Electronic supplementary material for: **Quantifying pixel- and patch-scale Spartina patens dynamics during salt marsh restoration using multispectral UAV imagery**

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Figures/Tables (supplemental)

Table S1. Image acquisition details

Table S2. Predictor variables and feature sets

Table S3. Restoration East OOB confusion matrix (2020)

Table S4. Restoration East OOB confusion matrix (2021)

Table S5. Restoration East OOB confusion matrix (2022)

Table S6. Restoration West OOB confusion matrix (2020)

Table S7. Restoration West OOB confusion matrix (2021)

Table S8. Restoration West OOB confusion matrix (2022)

Table S9. Restoration East independent validation matrix (2020)

Table S10. Restoration East independent validation matrix (2021)

Table S11. Restoration East independent validation matrix (2022)

Table S12. Restoration West independent validation matrix (2020)

Table S13. Restoration West independent validation matrix (2021)

Table S14. Restoration West independent validation matrix (2022)

Figure S1. Top-10 predictor variable importance in Restoration East

Figure S2. Top-10 predictor variable importance in Restoration West

Table S15. Percent classified pixels by class and year

Table S16. Class-specific temporal persistence

Table S17. East transition matrix (2020–2021)

Table S18. East transition matrix (2021–2022)

Table S19. East transition matrix (2020–2022)

Table S20. West transition matrix (2020–2021)

Table S21. West transition matrix (2021–2022)

Table S22. West transition matrix (2020–2022)

Figure S3. *S. patens* gains and losses within patch buffer zones

Table S23. Highest-ranked predictor summary

Figure S4. Top 20 predictors (*S. patens* vs. *S. alterniflora* Dense, Restoration East, 2020)

Figure S5. Top 20 predictors (*S. patens* vs. Dense, Restoration East, 2021)

Figure S6. Top 20 predictors (*S. patens* vs. Dense, Restoration East, 2022)

Figure S7. Top 20 predictors (*S. patens* vs. Dense, Restoration West, 2020)

Figure S8. Top 20 predictors (*S. patens* vs. Dense, Restoration West, 2021)

Figure S9. Top 20 predictors (*S. patens* vs. Dense, Restoration West, 2022)

Figure S10. Top 20 predictors (*S. patens* vs. Sparse, Restoration East, 2020)

Figure S11. Top 20 predictors (*S. patens* vs. Sparse, Restoration East, 2021)

Figure S12. Top 20 predictors (*S. patens* vs. Sparse, Restoration East, 2022)

Figure S13. Top 20 predictors (*S. patens* vs. Sparse, Restoration West, 2020)

Figure S14. Top 20 predictors (*S. patens* vs. Sparse, Restoration West, 2021)

Figure S15. Top 20 predictors (*S. patens* vs. Sparse, Restoration West, 2022)

Figure S16. Representative top 12 predictor distributions for *S. patens* and *S. alterniflora*

Table S1. Summary of drone imagery acquisition details for salt marsh restoration sites East and West in Aulac, New Brunswick, from 2020 to 2022, including flight timing, environmental conditions, and acquisition parameters.

Date	Site	Flight Start Time	Tidal Height (m)	Cloud cover (%)	Solar Azimuth (°)	Solar Altitude (°)	UAV Course Angle (°)
6/16/2020	East	11:25	2.8	0%	125	56	330
	West	10:40	3.3	0%	112	49	308
7/11/2020	East	10:20	7.3	75-95%	115	40	330
	West	11:00	6.5	75-95%	125	46	308
8/13/2020	East	14:40	4.1	0%	223	62	330
	West	15:30	3.7	0%	240	55	308
6/13/2021	East	12:38	10.1	5-10%	159	58	218
	West	11:14	6.9	5-10%	128	50	218
7/12/2021	East	11:47	7.1	100%	133	59	60
	West	13:05	9.9	100%	170	66	230
8/10/2021	East	13:35	9.7	100%	190	67	60
	West	12:33	7.9	100%	155	66	230
6/7/2022	East	11:38	2.9	0%	138	51	260
	West	10:47	1.1	0%	122	44	220
7/4/2022	East	11:59	2.9	25%	136	61	215
	West	13:20	5.4	25%	179	67	270
8/16/2022	East	12:45	2.5	0%	162	66	230
	West	10:26	5.3	0%	109	49	224

Table S2. Predictor variables derived from multispectral drone imagery and used in Random Forest classification. Spectral reflectance bands, vegetation indices, and textural features were calculated for each image acquisition.

Category	Variable Names	Description
MicaSense reflectance bands	Blue444, Blue475, Green531, Green560, Red650, Red668, RedEdge705, RedEdge,717, RedEdge740, NIR842.	Raw reflectance bands from MicaSense Dual Camera System. Each name includes electromagnetic wavelength.
Spectral indices	Normalized Difference Vegetation Index (NDVI), Normalized Difference Aquatic Vegetation Index (NDAVI), Green Normalized Difference Vegetation Index (GNDVI), Normalized Difference Red Edge Index (NDRE), Normalized Green Index (NG), Difference Vegetation Index (DVI), Green Difference Vegetation Index (GDVI), Normalized Red Index (NR), Normalized Near-Infrared Index (NNIR), Green Ratio Vegetation Index (GRVI), Red Ratio Vegetation Index (RVI), Red Edge Ratio Vegetation Index (RERVI), Water Adjusted Vegetation Index (WAVI).	Derived from MicaSense reflectance bands to capture vegetation greenness, pigment content, structure, and aquatic vegetation presence.
Textural features	Homogeneity, Contrast, Dissimilarity, Entropy, Angular second moment, Angular correlation, Mean, Standard deviation, GLDV angular second moment, GLDV entropy	Derived from MicaSense reflectance bands using GLCM and GLDV methods to quantify spatial variation, texture complexity, and structural heterogeneity in salt marsh vegetation.

Table S3. Out-of-bag (OOB) confusion matrix for the Random Forest classification of the Restoration East site in Aulac for 2020. Values represent predicted pixel counts relative to reference class labels. Summary metrics include user's accuracy (UA), producer's accuracy (PA), error of omission (EO), error of commission (EC), overall accuracy, average accuracy, and the Kappa coefficient. See Table 1 for full land cover class names and descriptions.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**2463**	0	1	1	1	0	1	2467	99.8	0.2
2. *S. alterniflora* - Dense	0	**8102**	13	1	0	0	0	8116	99.8	0.2
3. *S. alterniflora* - Sparse	0	13	**4006**	0	1	0	2	4022	99.6	0.4
4. *S. pectinata* - Dike edge	4	1	2	**2611**	0	0	1	2619	99.7	0.3
5. Mud	0	0	0	0	**5281**	5	0	5286	99.9	0.1
6. Rock	0	0	0	0	4	**2636**	3	2643	99.7	0.3
7. Wrack	0	0	1	0	2	2	**1772**	1777	99.7	0.3
Total	2467	8116	4023	2613	5289	2643	1779	26930		
UA (%)	99.8	99.8	99.6	99.9	99.8	99.7	99.6			
EC (%)	0.2	0.2	0.4	0.1	0.2	0.3	0.4			
Average accuracy (%)	99.8									
Overall accuracy (%)	99.8									
Kappa coefficient	0.997									

Table S4. Out-of-bag (OOB) confusion matrix for the Random Forest classification of the Restoration East site in Aulac for 2021. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**2514**	7	2	5	1	0	0	2529	99.4	0.6
2. *S. alterniflora* - Dense	0	**7917**	6	0	0	0	0	7923	99.9	0.1
3. *S. alterniflora* - Sparse	1	6	**3996**	0	0	1	0	4004	99.8	0.2
4. *S. pectinata* - Dike edge	3	5	0	**2725**	0	0	1	2734	99.7	0.3
5. Mud	0	0	0	0	**4588**	5	0	4593	99.9	0.1
6. Rock	0	0	0	1	6	**2466**	2	2475	99.6	0.4
7. Wrack	0	0	0	0	0	12	**1806**	1818	99.3	0.7
Total	2518	7935	4004	2731	4595	2484	1809	26076		
UA (%)	99.8	99.8	99.8	99.8	99.8	99.3	99.8			
EC (%)	0.2	0.2	0.2	0.2	0.2	0.7	0.2			
Average accuracy (%)	99.7									
Overall accuracy (%)	99.7									
Kappa coefficient	0.997									

Table S5. Out-of-bag (OOB) confusion matrix for the Random Forest classification of the Restoration East site in Aulac for 2022. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**2591**	1	0	0	0	0	0	2592	100	0
2. *S. alterniflora* - Dense	1	**7320**	8	0	0	0	0	7329	99.9	0.1
3. *S. alterniflora* - Sparse	1	15	**4217**	0	0	0	0	4233	99.6	0.4
4. *S. pectinata* - Dike edge	1	1	0	**3118**	0	0	0	3120	99.9	0.1
5. Mud	0	0	0	0	**5015**	1	0	5016	100	0
6. Rock	0	0	0	0	1	**2675**	1	2677	99.9	0.1
7. Wrack	0	0	0	0	0	4	**1818**	1822	99.8	0.2
Total	2594	7337	4225	3118	5016	2680	1819	26789		
UA (%)	99.9	99.8	99.8	100	99.9	99.8	99.9			
EC (%)	0.1	0.2	0.2	0	0.1	0.2	0.1			
Average accuracy (%)	99.9									
Overall accuracy (%)	99.9									
Kappa coefficient	0.999									

Table S6. Out-of-bag (OOB) confusion matrix for the Random Forest classification of the Restoration West site in Aulac for 2020. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**1136**	0	0	5	0	0	0	1141	99.6	0.4
2. *S. alterniflora* - Dense	0	**6601**	22	0	0	0	0	6623	99.7	0.3
3. *S. alterniflora* - Sparse	0	8	**7239**	0	0	4	0	7251	99.8	0.2
4. *S. pectinata* - Dike edge	2	1	0	**1939**	0	0	0	1942	99.8	0.2
5. Mud	0	0	0	0	**3636**	2	0	3638	99.9	0.1
6. Rock	0	1	0	0	0	**3710**	0	3711	100	0
7. Wrack	0	0	0	0	0	9	**2095**	2104	99.6	0.4
Total	1138	6611	7261	1944	3636	3725	2095	26410		
UA (%)	99.8	99.8	99.7	99.7	100	99.6	100			
EC (%)	0.2	0.2	0.3	0.3	0	0.4	0			
Average accuracy (%)	99.8									
Overall accuracy (%)	99.8									
Kappa coefficient	0.997									

Table S7. Out-of-bag (OOB) confusion matrix for the Random Forest classification of the Restoration West site in Aulac for 2021. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**1504**	7	1	2	0	0	0	1514	99.3	0.7
2. *S. alterniflora* - Dense	0	**9390**	8	0	0	0	0	9398	99.9	0.1
3. *S. alterniflora* - Sparse	0	22	**4144**	0	0	1	0	4167	99.4	0.6
4. *S. pectinata* - Dike edge	0	0	0	**1932**	0	0	0	1932	100	0
5. Mud	0	0	0	0	**3323**	5	0	3328	99.8	0.2
6. Rock	0	0	2	0	3	**3041**	1	3047	99.8	0.2
7. Wrack	0	0	1	1	0	11	**2262**	2275	99.4	0.6
Total	1504	9419	4156	1935	3326	3058	2263	25661		
UA (%)	100	99.7	99.7	99.8	99.9	99.4	100			
EC (%)	0	0.3	0.3	0.2	0.1	0.6	0			
Average accuracy (%)	99.7									
Overall accuracy (%)	99.7									
Kappa coefficient	0.997									

Table S8. Out-of-bag (OOB) confusion matrix for the Random Forest classification of the Restoration West site in Aulac for 2022. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**1699**	1	1	1	0	0	0	1702	99.8	0.2
2. *S. alterniflora* - Dense	0	**7937**	5	0	0	0	0	7942	99.9	0.1
3. *S. alterniflora* - Sparse	0	9	**6348**	0	1	1	0	6359	99.8	0.2
4. *S. pectinata* - Dike edge	0	0	0	**1826**	0	0	0	1826	100	0
5. Mud	0	0	1	0	**3296**	0	0	3297	100	0
6. Rock	0	0	1	0	2	**3055**	0	3058	99.9	0.1
7. Wrack	0	0	0	0	0	3	**2496**	2499	99.9	0.1
Total	1699	7947	6356	1827	3299	3059	2496	26683		
UA (%)	100	99.9	99.9	99.9	99.9	99.9	100			
EC (%)	0	0.1	0.1	0.1	0.1	0.1	0			
Average accuracy (%)	99.9									
Overall accuracy (%)	99.9									
Kappa coefficient	0.999									

Table S9. Independent validation confusion matrix for the Random Forest classification of the Restoration East site in Aulac for 2020. Summarized in Table 2. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**1274**	63	48	336	30	0	36	1787	71.3	28.7
2. *S. alterniflora* - Dense	19	**4257**	107	119	0	0	0	4502	94.6	5.4
3. *S. alterniflora* - Sparse	105	169	**2371**	45	21	0	7	2718	87.2	12.8
4. *S. pectinata* - Dike edge	127	22	39	**1992**	0	0	0	2180	91.4	8.6
5. Mud	0	92	7	2	**3335**	10	18	3464	96.3	3.7
6. Rock	0	2	0	0	46	**1224**	137	1409	86.9	13.1
7. Wrack	0	0	33	9	5	28	**1125**	1200	93.8	6.3
Total	1525	4605	2605	2503	3437	1262	1323	17260		
UA (%)	83.5	92.4	91.0	79.6	97.0	97.0	85.0			
EC (%)	16.5	7.6	9.0	2.0	3.0	3.0	15.0			
Average accuracy (%)	89.1									
Overall accuracy (%)	90.3									
Kappa coefficient	0.882									

Table S10. Independent validation confusion matrix for the Random Forest classification of the Restoration East site in Aulac for 2021. Summarized in Table 2. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**1511**	51	11	257	6	0	0	1836	82.3	17.7
2. *S. alterniflora* - Dense	11	**5181**	63	101	0	0	0	5356	96.7	3.3
3. *S. alterniflora* - Sparse	68	50	**2431**	54	38	0	1	2642	92.0	8.0
4. *S. pectinata* - Dike edge	91	23	3	**2051**	2	0	0	2170	94.5	5.5
5. Mud	0	0	0	0	**3895**	88	12	3995	97.5	2.5
6. Rock	0	0	1	0	107	**1343**	38	1489	90.2	9.8
7. Wrack	6	0	10	4	7	3	**1073**	1103	97.3	2.7
Total	1687	5305	2519	2467	4055	1434	1124	18591		
UA (%)	89.6	97.7	96.5	83.1	96.1	93.7	95.5			
EC (%)	10.4	2.3	3.5	16.9	3.9	6.3	4.5			
Average accuracy (%)	93.0									
Overall accuracy (%)	94.1									
Kappa coefficient	0.927									

Table S11. Independent validation confusion matrix for the Random Forest classification of the Restoration East site in Aulac for 2022. Summarized in Table 2. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**1493**	20	122	51	0	0	3	1689	88.4	11.6
2. *S. alterniflora* - Dense	35	**4690**	60	107	0	0	0	4892	95.9	4.1
3. *S. alterniflora* - Sparse	25	84	**3191**	7	0	0	16	3323	96.0	4.0
4. *S. pectinata* - Dike edge	35	13	76	**1904**	0	0	0	2028	93.9	6.1
5. Mud	0	0	61	0	**3613**	69	44	3787	95.4	4.6
6. Rock	0	0	1	0	107	**1217**	23	1348	90.3	9.7
7. Wrack	0	0	15	1	7	5	**1002**	1030	97.3	2.7
Total	1588	4807	3526	2070	3727	1291	1088	18097		
UA (%)	94.0	97.6	90.5	92.0	96.9	94.3	92.1			
EC (%)	6.0	2.4	9.5	8.0	3.1	5.7	7.9			
Average accuracy (%)	93.9									
Overall accuracy (%)	94.5									
Kappa coefficient	0.933									

Table S12. Independent validation confusion matrix for the Random Forest classification of the Restoration West site in Aulac for 2020. Summarized in Table 3. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**657**	6	1	37	0	0		701	93.7	6.3
2. *S. alterniflora* - Dense	46	**3846**	75	35	0	17	2	4021	95.6	4.4
3. *S. alterniflora* - Sparse	35	82	**4215**	0	0	27	14	4373	96.4	3.6
4. *S. pectinata* - Dike edge	50	17	0	**1208**	0	0	3	1278	94.5	5.5
5. Mud	0	0	9	0	**1622**	35	9	1675	96.8	3.2
6. Rock	0	0	2	0	117	**1434**	123	1676	85.6	14.4
7. Wrack	4	0	13	3	42	24	**1107**	1193	92.8	7.2
Total	792	3951	4315	1283	1781	1537	1258	14917		
UA (%)	83.0	97.3	97.7	94.2	91.1	93.3	88.0			
EC (%)	17.0	2.7	2.3	5.8	8.9	6.7	12.0			
Average accuracy (%)	92.9									
Overall accuracy (%)	94.4									
Kappa coefficient	0.931									

Table S13. Independent validation confusion matrix for the Random Forest classification of the Restoration West site in Aulac for 2021. Summarized in Table 3. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**892**	12	16	78	0	0	0	998	89.4	10.6
2. *S. alterniflora* - Dense	9	**6031**	164	82	0	0	0	6286	95.9	4.1
3. *S. alterniflora* - Sparse	0	106	**2444**	0	2	17	0	2569	95.1	4.9
4. *S. pectinata* - Dike edge	60	77	8	**1082**	0	0	2	1229	88.0	12.0
5. Mud	0	0	6	0	**1884**	38	9	1937	97.3	2.7
6. Rock	0	0	79	0	71	**1953**	182	2285	85.5	14.5
7. Wrack	0	0	1	1	26	17	**1344**	1389	96.8	3.2
Total	961	6226	2718	1243	1983	2025	1537	16693		
UA (%)	92.8	96.9	89.9	87.0	95.0	96.4	87.4			
EC (%)	7.2	3.1	10.1	13.0	5.0	3.6	12.6			
Average accuracy (%)	92.4									
Overall accuracy (%)	93.6									
Kappa coefficient	0.919									

Table S14 Independent validation confusion matrix for the Random Forest classification of the Restoration West site in Aulac for 2022. Summarized in Table 3. Values, abbreviations, and summary metrics are defined in Table S3.

Class	1	2	3	4	5	6	7	Total	PA (%)	EO (%)
1. *Spartina patens*	**691**	40	3	30	0	0	0	764	90.4	9.6
2. *S. alterniflora* - Dense	55	**4295**	77	57	0	0	0	4484	95.8	4.2
3. *S. alterniflora* - Sparse	23	103	**4119**	0	1	0	0	4246	97.0	3.0
4. *S. pectinata* - Dike edge	58	46	2	**1162**	0	0	1	1269	91.6	8.4
5. Mud	0	0	39	0	**1941**	62	0	2042	95.1	4.9
6. Rock	0	0	7	0	72	**1893**	76	2048	92.4	7.6
7. Wrack	0	0	32	0	1	7	**1569**	1609	97.5	2.5
Total	827	4484	4279	1249	2015	1962	1646	16462		
UA (%)	83.6	95.8	96.3	93.0	96.3	96.5	95.3			
EC (%)	16.4	4.2	3.7	7.0	3.7	3.5	4.7			
Average accuracy (%)	94.0									
Overall accuracy (%)	95.2									
Kappa coefficient	0.941									

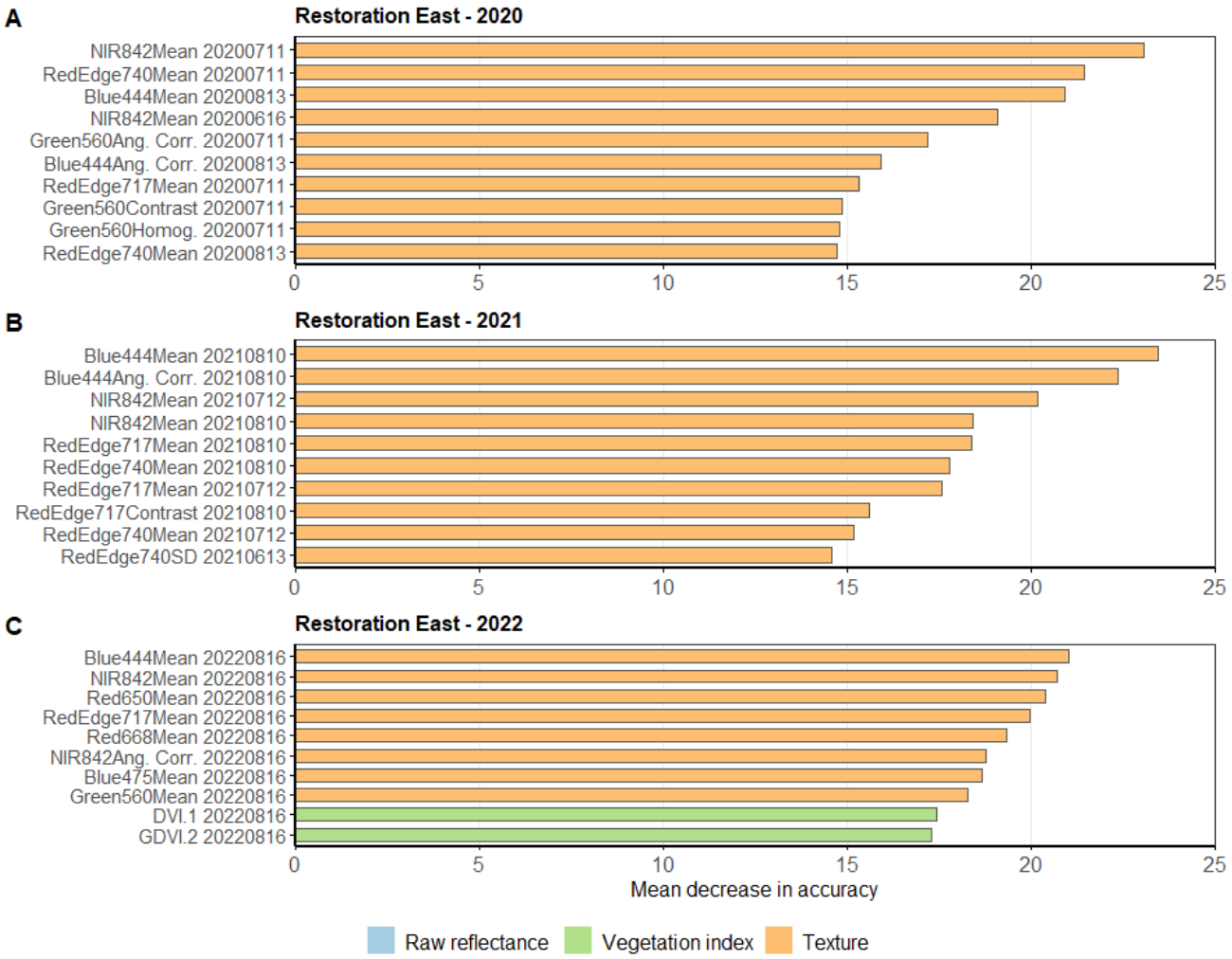

Figure S1. Top-ranked predictor variables in the Random Forest models used to generate the seven-class land-cover classifications for Restoration East, Aulac, in (A) 2020, (B) 2021, and (C) 2022. The corresponding classified maps are presented in Figure 5. Variable importance is expressed as mean decrease in accuracy, calculated as the average reduction in out-of-bag classification accuracy following random permutation of each predictor across all trees. Higher values indicate greater importance to overall classification performance across all land-cover classes.

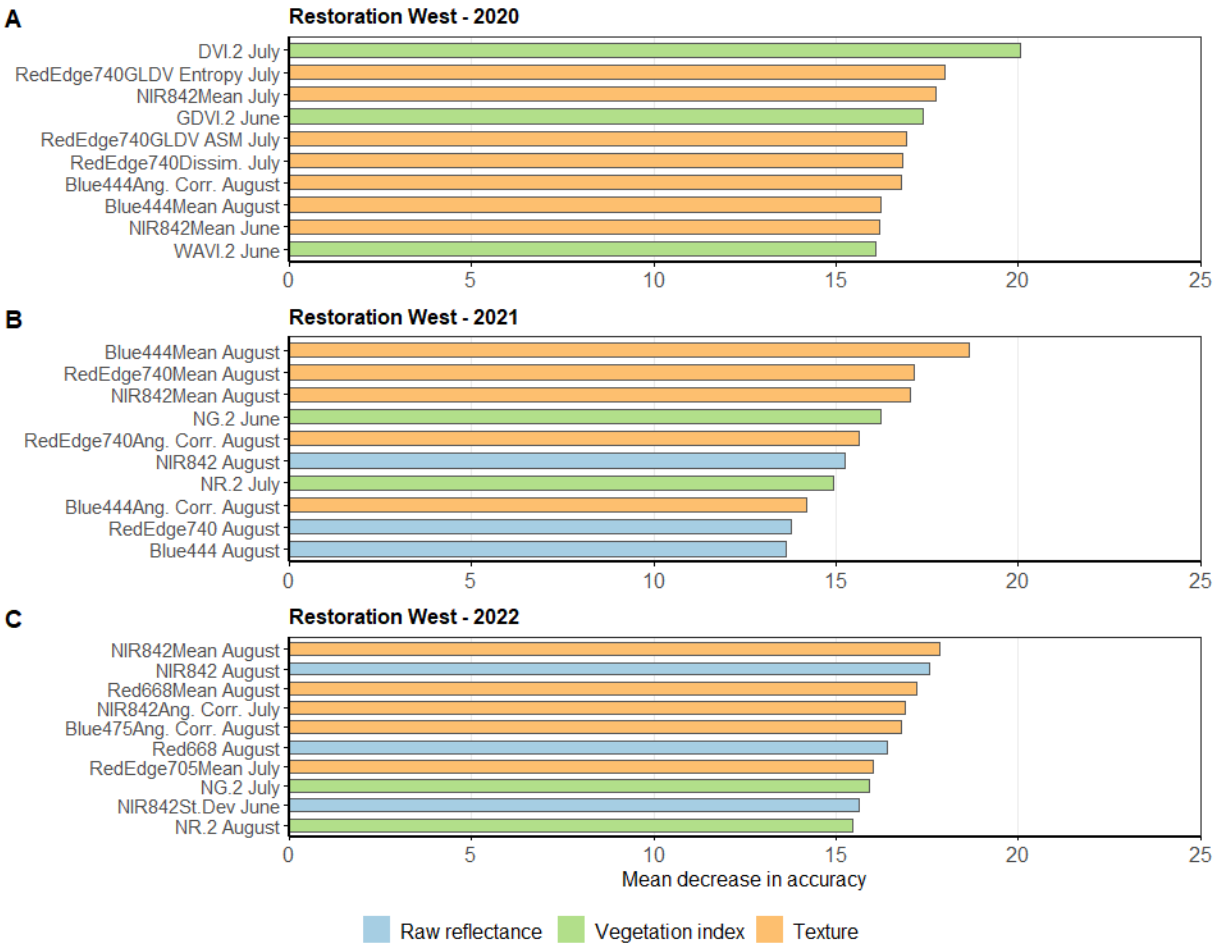

Figure S2. Top-ranked predictor variables in the Random Forest models used to generate the seven-class land-cover classifications for Restoration West, Aulac, in (A) 2020, (B) 2021, and (C) 2022. The corresponding classified maps are presented in Figure 6. Variable importance is expressed as mean decrease in accuracy, calculated as the average reduction in out-of-bag classification accuracy following random permutation of each predictor across all trees. Higher values indicate greater importance to overall classification performance across all land-cover classes.

Table S15. Percent of total classified pixels belonging to each vegetation or substrate class (see Table 1) for the classification at the Restoration East and Restoration West sites in Aulac (2020–2022). Total classified pixels were approximately18.3 million for Restoration East and 29.6 million for Restoration West in each year. Values are calculated within year and sum to 100% for each site-year combination. Results are summarized in Figure 7.

Site	Class	2020 (%)	2021(%)	2022 (%)
East	1	1.8	2.4	2.8
	2	35.7	37.2	30.4
	3	19.3	17.2	24.2
	4	1.9	1.9	2.1
	5	30.6	29.4	29.3
	6	8.1	8.1	7.9
	7	2.7	3.8	3.3
West	1	0.8	0.8	1.5
	2	31.6	54.6	38.4
	3	43.6	21.4	38.1
	4	1.4	1.4	1.4
	5	17.0	16.4	15.7
	6	4.6	4.2	3.3
	7	0.9	1.1	1.4

Table S16. Class-specific temporal persistence (%) in the annual land-cover classifications at Restoration East and Restoration West, Aulac. Persistence represents the percentage of pixels assigned to each land-cover class at the beginning of an interval that retained the same classification at the end of the interval (2020–2021, 2021–2022, and 2020–2022). Mean class persistence is the unweighted mean across the seven classes, and overall pixel agreement is the percentage of all classified pixels that retained the same class. Full class names and descriptions are provided in Table 1. This table supports the pixel-level transition results and complements Figures 8–10 and Tables S17–S22.

Site	Class	2020-2021 (%)	2021-2022 (%)	2020-2022(%)
East	1. *Spartina patens*	45.6	45.4	46.3
	2. *S. alterniflora* - Dense	78.0	65.9	65.6
	3. *S. alterniflora* - Sparse	46.7	63.6	59.9
	4. *S. pectinata* - Dike edge	66.6	70.9	76.4
	5. Mud	87.9	91.2	86.3
	6. Rock	71.6	69.4	66.6
	7. Wrack	69.5	58.5	62.7
	Mean persistence (%)	64.6	66.1	64.0
	Overall pixel agreement (%)	73.4	72.5	70.7
West	1. *Spartina patens*	38.1	57.9	38.3
	2. *S. alterniflora* - Dense	69.9	52.2	62.3
	3. *S. alterniflora* - Sparse	25.9	55.4	58.8
	4. *S. pectinata* - Dike edge	59.0	62.2	56.0
	5. Mud	87.1	88.9	83.3
	6. Rock	56.3	56.2	52.3
	7. Wrack	52.1	66.8	59.9
	Mean persistence (%)	55.5	62.8	58.7
	Overall pixel agreement (%)	52.4	59.4	63.6

Table S17. Pixel-level transition matrix comparing the 2020 and 2021 land-cover classifications at Restoration East, Aulac. Rows represent land-cover classes in 2020 and columns represent classes in 2021; cell values are the numbers of pixels undergoing each transition. Diagonal values, shown in bold, represent pixels that retained the same class. Class persistence (CP) is the percentage of pixels within each 2020 class that retained the same classification in 2021. Mean class persistence (MCP) is the unweighted mean of CP across the seven classes, and overall pixel agreement (OPA) is the percentage of all classified pixels that retained the same class. Class numbers correspond to Table 1. This matrix supports the pixel-level transition results and calculations summarized in Table S16 and Figures 8–10.

Class	1	2	3	4	5	6	7	Total	CP (%)
1. *Spartina patens*	**149746**	66220	41498	31479	16959	2996	19261	328159	45.6
2. *S. alterniflora* - Dense	126739	**5093689**	1229818	46940	22392	7474	6257	6533309	78.0
3. *S. alterniflora* - *S*parse	81609	1579817	**1651566**	33542	102208	43870	41996	3534608	46.7
4. *S. pectinata* - Dike	58110	26955	15891	**229637**	2842	4131	7256	344822	66.6
5. Mud	20766	32334	158477	2787	**4923940**	308554	151960	5598818	87.9
6. Rock	1741	5024	30083	4691	258850	**1057220**	118732	1476341	71.6
7. Wrack	6959	2362	20276	3867	49753	66504	**341610**	491331	69.5
Total	445670	6806401	3147609	352943	5376944	1490749	687072	18307388	
MCP (%)	64.6								
OPA (%)	73.4								

Table S18. Pixel-level transition matrix comparing the 2021 and 2022 land-cover classifications at Restoration East, Aulac. Cell values represent the numbers of pixels transitioning between land-cover classes. Class persistence and summary metrics are defined in Table S17. This matrix supports the pixel-level transition results summarized in Table S16 and Figures 8–10.

Class	1	2	3	4	5	6	7	Total	CP (%)
1. *Spartina patens*	**202427**	80667	68767	63819	11219	7312	11459	445670	45.4
2. *S. alterniflora* - Dense	100600	**4485249**	2153800	23497	10447	11902	20906	6806401	65.9
3. *S. alterniflora* - *S*parse	92536	930766	**2002411**	22772	37833	38627	22664	3147609	63.6
4. *S. pectinata* - Dike	35533	33582	18584	**250167**	3249	5134	6694	352943	70.9
5. Mud	39939	27548	99027	949	**4901608**	259566	48307	5376944	91.2
6. Rock	4759	11046	46801	3156	292466	**1034704**	97817	1490749	69.4
7. Wrack	36782	4156	39883	12387	100609	91365	**401890**	687072	58.5
Total	512576	5573014	4429273	376747	5357431	1448610	609737	18307388	
MCP (%)	66.1								
OPA (%)	72.5								

Table S19. Pixel-level transition matrix comparing the 2020 and 2022 land-cover classifications at Restoration East, Aulac. Cell values represent the numbers of pixels transitioning between land-cover classes. Class persistence and summary metrics are defined in Table S17. This matrix supports the cumulative 2020–2022 persistence and overall pixel agreement reported in Table S16.

Class	1	2	3	4	5	6	7	Total	CP (%)
1. *Spartina patens*	**151979**	55803	40759	36261	21006	8826	13525	328159	46.3
2. *S. alterniflora* - Dense	96070	**4288293**	2034671	26189	36407	30857	20822	6533309	65.6
3. *S. alterniflora* - *S*parse	118428	1074382	**2117796**	27715	107434	54156	34697	3534608	59.9
4. *S. pectinata* - Dike	30512	21545	12426	**263453**	3917	5871	7098	344822	76.4
5. Mud	80435	107257	158201	6930	**4832334**	310147	103514	5598818	86.3
6. Rock	7018	21229	37811	3079	302364	**982642**	122198	1476341	66.6
7. Wrack	28134	4505	27609	13120	53969	56111	**307883**	491331	62.7
Total	512576	5573014	4429273	376747	5357431	1448610	609737	18307388	
MCP (%)	64.0								
OPA (%)	70.7								

Table S20. Pixel-level transition matrix comparing the 2020 and 2021 land-cover classifications at Restoration West, Aulac. Cell values represent the numbers of pixels transitioning between land-cover classes. Class persistence and summary metrics are defined in Table S17. This matrix supports the pixel-level transition results summarized in Table S16 and Figures 8–10.

Class	1	2	3	4	5	6	7	Total	CP (%)
1. *Spartina patens*	**89010**	55130	7382	71540	622	442	9475	233601	38.1
2. *S. alterniflora* - Dense	56697	**6548892**	2657456	60346	3748	11057	25665	9363861	69.9
3. *S. alterniflora* - Sparse	44231	9356475	**3352838**	11719	60724	72568	23685	12922240	25.9
4. *S. pectinata* - Dike	40027	68463	18208	**243926**	1468	6747	34699	413538	59.0
5. Mud	8153	91665	188515	1021	**4382285**	335802	26574	5034015	87.1
6. Rock	5567	37512	84748	2719	397121	**765907**	66381	1359955	56.3
7. Wrack	6545	13180	21796	20369	17338	53826	**144434**	277488	52.1
Total	250230	16171317	6330943	411640	4863306	1246349	330913	29604698	
MCP (%)	55.5								
OPA (%)	52.4								

Table S21. Pixel-level transition matrix comparing the 2021 and 2022 land-cover classifications at Restoration West, Aulac. Cell values represent the numbers of pixels transitioning between land-cover classes. Class persistence and summary metrics are defined in Table S17. This matrix supports the pixel-level transition results summarized in Table S16 and Figures 8–10.

Class	1	2	3	4	5	6	7	Total	CP (%)
1. *Spartina patens*	**144783**	42665	12975	42948	122	399	6347	250239	57.9
2. *S. alterniflora* - Dense	178660	**8443859**	7442668	75160	235	1456	29580	16171618	52.2
3. *S. alterniflora* - *S*parse	38808	2700792	**3510381**	21221	21619	21189	17073	6331083	55.4
4. *S. pectinata* - Dike	62873	36860	8555	**256353**	401	1223	45754	412019	62.2
5. Mud	18783	91943	196935	1650	**4322334**	217349	14311	4863305	88.9
6. Rock	7592	59173	101932	2886	295459	**700916**	78709	1246667	56.2
7. Wrack	6385	1392	19766	15761	21890	44641	**221149**	330984	66.8
Total	457884	11376684	11293212	415979	4662060	987173	412923	29605915	
MCP (%)	62.8								
OPA (%)	59.4								

Table S22. Pixel-level transition matrix comparing the 2020 and 2022 land-cover classifications at Restoration West, Aulac. Cell values represent the numbers of pixels transitioning between land-cover classes. Class persistence and summary metrics are defined in Table S17. This matrix supports the cumulative 2020–2022 persistence and overall pixel agreement reported in Table S16.

Class	1	2	3	4	5	6	7	Total	CP (%)
1. *Spartina patens*	**89538**	36052	14152	74045	832	416	18565	233600	38.3
2. *S. alterniflora* - Dense	130158	**5829283**	3276533	63912	5402	5454	53119	9363861	62.3
3. *S. alterniflora* - Sparse	124938	5039492	**7604239**	21183	67172	40010	25206	12922240	58.8
4. *S. pectinata* - Dike	53737	47734	14515	**231534**	1362	5368	59288	413538	56.0
5. Mud	31200	326071	272361	4224	**4191810**	195147	13201	5034014	83.3
6. Rock	11606	85588	90256	1687	382663	**710852**	77303	1359955	52.3
7. Wrack	16707	12184	21001	18908	12819	29686	**166183**	277488	59.9
Total	457884	11376404	11293057	415493	4662060	986933	412865	29604696	
MCP (%)	58.7								
OPA (%)	63.6								

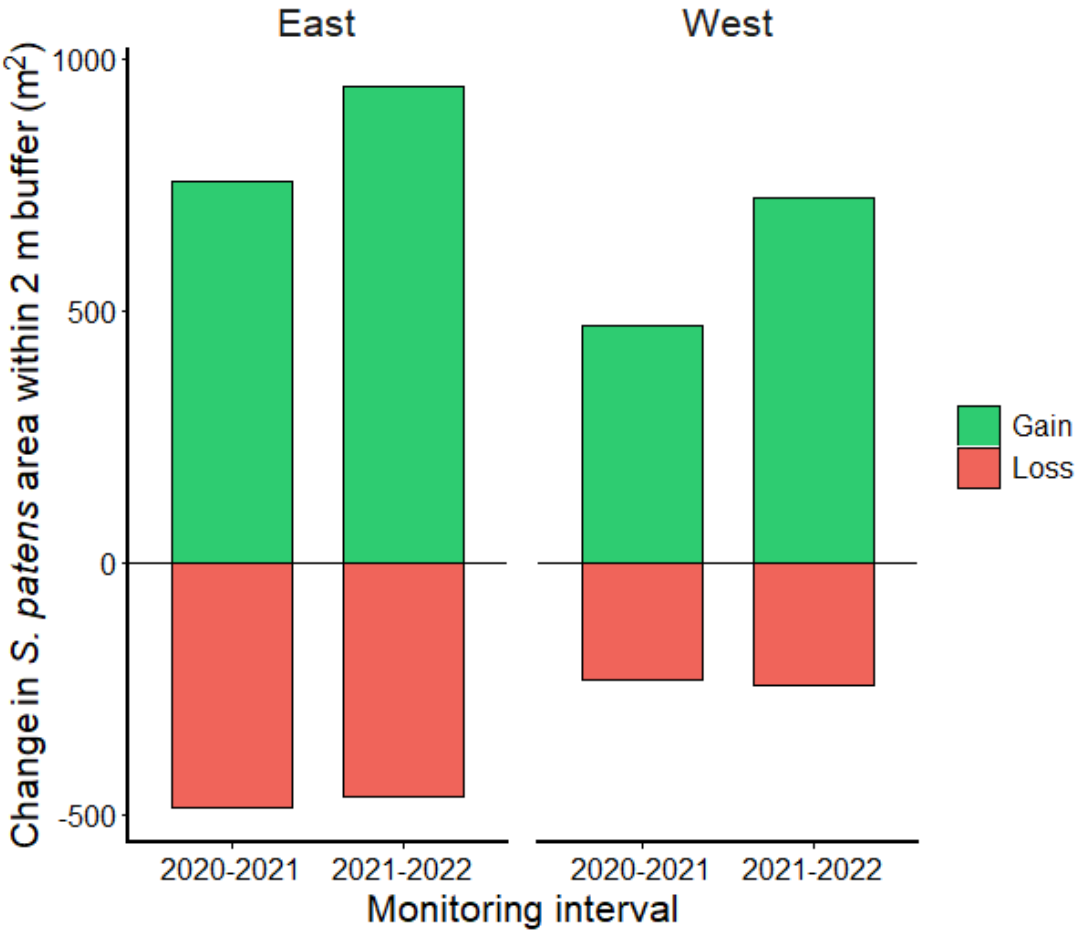

Figure S3. Total gains and losses of *Spartina patens* within 2-m buffers surrounding persistent *S. patens* patch cores at Restoration East and Restoration West, Aulac, during the 2020–2021 and 2021–2022 monitoring intervals. Patch cores were defined as contiguous areas classified as *S. patens* in both years of an interval and exceeding 0.249 m² in area (range: 0.25–127 m²); these correspond to the dark-green pixels in Figures 11–12. The analysis included 269 and 274 patch cores at Restoration East and 113 and 134 patch cores at Restoration West during the 2020–2021 and 2021–2022 intervals, respectively. Bars show total *S. patens* gains as positive values and losses as negative values. Areas were derived from pixel counts using a spatial resolution of 7.4 cm per pixel (0.005476 m² per pixel). This figure complements Figures 11–12 and 14.

Table S23. Summary of the highest-ranked predictor variables distinguishing *Spartina patens* from dense and sparse *S. alterniflora* across six site-year combinations (Restoration East and Restoration West, 2020–2022) at Aulac. Values are pooled frequencies, with percentages in parentheses, among the top 20 predictors from each site-year comparison (120 selected predictors per *Spartina* comparison). Predictor-type and acquisition-month percentages are calculated relative to all 120 selected predictors. Spectral-region percentages are calculated relative to predictors with an identifiable source band and exclude vegetation indices. Textural-feature and vegetation-index percentages are calculated relative to the total numbers of selected textural features and vegetation indices, respectively. This table complements the predictor-type summaries in Figure 15 and the mean spectral-band contributions in Figure 16. Site-year-specific predictor rankings are presented in Figures S4–S15, and complete predictor definitions are provided in Table S2.

Category	Variable	Frequency associated with dense *S. alterniflora* (%)	Frequency associated with sparse *S. alterniflora* (%)
Acquisition month	June	11 (9.2)	2 (1.7)
	July	19 (15.8)	46 (38.3)
	August	90 (75.0)	72 (60.0)
Predictor type	Raw reflectance	40 (33.3)	26 (21.7)
	Vegetation index	3 (2.5)	40 (33.3)
	Textural feature	77 (64.2)	54 (45.0)
Spectral region	Blue	31 (26.5)	1 (1.2)
	Green	24 (20.5)	3 (3.8)
	Red	12 (10.3)	1 (1.2)
	Red-edge	36 (30.4)	34 (42.5)
	Near-infrared	14 (12.0)	41 (51.2)
Textural feature	Mean	39 (50.6)	28 (51.9)
	Homogeneity	10 (13.0)	9 (16.7)
	GLDV Entropy	9 (11.7)	4 (7.4)
	Entropy	7 (9.1)	4 (7.4)
	Dissimilarity	6 (7.8)	4 (7.4)
	GLDV ASM	5 (6.5)	3 (5.6)
	ASM	1 (1.3)	1 (1.9)
	Angular Correlation	-	1 (1.9)
Vegetation index	WAVI	1 (33.3)	19 (47.5)
	GDVI	-	10 (25.0)
	DVI	-	9 (22.5)
	NDVI	1 (33.3)	-
	NG	1 (33.3)	1 (2.5)
	NR	-	1 (2.5)

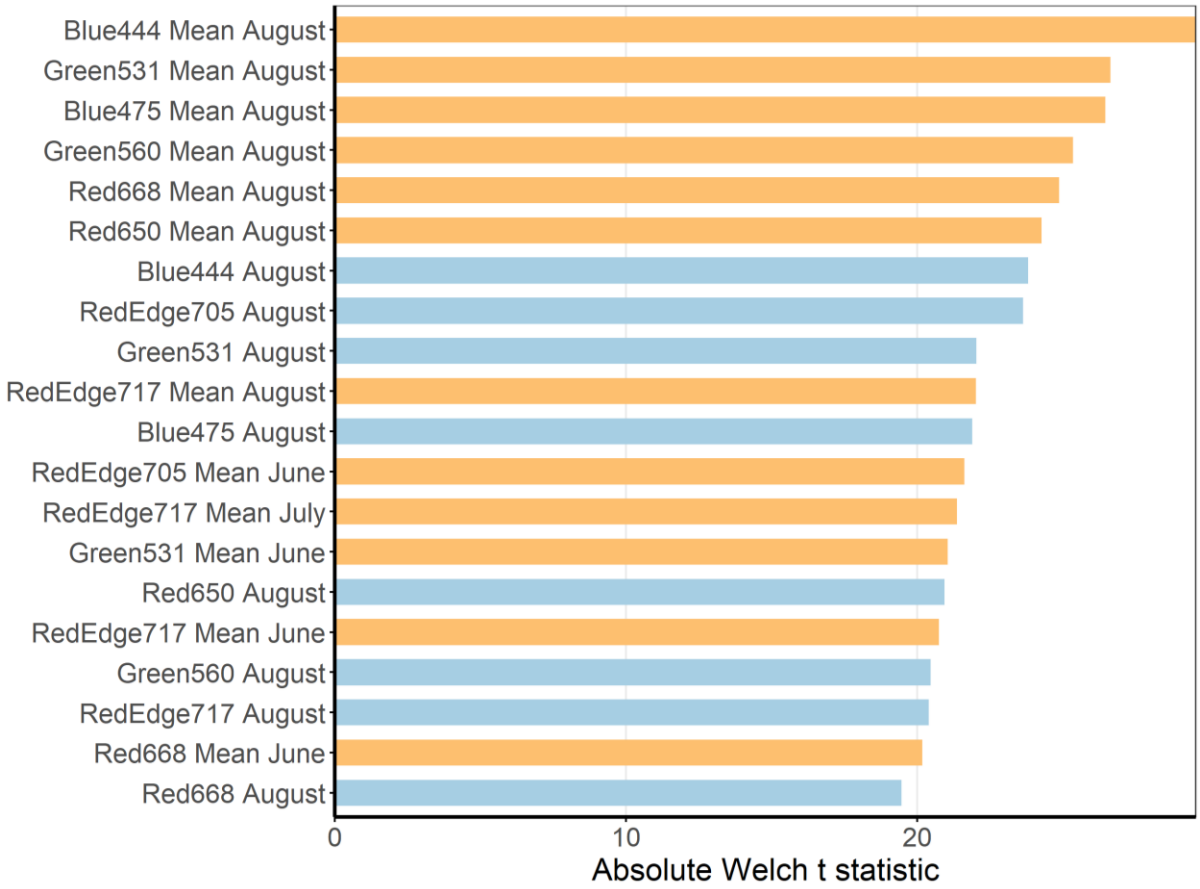

Figure S4. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from dense *S. alterniflora* at Restoration East in 2020. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 157 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15; distributions of the highest-ranked predictors for this comparison are shown in Figure S16.

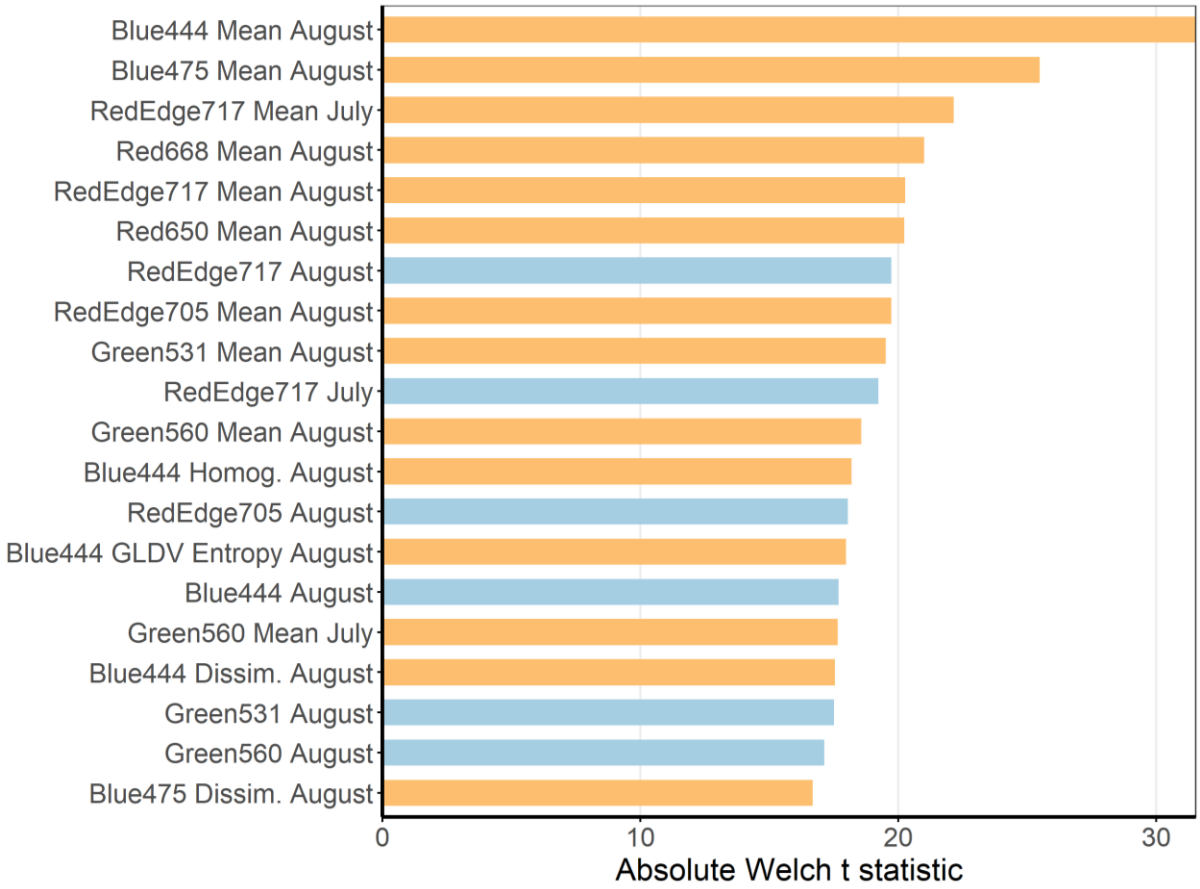

Figure S5. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from dense *S. alterniflora* at Restoration East in 2021. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 165 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

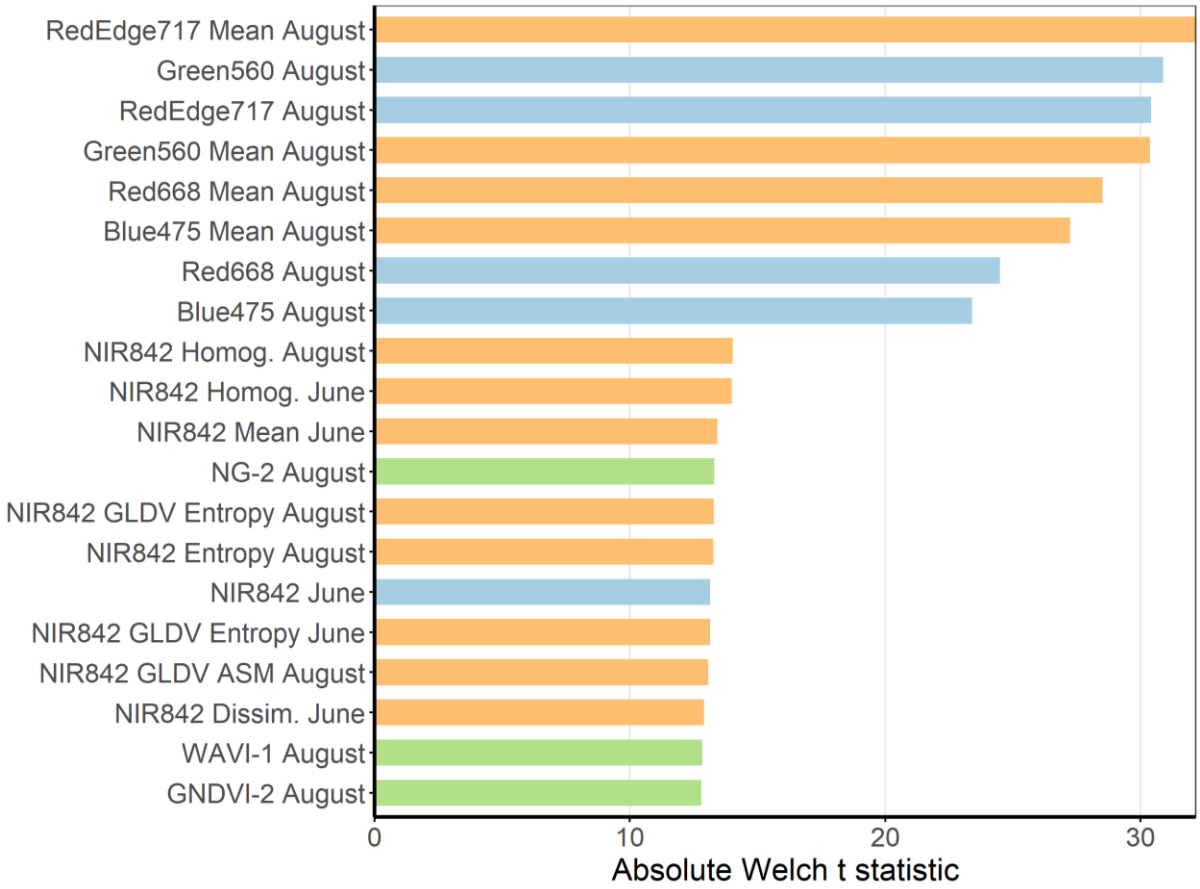

Figure S6. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from dense *S. alterniflora* at Restoration East in 2022. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 161 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

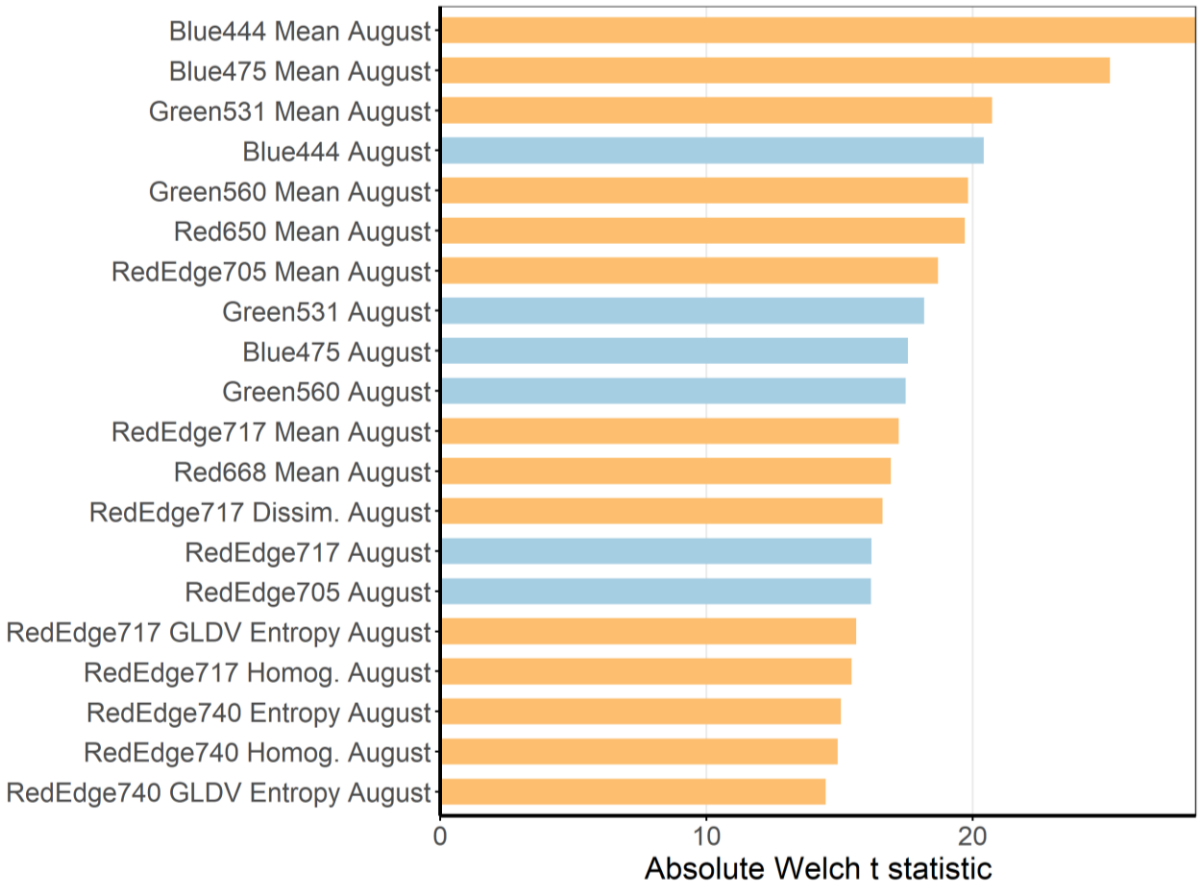

Figure S7. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from dense *S. alterniflora* at Restoration West in 2020. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 81 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

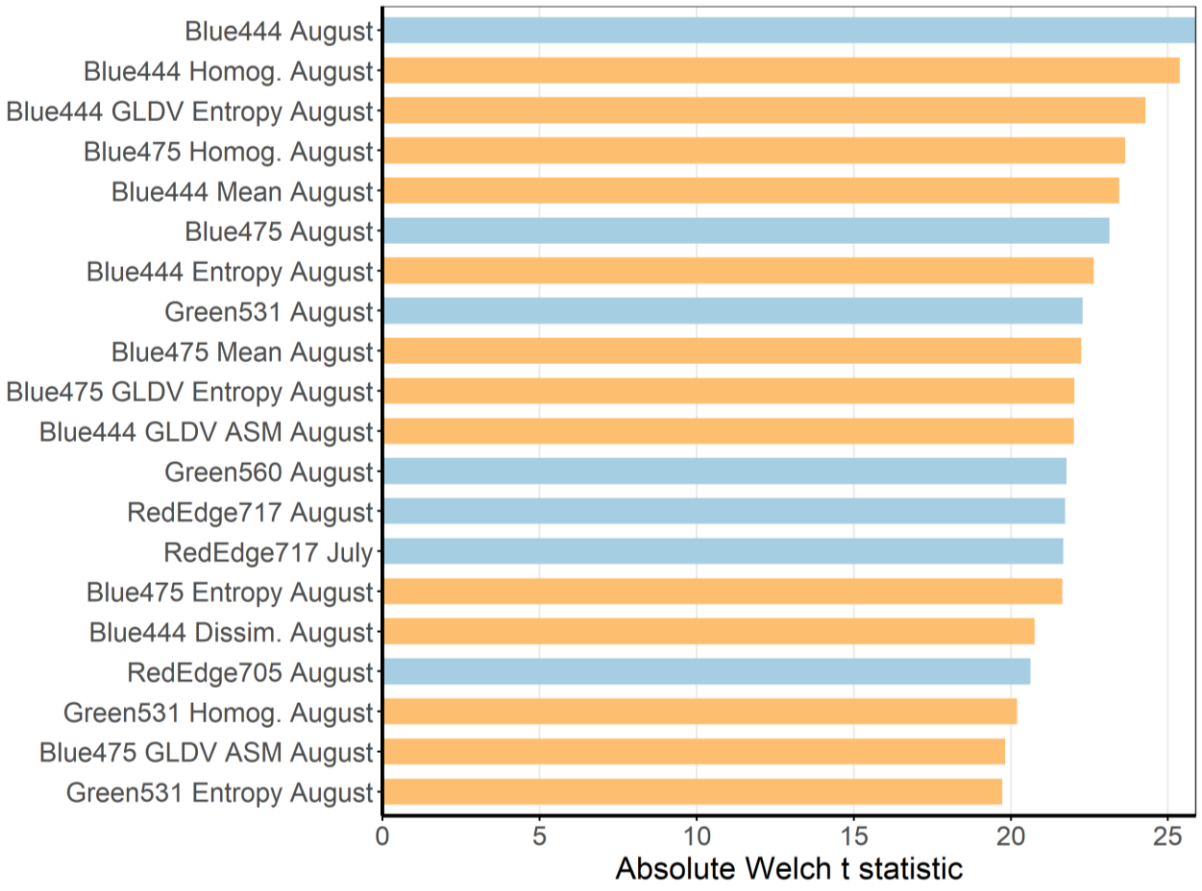

Figure S8. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from dense *S. alterniflora* at Restoration West in 2021. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 103 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

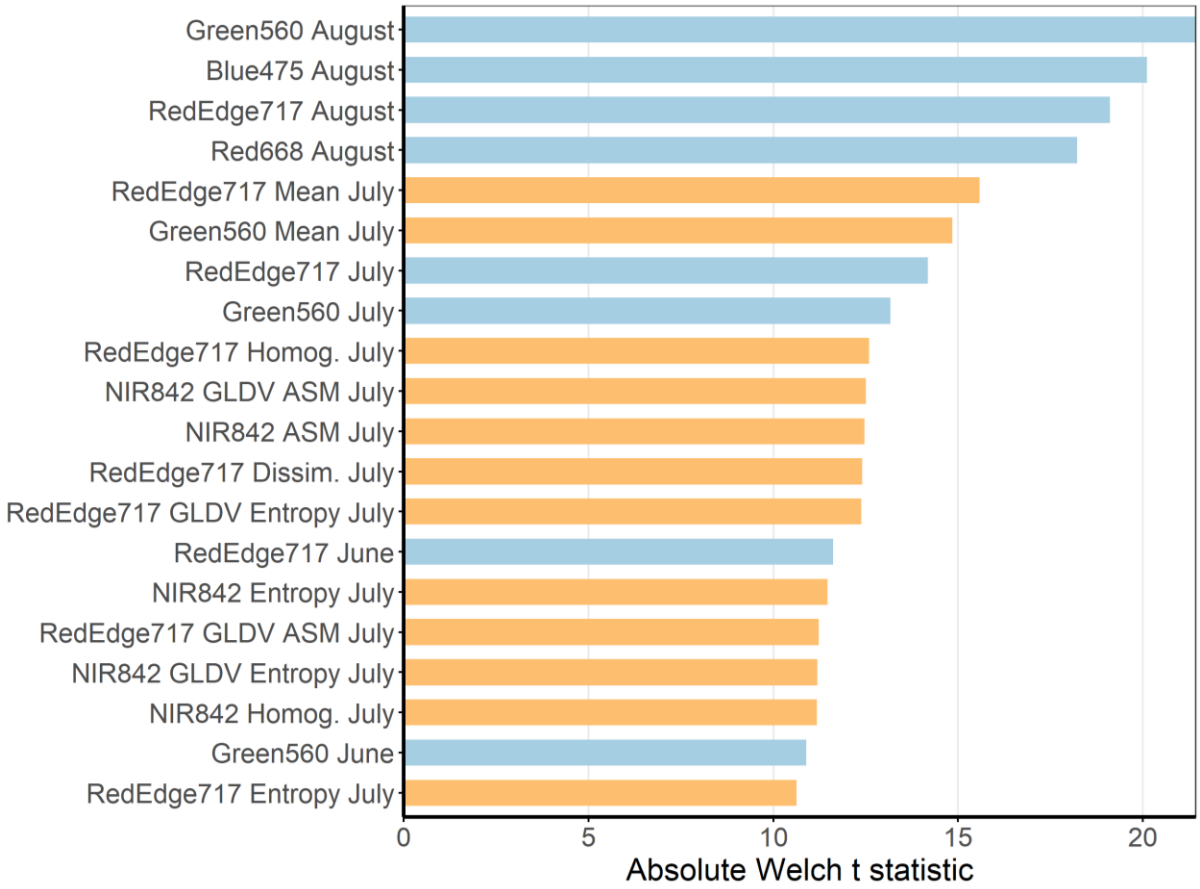

Figure S9. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from dense *S. alterniflora* at Restoration West in 2022. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 116 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

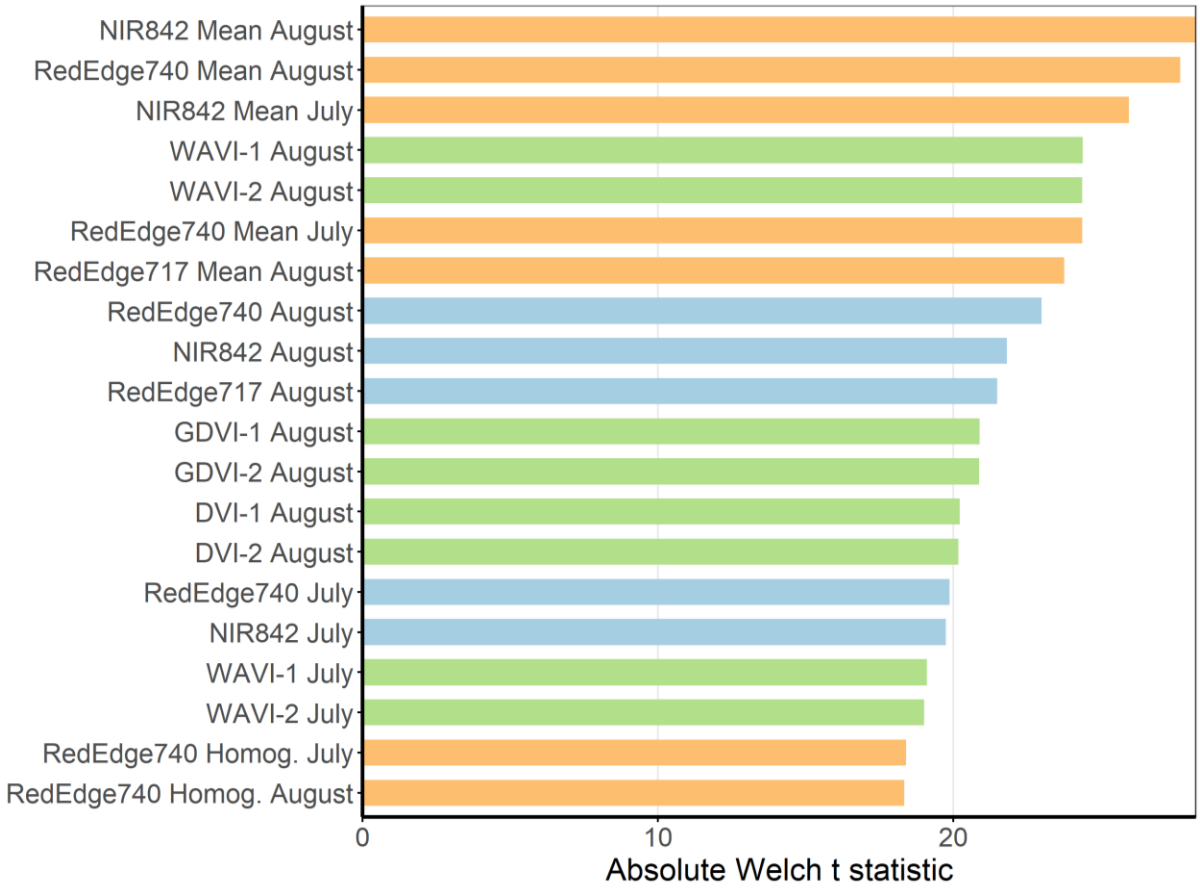

Figure S10. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from sparse *S. alterniflora* at Restoration East in 2020. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 157 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

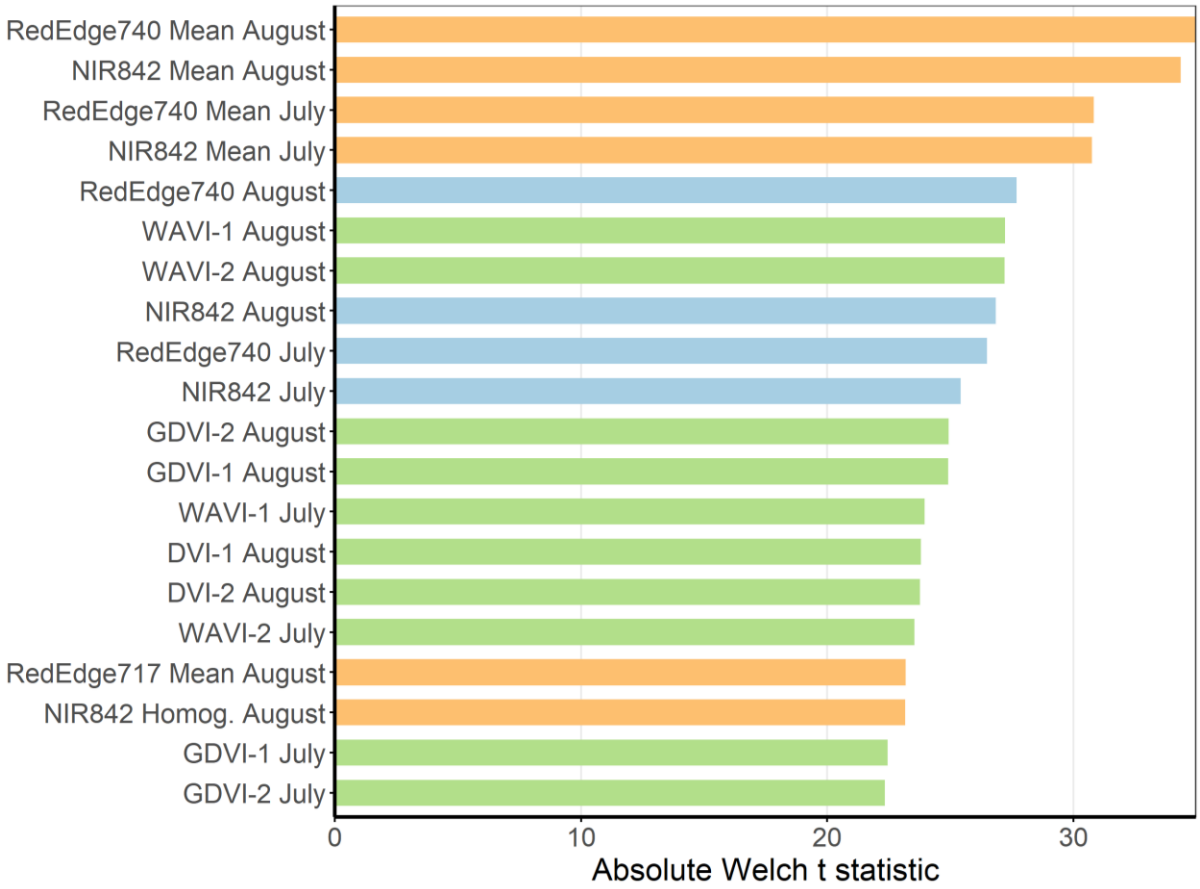

Figure S11. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from sparse *S. alterniflora* at Restoration East in 2021. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 165 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

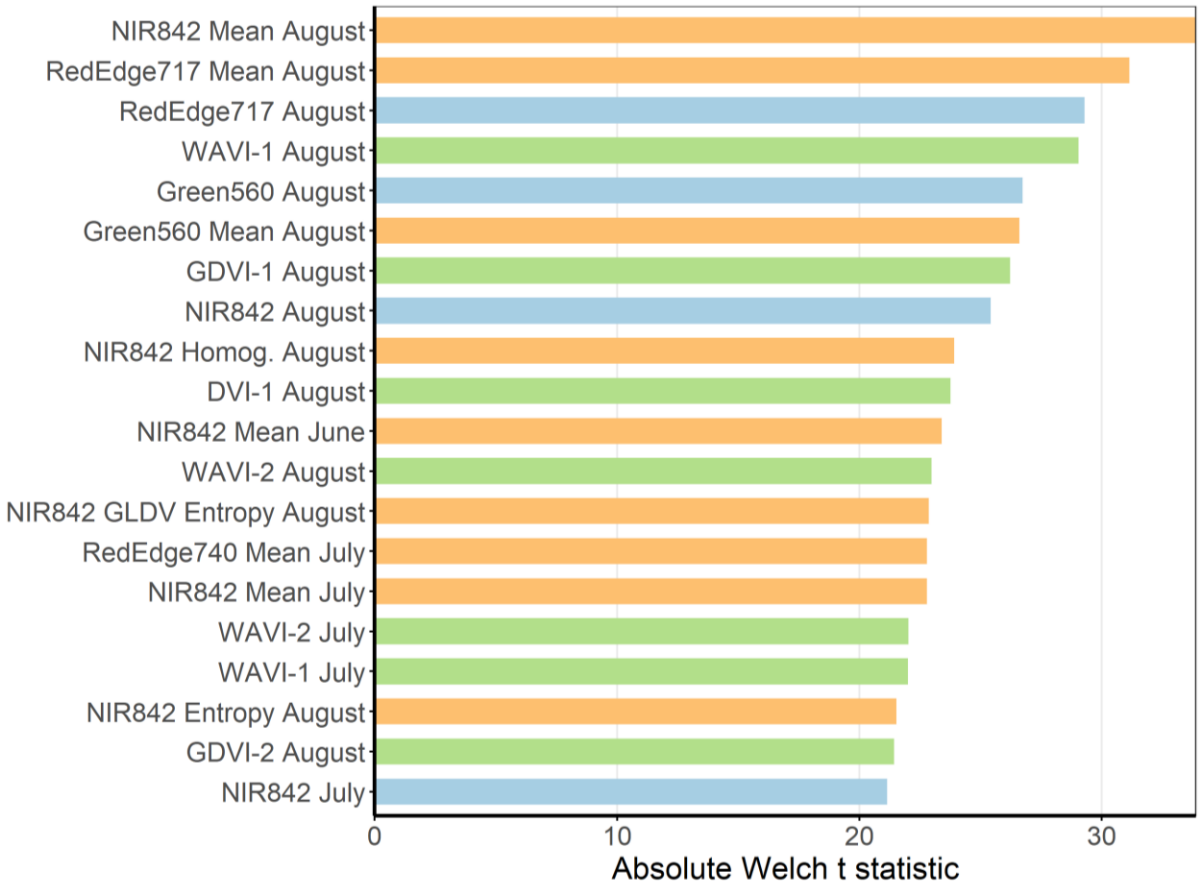

Figure S12. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from sparse *S. alterniflora* at Restoration East in 2022. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 161 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

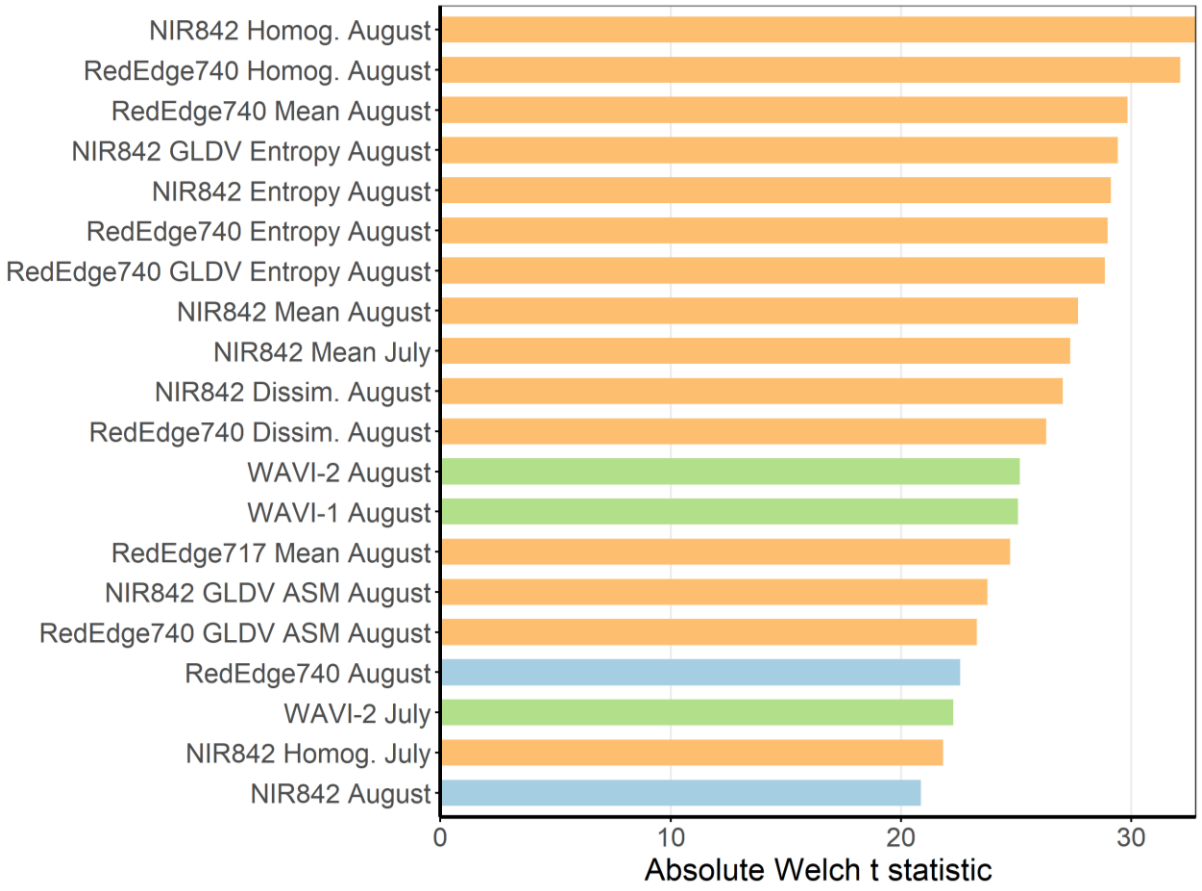

Figure S13. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from sparse *S. alterniflora* at Restoration West in 2020. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 81 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

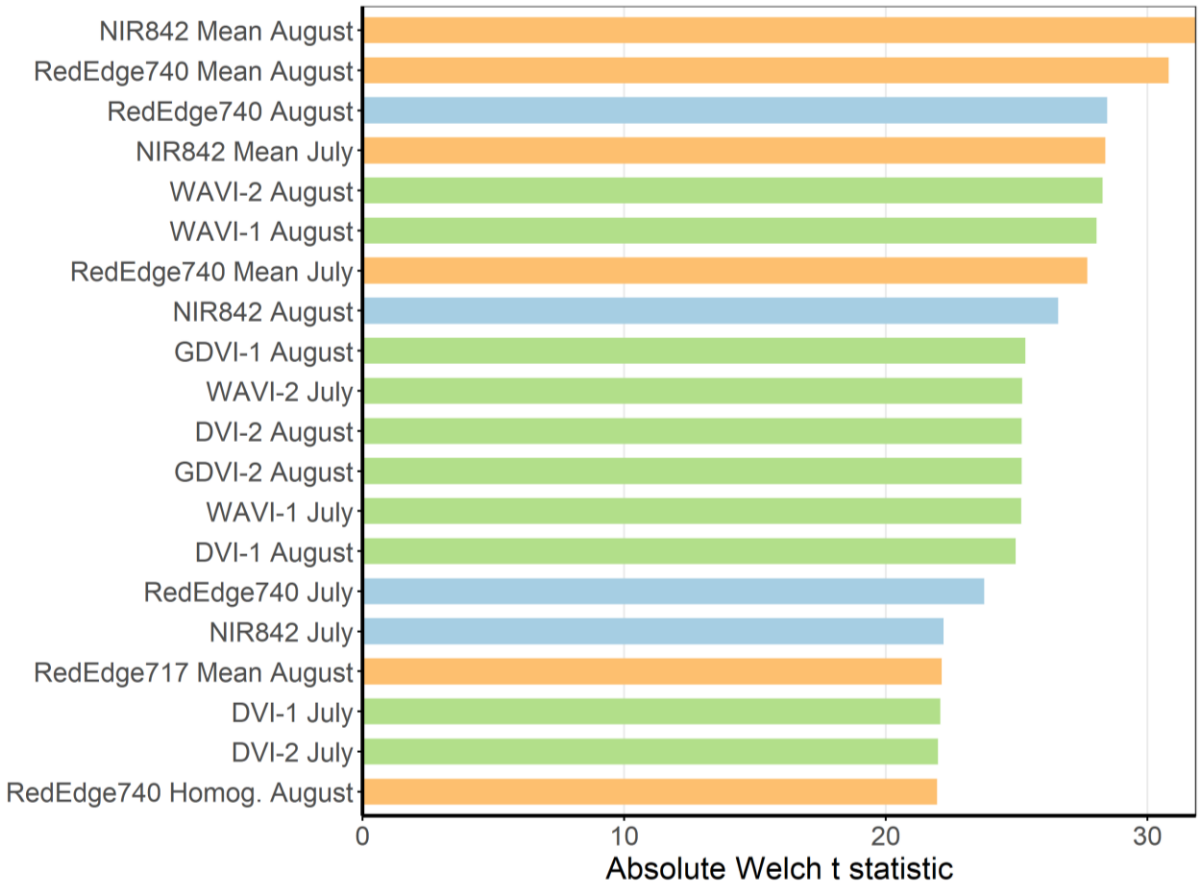

Figure S14. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from sparse *S. alterniflora* at Restoration West in 2021. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 103 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

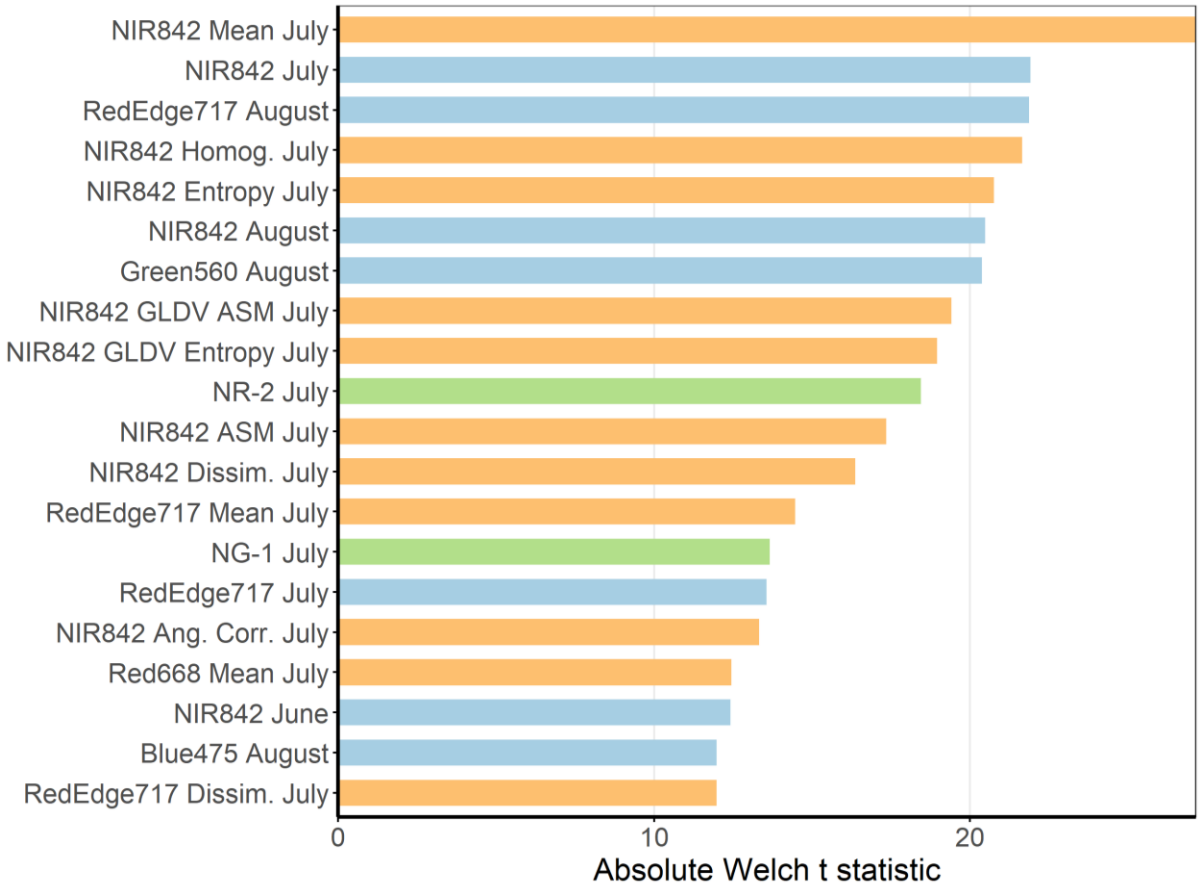

Figure S15. Twenty highest-ranked predictor variables distinguishing *Spartina patens* from sparse *S. alterniflora* at Restoration West in 2022. Predictors were ranked by the absolute Welch two-sample *t* statistic calculated from 116 observations per class. Each observation represented one pixel randomly selected from a distinct training or validation polygon. Larger absolute *t* statistics indicate greater separation between classes. Colours indicate predictor type (blue = raw reflectance, green = vegetation index, orange = textural feature). Results are summarized in Figure 15.

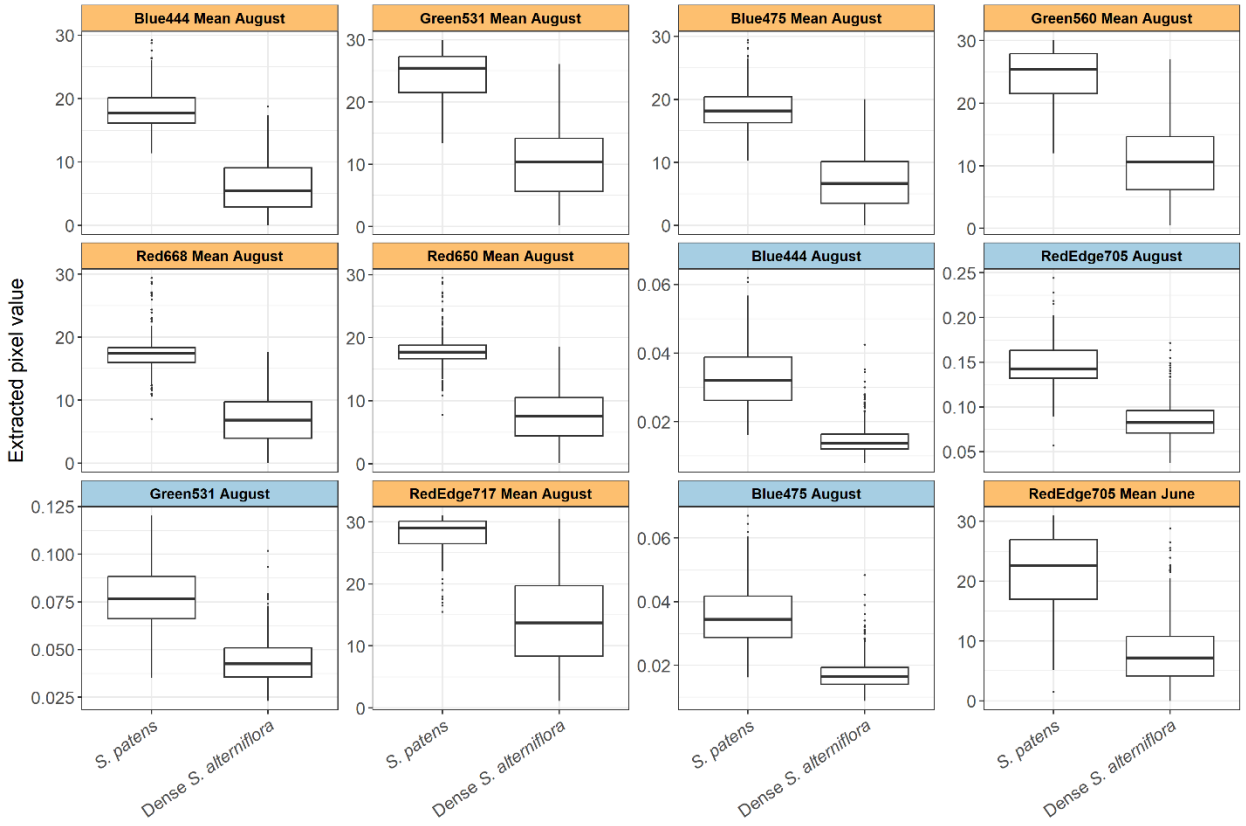

Figure S16. Representative boxplots showing the distributions of the 12 highest-ranked predictor variables distinguishing *Spartina patens* from dense *S. alterniflora* at Restoration East in 2020. This site-year comparison is presented as an example of the class-level distributions underlying the Welch *t* statistic rankings; analogous boxplots for the other site-year comparisons are not shown. Predictors are ordered by their absolute Welch two-sample *t* statistics (Figure S4) and were calculated from 157 observations per class, with each observation representing one pixel randomly selected from a distinct training or validation polygon. Orange panels represent textural features, and blue panels represent raw reflectance variables. Boxes show the median and interquartile range, whiskers extend to 1.5 times the interquartile range, and points represent outliers.