.888	0.87
up	ENOC	0.864	0.848	0.846	0.849	0.833
up	HGSC	<b>0.92</b>	0.902	0.914	0.908	0.909
up	LGSC	0.707	0.816	0.913	0.707	0.889
up	MUC	0.816	0.756	0.878	0.812	0.864
down	CCOC	0.901	0.886	0.905	0.895	0.883
down	ENOC	0.84	0.853	0.849	0.81	0.82
down	HGSC	0.881	0.876	0.855	0.863	0.845
down	LGSC	0.904	0.895	0.91	0.902	0.858
down	MUC	0.856	0.895	0.859	0.861	0.852
smote	CCOC	0.899	0.894	0.895	0.896	0.89
smote	ENOC	0.872	0.868	0.854	0.856	0.846
smote	HGSC	<b>0.92</b>	0.902	0.907	0.913	0.895
smote	LGSC	0.835	0.816	0.898	0.84	0.863
smote	MUC	0.856	0.788	0.882	0.848	0.877

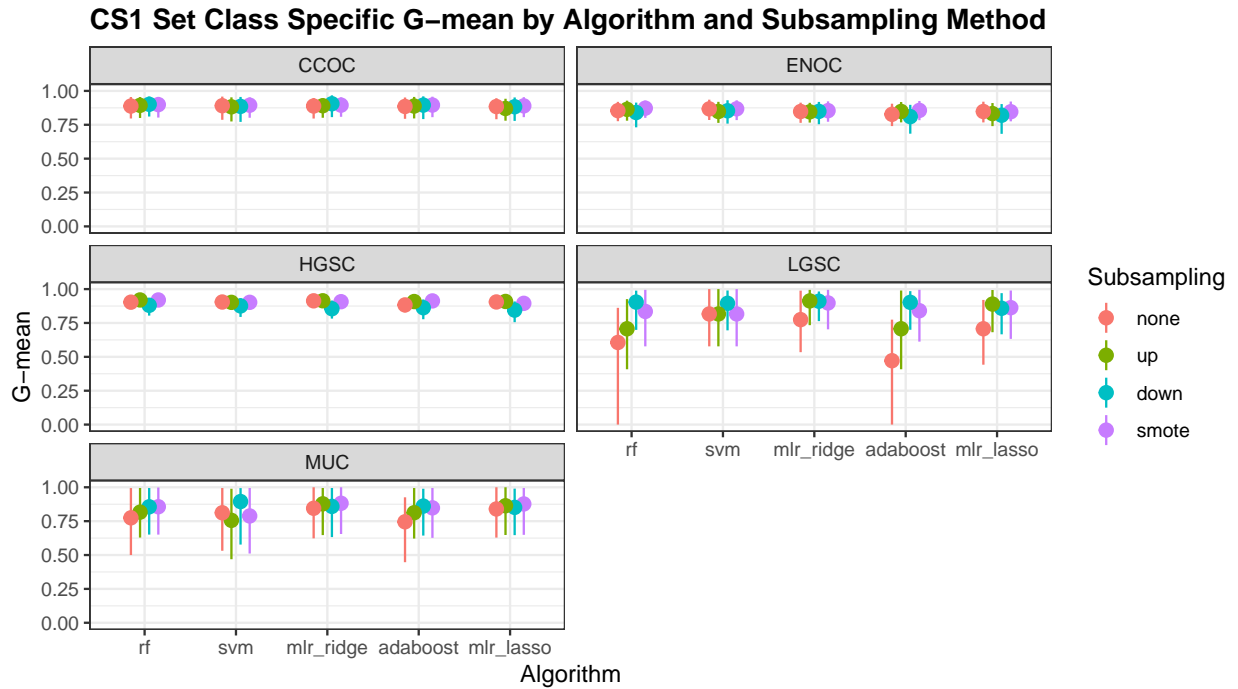


Figure 4.32: CS1 Set Class-Specific G-mean

Table 4.31: CS2 Set Accuracy by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.924	0.926	<b>0.938</b>	0.91	0.931
up	0.926	0.926	0.922	0.931	0.921
down	0.859	0.843	0.815	0.844	0.817
smote	0.928	0.922	0.915	0.925	0.902

## 4.4 CS2 Set

### 4.4.1 Accuracy

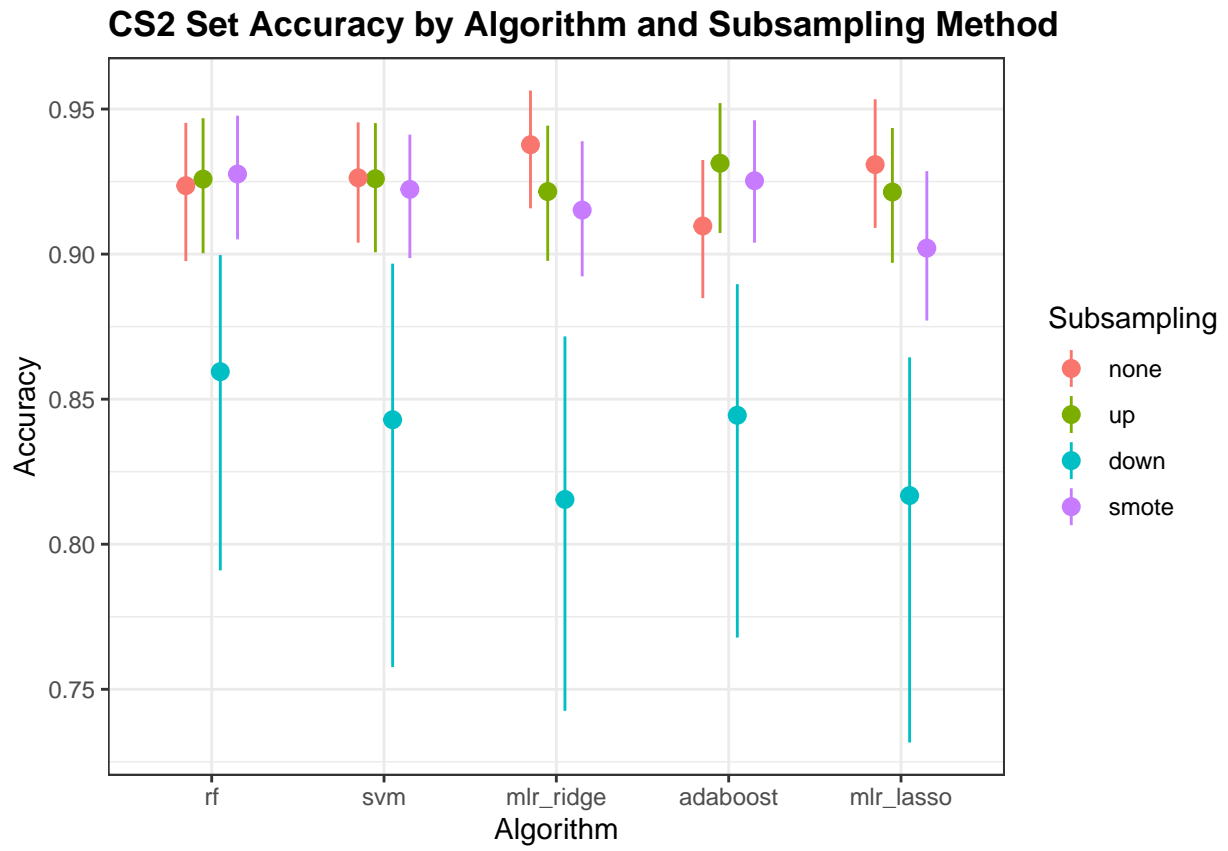


Figure 4.33: CS2 Set Accuracy

Table 4.32: CS2 Set Class-Specific Accuracy by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.984	0.981	<b>0.987</b>	0.983	0.983
none	ENOC	0.974	0.981	0.98	0.967	0.977
none	HGSC	0.931	0.936	0.949	0.913	0.946
none	LGSC	0.977	0.977	0.977	0.976	0.975
none	MUC	0.983	0.977	0.983	0.981	0.981
up	CCOC	0.986	0.98	0.986	0.986	0.984
up	ENOC	0.977	0.98	0.969	0.98	0.969
up	HGSC	0.931	0.933	0.938	0.941	0.941
up	LGSC	0.977	0.98	0.972	0.977	0.972
up	MUC	0.981	0.977	0.98	0.981	0.979
down	CCOC	0.98	0.956	0.977	0.979	0.97
down	ENOC	0.96	0.958	0.954	0.959	0.943
down	HGSC	0.879	0.867	0.842	0.866	0.844
down	LGSC	0.948	0.954	0.921	0.939	0.922
down	MUC	0.956	0.961	0.947	0.951	0.963
smote	CCOC	0.984	0.979	0.986	0.984	0.981
smote	ENOC	0.976	0.98	0.966	0.976	0.961
smote	HGSC	0.943	0.934	0.933	0.941	0.923
smote	LGSC	0.979	0.98	0.97	0.979	0.964
smote	MUC	0.974	0.973	0.978	0.972	0.976

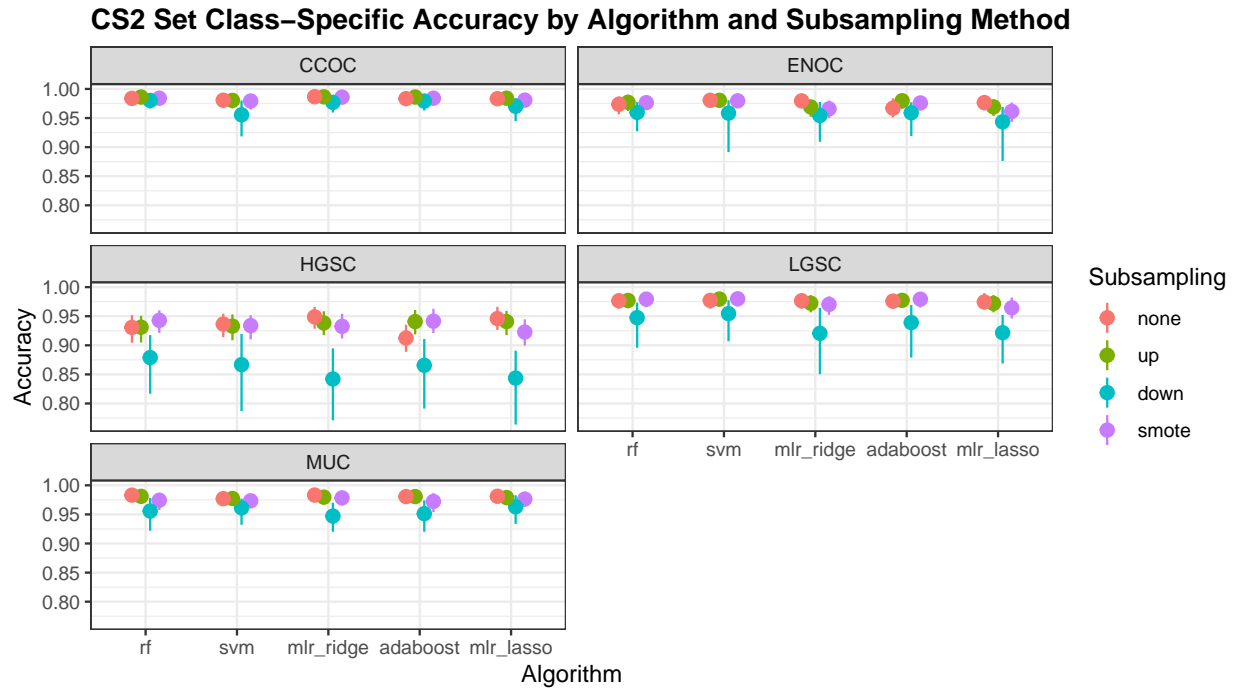


Figure 4.34: CS2 Set Class-Specific Accuracy

Table 4.33: CS2 Set Macro-Averaged F1-Score by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.714	0.766	0.757	0.751	0.745
up	0.722	0.755	<b>0.784</b>	0.741	0.761
down	0.703	0.675	0.656	0.68	0.645
smote	0.782	0.758	0.771	0.775	0.741

#### 4.4.2 F1-Score

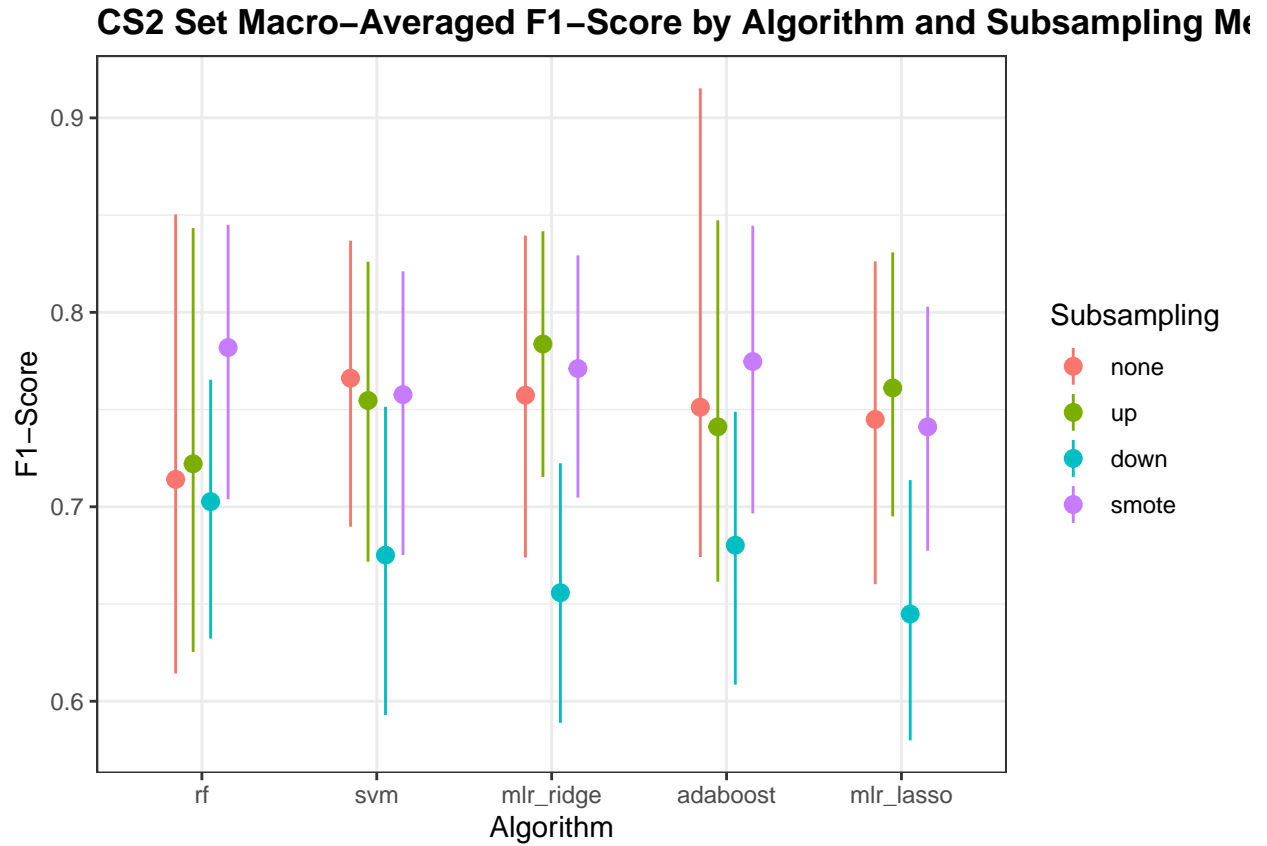


Figure 4.35: CS2 Set F1-Score

Table 4.34: CS2 Set Class-Specific F1-Score by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.889	0.857	0.903	0.875	0.884
none	ENOC	0.471	0.706	0.667	0.267	0.632
none	HGSC	0.958	0.961	<b>0.968</b>	0.948	0.966
none	LGSC	0.222	0.5	0.375	0.286	0.4
none	MUC	0.882	0.835	0.885	0.865	0.878
up	CCOC	0.895	0.848	0.909	0.895	0.895
up	ENOC	0.556	0.696	0.609	0.632	0.6
up	HGSC	0.958	0.959	0.96	0.963	0.962
up	LGSC	0.25	0.5	0.583	0.286	0.522
up	MUC	0.87	0.833	0.864	0.87	0.857
down	CCOC	0.87	0.755	0.844	0.857	0.809
down	ENOC	0.556	0.538	0.5	0.533	0.444
down	HGSC	0.919	0.909	0.89	0.909	0.893
down	LGSC	0.432	0.452	0.343	0.389	0.333
down	MUC	0.745	0.75	0.717	0.724	0.768
smote	CCOC	0.895	0.842	0.9	0.895	0.872
smote	ENOC	0.667	0.667	0.588	0.667	0.556
smote	HGSC	0.963	0.959	0.957	0.963	0.95
smote	LGSC	0.556	0.533	0.558	0.571	0.5
smote	MUC	0.837	0.811	0.857	0.824	0.842

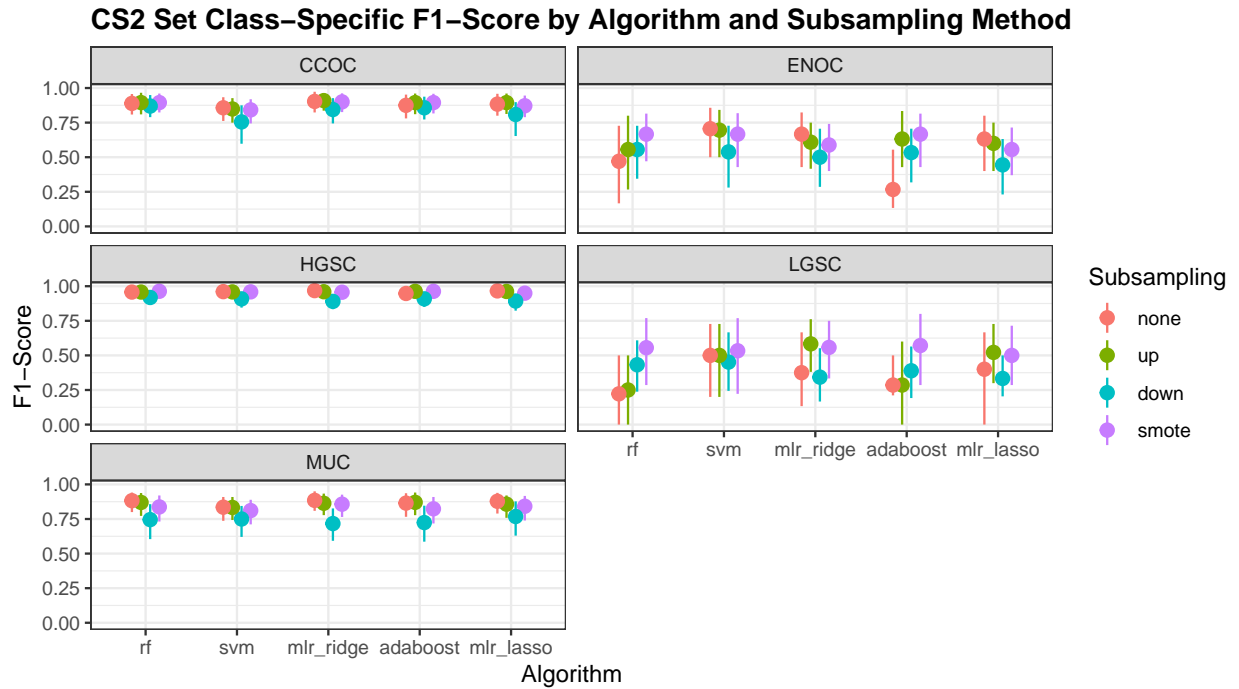


Figure 4.36: CS2 Set Class-Specific F1-Score

Table 4.35: CS2 Set Kappa by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.761	0.779	<b>0.811</b>	0.703	0.799
up	0.764	0.767	0.798	0.794	0.789
down	0.676	0.641	0.605	0.646	0.602
smote	0.802	0.766	0.781	0.797	0.75

#### 4.4.3 Kappa

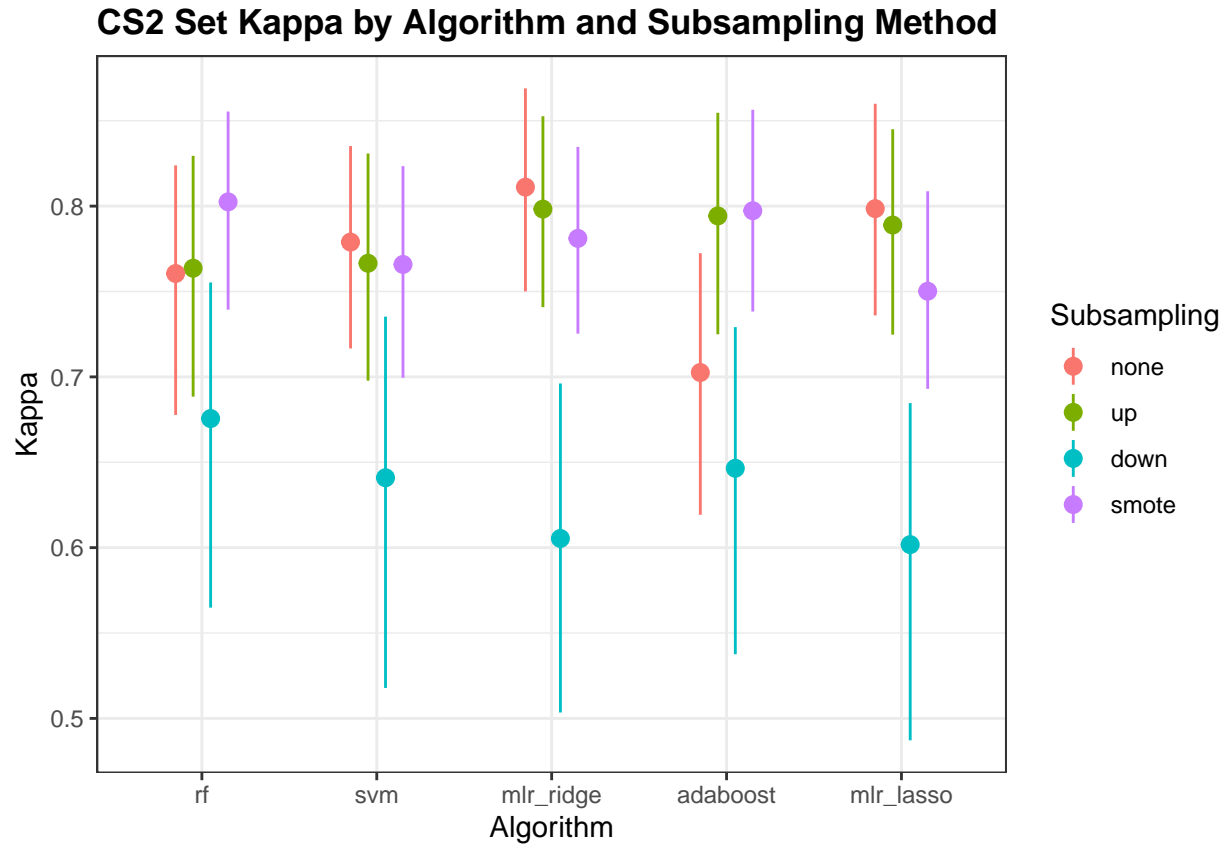


Figure 4.37: CS2 Set Kappa

Table 4.36: CS2 Set Class-Specific Kappa by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.88	0.848	0.896	0.868	0.874
none	ENOC	0.459	0.697	0.655	0.191	0.62
none	HGSC	0.767	0.794	0.834	0.692	0.828
none	LGSC	0.148	0.486	0.357	0	0.39
none	MUC	0.873	0.823	0.875	0.856	0.869
up	CCOC	0.888	0.839	<b>0.902</b>	0.888	0.885
up	ENOC	0.544	0.684	0.594	0.622	0.586
up	HGSC	0.764	0.775	0.823	0.806	0.823
up	LGSC	0.214	0.486	0.568	0.264	0.506
up	MUC	0.86	0.823	0.853	0.859	0.842
down	CCOC	0.859	0.732	0.832	0.847	0.792
down	ENOC	0.533	0.516	0.484	0.512	0.414
down	HGSC	0.688	0.656	0.617	0.659	0.617
down	LGSC	0.41	0.429	0.314	0.364	0.306
down	MUC	0.722	0.729	0.687	0.696	0.747
smote	CCOC	0.888	0.832	0.893	0.887	0.863
smote	ENOC	0.655	0.655	0.568	0.651	0.54
smote	HGSC	0.829	0.786	0.81	0.825	0.781
smote	LGSC	0.542	0.523	0.544	0.561	0.484
smote	MUC	0.824	0.797	0.845	0.808	0.831

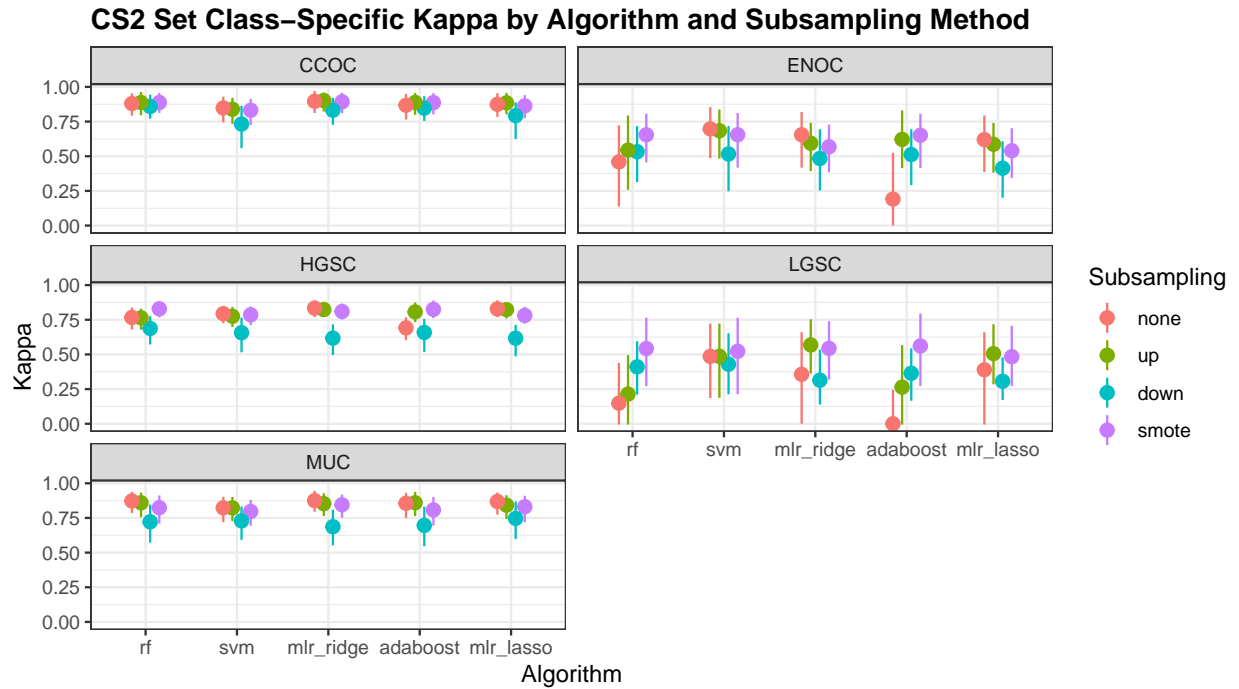


Figure 4.38: CS2 Set Class-Specific Kappa

Table 4.37: CS2 Set G-mean by Algorithm and Subsampling Method

sampling	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	0.363	0.693	0.649	0	0.657
up	0.499	0.652	<b>0.841</b>	0.576	0.773
down	0.829	0.802	0.808	0.811	0.792
smote	0.775	0.685	0.835	0.763	0.806

#### 4.4.4 G-mean

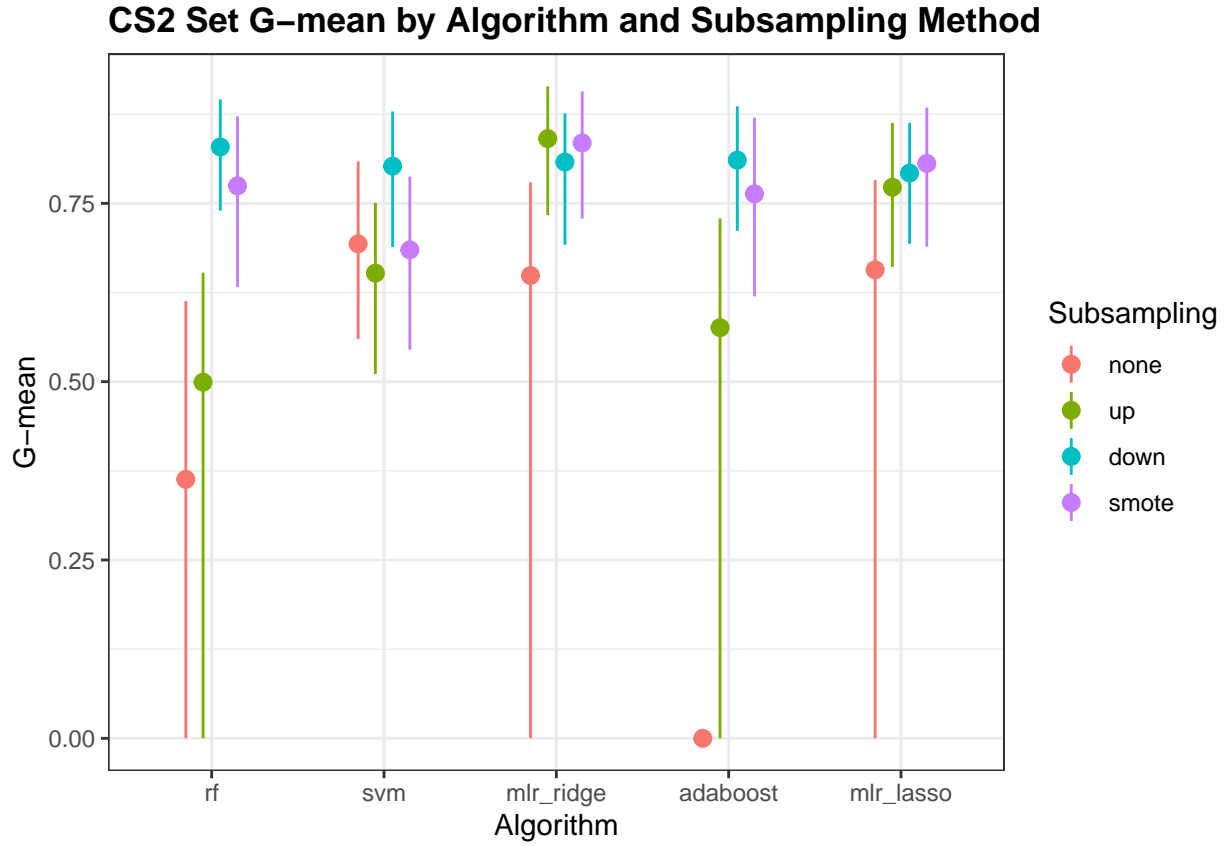


Figure 4.39: CS2 Set G-mean



Table 4.38: CS2 Set Class-Specific G-mean by Algorithm and Subsampling Method

sampling	histotype	rf	svm	mlr_ridge	adaboost	mlr_lasso
none	CCOC	0.913	0.891	0.933	0.889	0.928
none	ENOC	0.576	0.78	0.739	0.333	0.742
none	HGSC	0.83	0.866	0.889	0.773	0.894
none	LGSC	0.301	0.698	0.535	0	0.574
none	MUC	0.921	0.879	0.931	0.898	0.93
up	CCOC	0.911	0.866	<b>0.96</b>	0.931	0.943
up	ENOC	0.62	0.755	0.812	0.707	0.795
up	HGSC	0.828	0.84	0.937	0.871	0.921
up	LGSC	0.354	0.629	0.903	0.408	0.791
up	MUC	0.911	0.87	0.941	0.934	0.92
down	CCOC	0.958	0.936	0.928	0.947	0.918
down	ENOC	0.827	0.827	0.807	0.803	0.795
down	HGSC	0.904	0.888	0.881	0.893	0.878
down	LGSC	0.896	0.887	0.887	0.885	0.883
down	MUC	0.916	0.88	0.92	0.914	0.901
smote	CCOC	0.957	0.885	0.957	0.954	0.942
smote	ENOC	0.811	0.739	0.815	0.79	0.805
smote	HGSC	0.922	0.861	0.932	0.92	0.921
smote	LGSC	0.751	0.703	0.891	0.75	0.853
smote	MUC	0.935	0.877	0.934	0.929	0.919

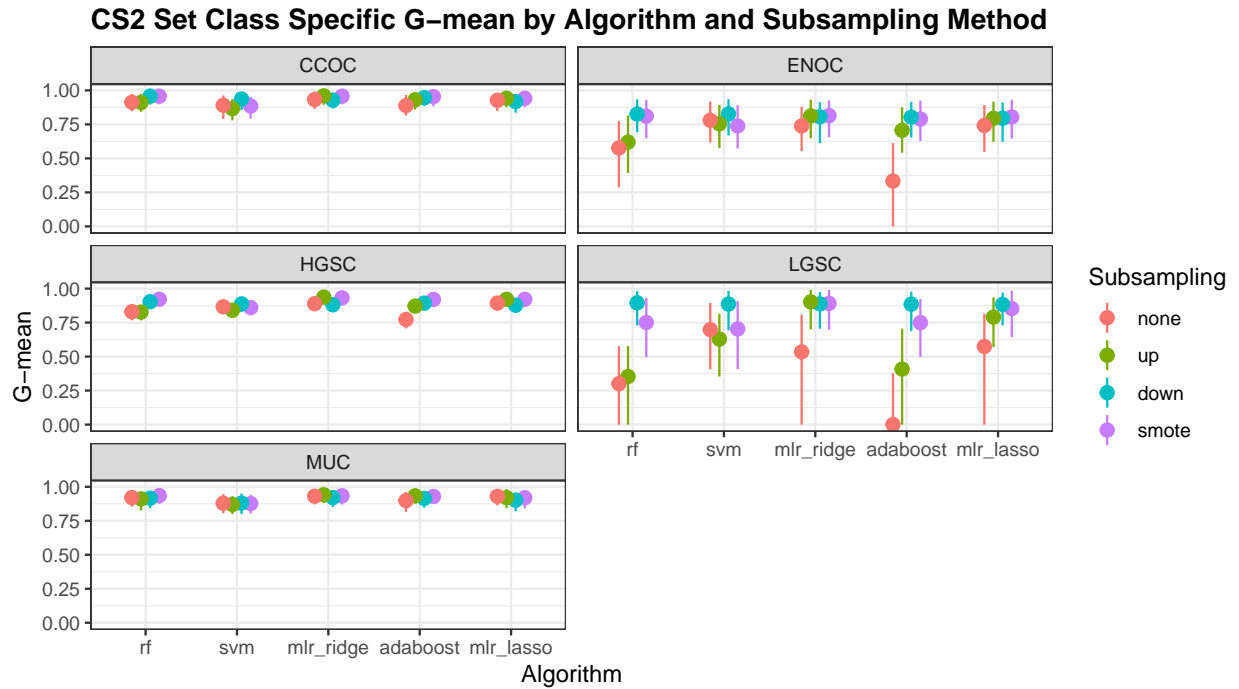


Figure 4.40: CS2 Set Class-Specific G-mean

Table 4.39: SMOTE Kappa by Algorithm and Dataset

dataset	rf	svm	mlr_ridge	adaboost	mlr_lasso
Training	<b>0.843</b>	0.816	0.782	0.821	0.769
CS1	0.777	0.768	0.767	0.766	0.746
CS2	0.802	0.766	0.781	0.797	0.75

## 4.5 SMOTE Kappa Summary

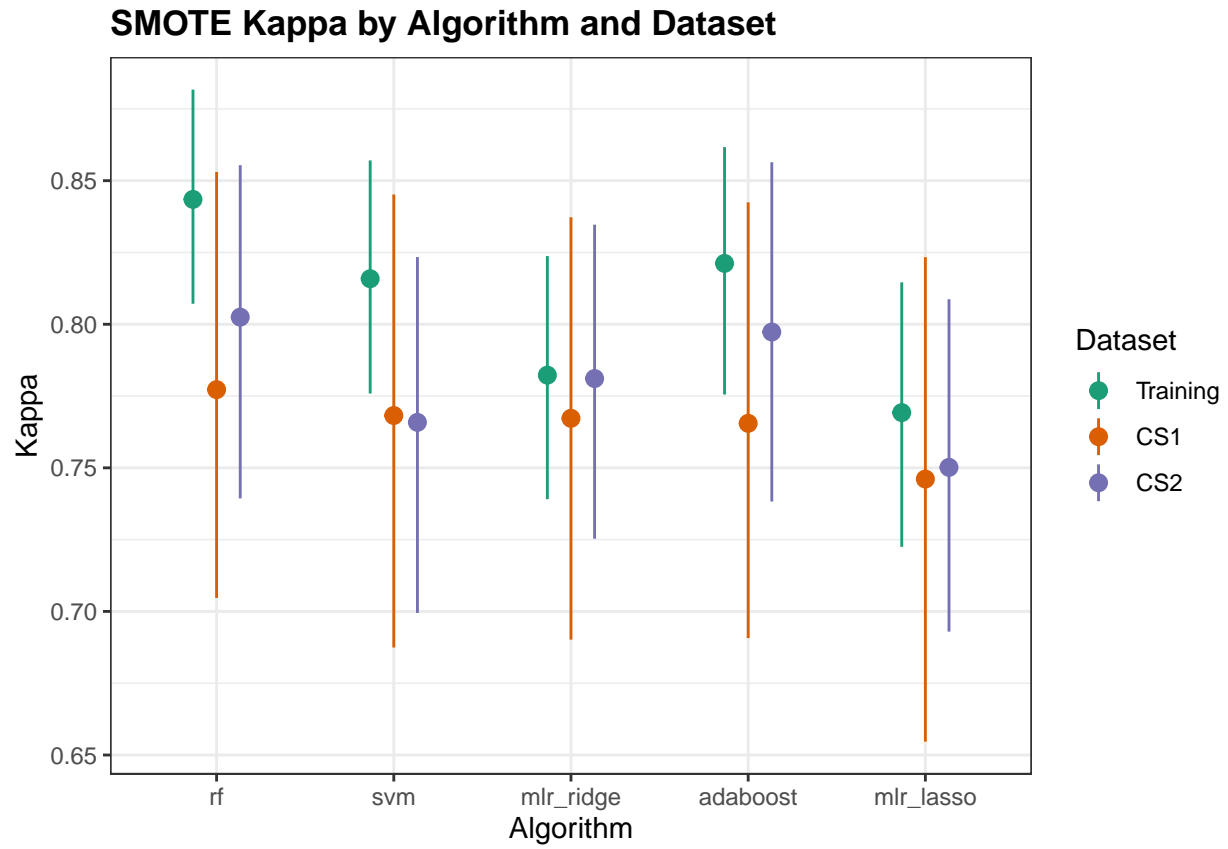


Figure 4.41: SMOTE Kappa by Algorithm and Dataset

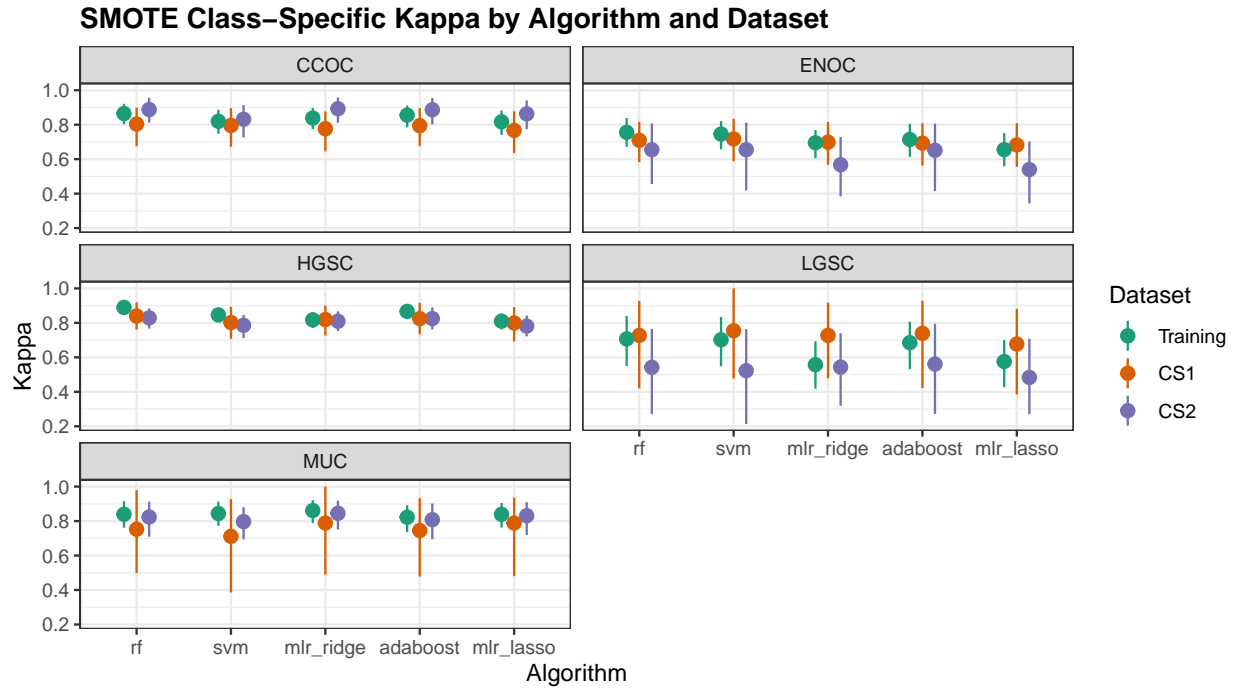


Figure 4.42: SMOTE Class-Specific Kappa by Algorithm and Dataset

## 4.6 Overlap with SPOT

There are 13 genes out of the 72 classifier set that overlap with the SPOT signature: HIF1A, CXCL10, DUSP4, SOX17, MITF, CDKN3, BRCA2, CEACAM5, ANXA4, SERPINE1, TCF7L1, CRABP2, DNAJC9.



## 4.7 Rank Aggregation

Show  entries

Search:

F1-Score Summary by Model and Class					
model	CCOC	ENOC	HGSC	LGSC	MUC
<input type="text" value="All"/>	<input type="text" value="All"/>	<input type="text" value="All"/>	<input type="text" value="All"/>	<input type="text" value="All"/>	<input type="text" value="All"/>
2S-rf-none	0.927	0.839	0.975	0.875	0.892
sequential-up	0.911	0.97	0.973	0.929	0.889
sequential-none	0.909	0.972	0.973	0.933	0.897
sequential-down	0.905	0.971	0.964	0.933	0.897
sequential-smote	0.907	0.97	0.973	0.933	0.897
2S-rf-up	0.925	0.844	0.975	0.875	0.896
2S-svm-up	0.894	0.853	0.973	0.914	0.885
2S-svm-smote	0.889	0.852	0.972	0.909	0.88
2S-rf-smote	0.919	0.839	0.974	0.875	0.889
2S-mlr_ridge-up	0.892	0.833	0.962	0.87	0.909
2S-adaboost-up	0.909	0.831	0.974	0.871	0.882
2S-svm-none	0.894	0.853	0.973	0.917	0.885
2S-mlr_ridge-none	0.899	0.833	0.968	0.889	0.912
2S-mlr_ridge-smote	0.894	0.833	0.966	0.867	0.909
2S-svm-down	0.88	0.829	0.963	0.909	0.875
2S-adaboost-down	0.9	0.806	0.964	0.867	0.871
2S-adaboost-smote	0.911	0.829	0.971	0.88	0.871
2S-adaboost-none	0.914	0.825	0.971	0.889	0.887
adaboost-up	0.873	0.765	0.976	0.667	0.857
2S-mlr_lasso-none	0.9	0.825	0.967	0.867	0.896
2S-mlr_ridge-down	0.892	0.828	0.959	0.857	0.9
2S-rf-down	0.909	0.824	0.964	0.867	0.871
2S-mlr_lasso-smote	0.901	0.825	0.965	0.865	0.883
rf-none	0.875	0.733	0.969	0.375	0.873
rf-smote	0.873	0.769	0.977	0.714	0.849
svm-none	0.857	0.776	0.971	0.667	0.857
mlr_ridge-none	0.871	0.758	0.97	0.37	0.885
rf-up	0.873	0.776	0.971	0.526	0.877
adaboost-smote	0.865	0.732	0.972	0.692	0.833
adaboost-none	0.862	0.702	0.961	0.167	0.857
2S-mlr_lasso-down	0.897	0.808	0.956	0.839	0.857
mlr_ridge-smote	0.85	0.716	0.959	0.571	0.868
svm-smote	0.831	0.762	0.969	0.71	0.851
mlr_lasso-none	0.865	0.734	0.971	0.483	0.862
mlr_ridge-up	0.846	0.675	0.948	0.545	0.862
mlr_lasso-smote	0.83	0.676	0.957	0.588	0.847
2S-mlr_lasso-up	0.897	0.825	0.96	0.857	0.892
svm-up	0.836	0.754	0.971	0.72	0.846
mlr_ridge-down	0.829	0.625	0.92	0.418	0.841
rf-down	0.849	0.645	0.934	0.481	0.8
adaboost-down	0.837	0.617	0.929	0.473	0.771
mlr_lasso-up	0.8	0.646	0.958	0.615	0.821
svm-down	0.781	0.639	0.931	0.519	0.8
mlr_lasso-down	0.805	0.602	0.907	0.377	0.785

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Table 4.40: Class-specific F1-scores on Confirmation Sets

method	HGSC	CCOC	ENOC	LGSC	MUC
2S-rf-none	0.915	0.874	0.772	0.419	0.745
sequential-none	0.902	0.910	0.917	0.485	0.711
2S-rf-smote	0.903	0.904	0.784	0.400	0.667
sequential-smote	0.907	0.923	0.921	0.556	0.800
rf-none	0.899	0.881	0.533	0.133	0.760

The 44 methods (algorithm-sampling combinations) are ordered in the table by their aggregated ranks using the Genetic Algorithm. We see that the best performing methods involve the 2-stage and sequential algorithms.

## 4.8 Test Set Performance

Now we'd like to see how our best methods perform in the confirmation and validation sets. The class-specific F1-scores will be used.

The top 4 methods are:

- **2S-rf-none**: 2-step method using random forest algorithm with no subsampling
- **sequential-up**: sequential algorithm with upsampling. The sequence of models and algorithms used are:
  - HGSC vs. non-HGSC using adaboost
  - MUC vs. non-MUC using random forest
  - CCOC vs. non-CCOC using random forest
  - ENOC vs. LGSC using random forest
- **sequential-none**: sequential algorithm with no subsampling. The sequence of models and algorithms used are:
  - HGSC vs. non-HGSC using SVM
  - MUC vs. non-MUC using ridge regression
  - CCOC vs. non-CCOC using random forest
  - ENOC vs. LGSC using SVM
- **sequential-down**: sequential algorithm with downsampling. The sequence of models and algorithms used are:
  - HGSC vs. non-HGSC using random forest
  - CCOC vs. non-CCOC using random forest
  - MUC vs. non-MUC using ridge regression
  - ENOC vs. LGSC using random forest

As a comparison we also show the F1-scores from the **rf-none** to see how the best methods improve from it.

### 4.8.1 Confirmation Set

In the confirmation set, **2S-rf-none** improves drastically in LGSC classification compared to **rf-none**, with moderate improvement in ENOC, and minor improvement in HGSC and CCOC. There is a decrease in MUC performance. **sequential-none** improves on **2S-rf-none** in all classes except for marginal decrease in HGSC performance.

Table 4.41: Class-specific F1-scores on Validation Sets

method	HGSC	CCOC	ENOC	LGSC	MUC
2S-rf-none	0.938	0.946	0.899	0.811	0.764
sequential-none	0.948	0.963	0.963	0.789	0.784
2S-rf-smote	0.933	0.940	0.882	0.750	0.778
sequential-smote	0.940	0.951	0.967	0.821	0.821
rf-none	0.929	0.857	0.630	0.182	0.727

#### 4.8.2 Validation Set

Similarly in the validation set, **2S-rf-none** improves drastically in LGSC classification compared to **rf-none**, with large improvement in ENOC, and minor improvement in HGSC and CCOC. There is a decrease in MUC performance. **sequential-none** improves on **2S-rf-none** in all classes except for a small decrease in CCOC performance and same performance for LGSC.