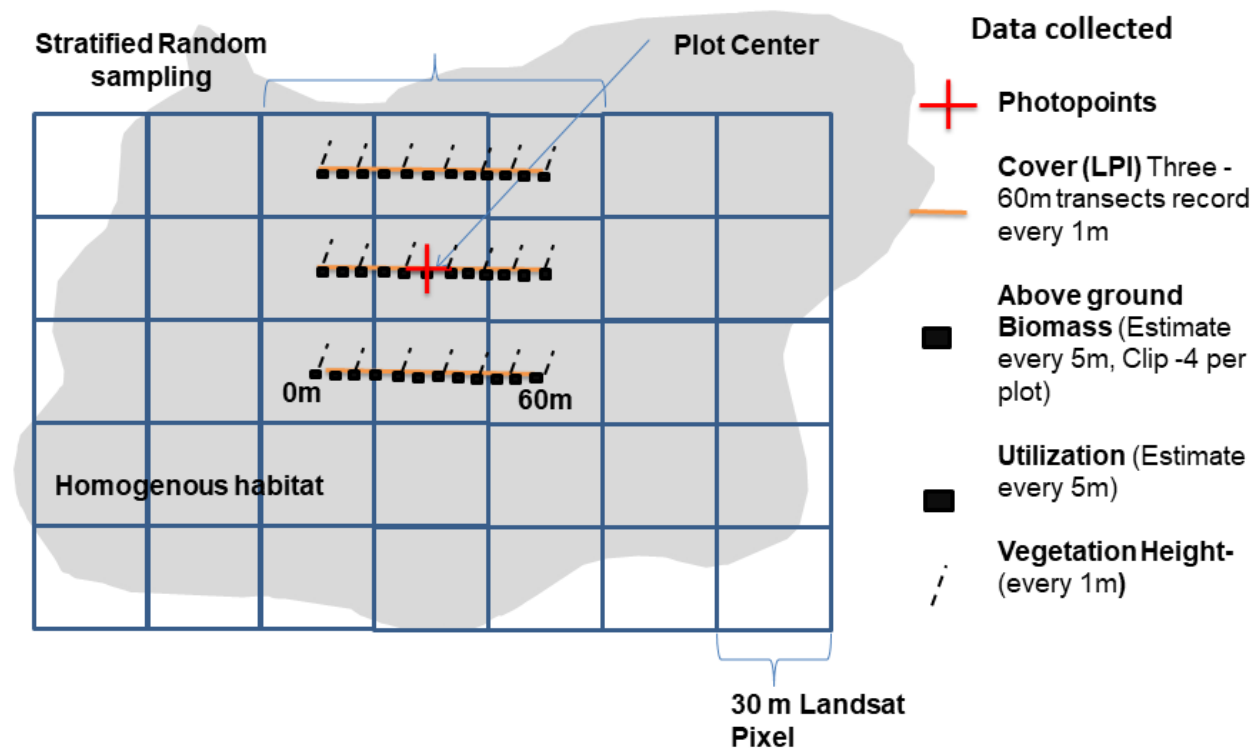


Supplementary Materials: The development of nearreal-time biomass and cover estimates for adaptive rangeland management using Landsat surface reflectance products

Vincent S. Jansen ^{1,*} Crystal A. Kolden ¹ and Heidi J. Schmalz ^{2,*}

Figure S1. Sampling site plot layout



Caption: Sample sites were selected using a stratified random sampling approach and homogeneity at the site was validated in the field. At each site, three 60m transects were established in an east-west direction and 30m apart in the north-south direction. Along each transect, cover, vegetation color and vegetation height of functional groups was collected at 1m intervals using line-point intercept. Above-ground biomass and utilization were estimated in 1 x 0.5m quadrats every 5m along each transect. All biomass was clipped in four quadrats: at 30m on the southern and northern transects and at 20m and 40m on the center transect.

Table S1. Paired Landsat 7 and Landsat 8 scenes used in model building (including timing of in-field vegetation sampling) and for sensor model comparisons.

Year	Scene Date	Julian Date	Sensor	Path/Row	Scene used for Model Creation	In-field Sampling Dates
2013	28 Jun	179	LS8	P43/R28		
2013	29 Jun	180	LS7	P42/R28		
2014	23 Jun	174	LS7	P43/R28		
2014	24 Jun	175	LS8	P42/R28		
2014	11 Sep	254	LS7	P43/R28		
2014	12 Sep	255	LS8	P42/R28		
2014	19 Sep	262	LS8	P43/R28	x	19 - 28 Sep
2014	20 Sep	263	LS7	P42/R28	x	19 - 28 Sep
2015	10 Jun	161	LS7	P43/R28	x	1 - 25 Jun
2015	11 Jun	162	LS8	P42/R28	x	1 - 25 Jun
2015	26 Jun	177	LS7	P43/R28		
2015	27 Jun	178	LS8	P42/R28		
2015	16 Oct	289	LS7	P43/R28	x	21 Sep - 6 Oct
2015	17 Oct	290	LS8	P42/R28	x	21 Sep - 6 Oct
2016	20 Jun	172	LS8	P43/R28	x	2 - 15 Jun
2016	21 Jun	173	LS7	P42/R28	x	2 - 15 Jun
2016	24 Sep	268	LS8	P43/R28	x	26 Sept - 7 Oct
2016	25 Sep	269	LS7	P42/R28	x	26 Sept - 7 Oct
2017	23 Jun	174	LS8	P43/R28		
2017	24 Jun	175	LS7	P42/R28		
2017	18 Aug	230	LS7	P43/R28		
2017	19 Aug	231	LS8	P42/R28		
2017	27 Sep	270	LS8	P43/R28		
2017	28 Sep	271	LS7	P42/R28		

Table S2. Candidate vegetation indices used in the best subset modeling step.

Index and abbreviation	Formula	Reference
Normalized Difference Vegetation Index (NDVI)	$\frac{NIR - RED}{NIR + RED}$	Tucker (1979)
Soil Adjusted Vegetation Index (SAVI)	$\frac{NIR - RED}{NIR + RED + 0.5} * (1 + 0.5)$	Huete (1988)
Renormalized Difference Vegetation Index (RDVI)	$\frac{NIR - RED}{\sqrt{(NIR + RED)}}$	Ruejean and Breon (1995); Haboudane et al. (2004)
Modified Triangular Vegetation Index 1 (MTVI1)	$1.2[1.2(NIR - GREEN) - 2.5(RED - GREEN)]$	Haboudane et al. (2004)
Normalized Canopy Index (NCI)	$\frac{MIR - GREEN}{MIR + GREEN}$	Vescovo & Gianelle (2008)
Normalized Difference Cover Index (NDCI) / Normalized Difference senescent vegetation index (NDSVI)	$\frac{MIR - RED}{MIR + RED}$	Marsett et al. (2006) Zhang & Guo (2008)
Plant Senesce Reflectance Index (PSRI)	$\frac{RED - GREEN}{NIR}$	Merzlyak et al. (1999)
Soil Adjusted Total Vegetation Index (SATVI)	$\frac{MIR - RED}{MIR + RED + 0.5} * (1 + 0.5) - (SWIR2/2)$	Marsett et al. (2006)
Normalized Burn Ratio or Normalized Difference Infrared Index 7 (NDII7)	$\frac{NIR - SWIR2}{NIR + SWIR2}$	Hardisky et al. (1983); Key & Benson (2006)
Normalized Difference Water Index (NDWI)	$\frac{NIR - MIR}{NIR + MIR}$	Hardisky et al. (1983); Gao (1996)
Enhanced Vegetation Index (EVI)	$(2.5) * \frac{NIR - RED}{NIR + 6 * RED - 7.5 * Blue + 1}$	Liu and Huete (1995)
Tasseled Cap Brightness index (BI)	$0.2043_{blue} + 0.4158_{green} + 0.5524_{red} + 0.5741_{NIR} + 0.3124_{MIR} + 0.2303_{SWIR2}$	Crist (1985)
Tasseled Cap Greenness index (GVI)	$-0.1603_{blue} - 0.2819_{green} - 0.4934_{red} + 0.7940_{NIR} - 0.0002_{MIR} - 0.1446_{SWIR2}$	Crist (1985)
Tasseled Cap Wetness index (WI)	$0.0315_{blue} + 0.2021_{green} + 0.3102_{red} + 0.1594_{NIR} - 0.6806_{MIR} - 0.6109_{SWIR2}$	Crist (1985)
Normalized Difference Tillage Index (NDTI)	$\frac{MIR - SWIR2}{MIR + SWIR2}$	Van Deventer et al., 1997

Figure S2. Workflow diagram for final algorithm development.

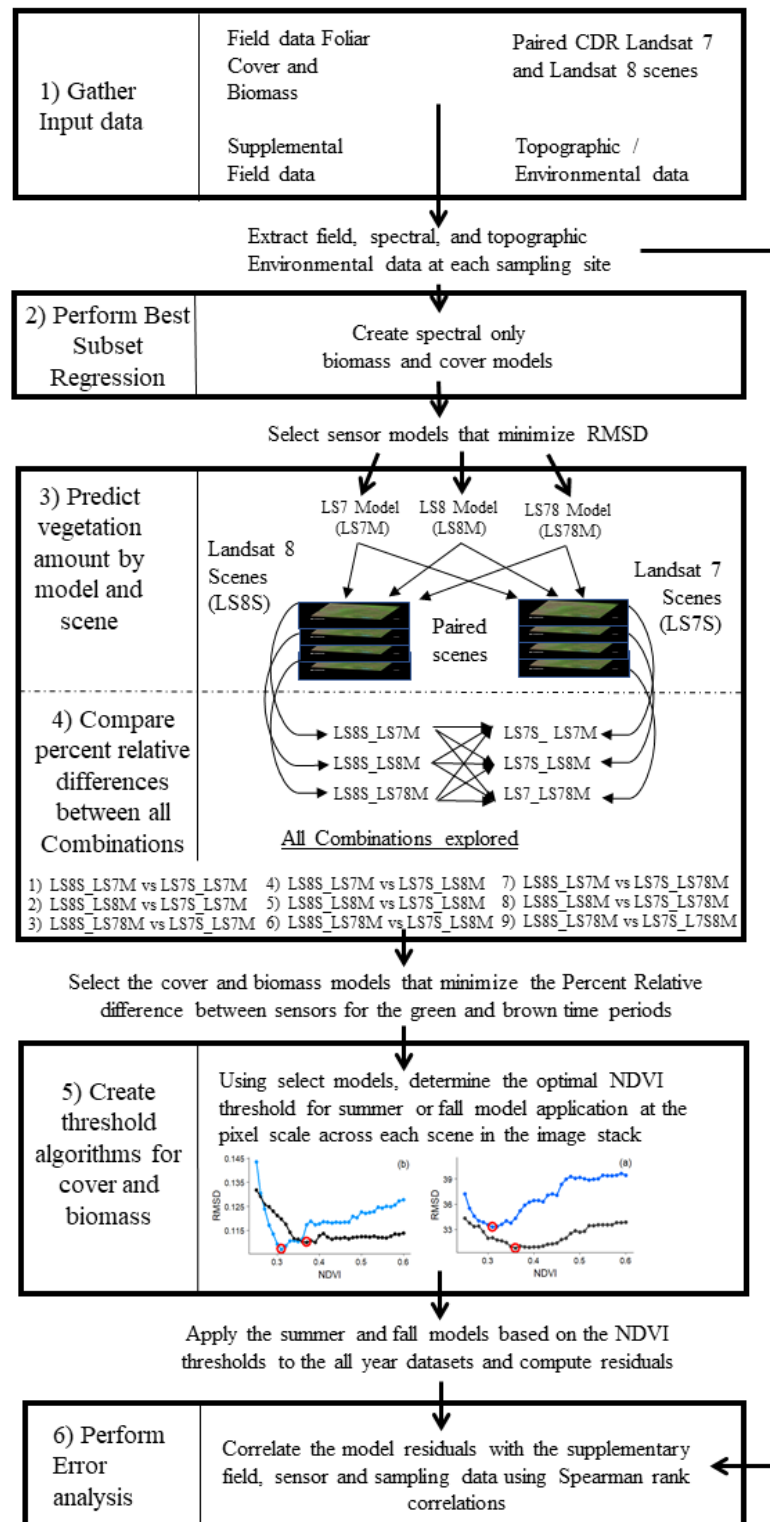


Table S3. The field, sensor and topographic variables used to correlate with residuals from the NDVI threshold algorithm. LPI is line-point intercept. NED is National Elevation Dataset. CDR is Climate Data Record

Variable	Data Source
% Mean Utilization	Utilization
% Perennial Grass	LPI - Top Canopy
% Annual Grass	LPI - Top Canopy
% Perennial Forb	LPI - Top Canopy
% Annual Forb	LPI - Top Canopy
% Litter Cover	LPI - Top Canopy
% Green Color	LPI - Top Canopy
% Brown & SD Color	LPI - Top Canopy
% Soil Surface	LPI - Soil Surface
% Rock	LPI - Soil Surface
% Moss or Lichen	LPI - Soil Surface
Aspect	NED 30m DEM
Slope	NED 30m DEM
Sensor Date	Landsat CDR
Prior Rain Lag (days)	Landsat CDR/Zumwalt WX Station
Infield Sample Lag (Days)	Sensor/Field
Infield Sample Date	Field Data

Table S4. Variable Selection using a bootstrapped best subset model approach for Green (Summer) Biomass data.

Time	Sensor	Model Rank	Variable Count	NDVI	SAVI	RDVI	MTVI	NCI	NDCI	PSRI	SATVI	NDII7	NDWI	EVI	TC-BRI	TC-GRE	TC-WET	NDTI
Green	LS7	1	1	0	0	0	0	0	0	0	0	73	927	0	0	0	0	0
	LS7	2	1	0	0	0	0	0	0	0	0	918	73	0	0	8	1	0
	LS8	1	1	0	0	0	0	0	0	0	28	853	97	0	0	0	22	0
	LS8	2	1	0	0	0	0	0	0	0	59	120	784	0	0	0	37	0
	LS7LS8	1	1	0	0	0	0	0	0	0	0	753	247	0	0	0	0	0
	LS7LS8	2	1	0	0	0	0	0	0	0	0	247	753	0	0	0	0	0
	LS7	1	2	5	20	24	61	1	61	184	3	647	258	681	3	43	7	2
	LS7	2	2	24	23	20	58	7	116	454	6	543	362	340	6	33	6	2
	LS8	1	2	3	1	2	333	0	0	2	55	848	81	176	188	17	242	52
	LS8	2	2	4	3	56	162	0	0	10	130	785	136	78	254	68	276	38
	LS7LS8	1	2	0	0	0	44	0	0	15	12	981	19	925	0	0	4	0
	LS7LS8	2	2	0	0	0	350	0	7	465	73	899	100	64	7	0	35	0

Table S5. Variable Selection using a bootstrapped best subset model approach for Brown (Fall) Biomass data.

Time	Sensor	Model Rank	Variable Count	NDVI	SAVI	RDVI	MTVII	NCI	NDCI	PSRI	SATVI	NDII7	NDWI	EVI	TC-BRI	TC-GRE	TC-WET	NDTI
Brown	LS7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000
	LS7	2	1	0	0	0	0	0	0	0	0	852	0	0	0	148	0	0
	LS8	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000
	LS8	2	1	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
	LS7LS8	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000
	LS7LS8	2	1	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
	LS7	1	2	28	5	4	39	190	14	256	2	217	217	50	94	85	16	783
	LS7	2	2	40	45	39	100	117	95	116	54	191	176	70	47	33	24	853
	LS8	1	2	0	0	5	2	134	9	256	4	183	182	10	64	328	4	819
	LS8	2	2	4	10	167	18	116	51	123	14	96	157	29	85	197	26	907
	LS7LS8	1	2	4	5	6	0	195	0	104	1	138	141	3	34	506	1	862
	LS7LS8	2	2	10	29	302	6	121	66	72	10	134	127	11	47	187	2	876

Table S6. Variable Selection using a bootstrapped best subset model approach for All Year (Green + Brown) Biomass data.

Time	Sensor	Model Rank	Variable Count	NDV I	SAV I	RDV I	MTV II	NC I	NDC I	PSRI	SATV I	NDII 7	NDW I	EV I	TC-BRI	TC-GRE	TC-WET	NDTI
All Year	LS7	1	1	0	0	0	0	0	0	0	0	196	0	0	0	0	0	804
	LS7	2	1	0	0	0	0	0	0	0	0	804	0	0	0	7	0	189
	LS8	1	1	0	0	0	0	0	0	0	0	258	0	0	0	0	0	742
	LS8	2	1	0	0	0	0	0	0	0	0	742	0	0	0	0	0	258
	LS7LS8	1	1	0	0	0	0	0	0	0	0	128	0	0	0	0	0	872
	LS7LS8	2	1	0	0	0	0	0	0	0	0	872	0	0	0	0	0	128
	LS7	1	2	1	0	0	642	6	0	131	0	333	41	148	0	646	2	50
	LS7	2	2	2	3	0	108	4	0	534	4	817	79	170	1	127	3	148
	LS8	1	2	27	0	0	10	0	0	2	13	955	671	2	1	0	3	316
	LS8	2	2	23	27	0	16	1	0	0	18	787	266	6	5	1	5	845
	LS7LS8	1	2	1	0	0	8	0	0	20	0	991	312	17	0	6	0	645
	LS7LS8	2	2	1	1	0	6	0	0	16	0	542	634	22	0	5	0	773

Table S7. Variable Selection using a bootstrapped best subset model approach for Green (Summer) Cover data.

Time	Sensor	Model Rank	Variable Count	NDVI	SAVI	RDVI	MTVII	NCI	NDCI	PSRI	SATVI	NDII7	NDWI	EVI	TC-BRI	TC-GRE	TC-WET	NDTI
Green	LS7	1	1	0	0	0	0	0	0	0	0	952	48	0	0	0	0	0
	LS7	2	1	0	1	10	0	0	0	0	0	48	928	0	0	1	0	12
	LS8	1	1	0	0	0	0	0	0	0	0	995	0	0	0	0	0	5
	LS8	2	1	114	59	1	0	0	0	2	0	5	547	0	0	0	0	272
	LS7LS8	1	1	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
	LS7LS8	2	1	0	2	0	0	0	0	0	0	0	959	0	0	0	0	39
	LS7	1	2	52	88	87	5	1	510	2	174	781	2	75	173	8	42	0
	LS7	2	2	215	148	57	17	13	343	5	140	695	17	50	221	19	60	0
	LS8	1	2	8	10	5	0	31	50	188	119	858	358	1	120	245	1	6
	LS8	2	2	29	27	88	13	57	101	177	158	744	218	1	159	192	11	25
	LS7LS8	1	2	20	22	0	0	42	619	17	63	916	64	12	104	110	11	0
	LS7LS8	2	2	190	68	16	10	161	180	16	29	926	52	63	77	177	35	0

Table S8. Variable Selection using a bootstrapped best subset model approach for the Fall (Brown) Cover data.

Time	Sensor	Model Rank	Variable Count	NDVI	SAVI	RDVI	MTVII	NCI	NDCI	PSRI	SATVI	NDII7	NDWI	EVI	TC-BRI	TC-GRE	TC-WET	NDTI
Brown	LS7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000
	LS7	2	1	0	0	0	0	0	0	0	0	524	0	0	0	476	0	0
	LS8	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000
	LS8	2	1	0	0	0	0	0	0	0	0	997	0	0	0	3	0	0
	LS7LS8	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000
	LS7LS8	2	1	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
	LS7	1	2	0	0	6	2	5	2	43	202	14	12	42	221	9	454	988
	LS7	2	2	2	1	9	0	13	4	16	636	14	22	23	86	2	186	986
	LS8	1	2	1	1	109	0	21	1	65	35	4	3	0	633	84	47	996
	LS8	2	2	3	3	186	0	23	4	36	300	9	8	2	123	151	160	992
	LS7LS8	1	2	0	0	87	0	11	1	2	24	1	2	0	774	41	58	999
	LS7LS8	2	2	0	0	155	3	2	1	2	492	2	2	0	72	93	177	999

Table S9. Variable Selection using a bootstrapped best subset model approach for the complete dataset (All Year) Cover data.

Time	Sensor	Model Rank	Variable Count	NDVI	SAVI	RDVI	MTVII	NCI	NDCI	PSRI	SATVI	NDII7	NDWI	EVI	TC-BRI	TC-GRE	TC-WET	NDTI
All Year	LS7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000
	LS7	2	1	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
	LS8	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000
	LS8	2	1	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
	LS7LS8	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000
	LS7LS8	2	1	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
	LS7	1	2	0	0	0	13	1	328	27	0	317	310	236	65	12	20	671
	LS7	2	2	0	0	0	20	1	213	115	21	150	133	411	58	6	28	844
	LS8	1	2	0	0	0	0	0	0	0	0	1000	1000	0	0	0	0	0
	LS8	2	2	0	0	0	211	23	455	0	1	0	3	13	161	0	134	999
	LS7LS8	1	2	0	0	0	0	0	2	0	0	994	994	0	4	0	0	6
	LS7LS8	2	2	0	0	0	6	3	538	2	0	6	6	179	215	0	51	994

Table S10. Top candidate models for Cover

Time	Sensor	Predictor Var	VIF	Train-N	r ²	rRMSE	RMSD	Test-N	r ²	rRMSE	RMSD
Green	LS7	NDII7	NA	60	0.70	16.89	0.11	20	0.70	17.39	0.11
	LS7	NDWI	NA	60	0.67	17.64	0.11	20	0.70	17.49	0.11
	LS7	NDII7, NDCI	1.61	60	0.74	15.63	0.10	20	0.68	17.98	0.11
	LS7	NDII7, NDCI	1.60	60	0.74	15.63	0.10	20	0.67	18.00	0.11
	LS8	NDII7	NA	93	0.78	16.07	0.10	30	0.75	13.00	0.08
	LS8	NDWI	NA	93	0.75	17.26	0.10	30	0.70	14.39	0.09
	LS8	NDII7, NDWI	54.33	93	0.79	15.84	0.10	30	0.77	12.35	0.08
	LS8	NDII7, NDWI	53.87	93	0.79	15.84	0.10	30	0.77	12.37	0.08
	LS78	NDII7	NA	153	0.75	16.44	0.10	50	0.72	14.85	0.09
	LS78	NDWI	NA	153	0.71	17.62	0.11	50	0.69	15.74	0.10
	LS78	NDII7, NDCI	1.77	153	0.77	15.80	0.10	50	0.70	15.53	0.10
	LS78	NDII7, TCGRE	15.77	153	0.76	15.96	0.10	50	0.69	15.41	0.10
Brown	LS7	NDTI	NA	78	0.78	19.87	0.10	26	0.81	17.07	0.09
	LS7	NDII7	NA	78	0.63	25.70	0.14	26	0.68	22.52	0.12
	LS7	NDTI, TCWET	1.15	78	0.80	19.21	0.10	26	0.81	17.04	0.09
	LS7	NDTI, SATVI	1.67	78	0.80	19.21	0.10	26	0.81	17.03	0.09
	LS8	NDTI	NA	99	0.72	21.73	0.11	32	0.72	22.71	0.13
	LS8	NDII7	NA	99	0.62	25.12	0.13	32	0.59	27.81	0.15
	LS8	NDTI, TCBRI	1.02	99	0.73	21.34	0.11	32	0.74	21.84	0.12
	LS8	NDTI, SATVI	1.18	99	0.73	21.46	0.11	32	0.73	22.05	0.12
	LS78	NDTI	NA	177	0.75	20.92	0.11	58	0.73	20.69	0.11
	LS78	NDII7	NA	177	0.59	26.82	0.14	58	0.62	25.49	0.14
	LS78	NDTI, TCBRI	1.01	177	0.76	20.51	0.11	58	0.74	19.97	0.11
	LS78	NDTI, SATVI	1.28	177	0.76	20.57	0.11	58	0.74	20.17	0.11
All Year	LS7	NDTI	NA	120	0.65	22.85	0.13	40	0.72	21.00	0.12
	LS7	NDII7	NA	120	0.48	27.57	0.15	40	0.57	25.70	0.15
	LS7	NDTI, NDII7	4.84	120	0.65	22.79	0.13	40	0.72	20.82	0.12
	LS7	NDTI, EVI	2.32	120	0.66	22.28	0.12	40	0.74	20.23	0.12
	LS8	NDTI	NA	184	0.69	20.55	0.12	62	0.70	21.02	0.12
	LS8	NDII7	NA	184	0.58	23.93	0.14	62	0.51	26.82	0.15
	LS8	NDII7, NDWI	29.58	184	0.72	19.53	0.11	62	0.72	19.58	0.11
	LS8	NDTI, NDCI	1.54	184	0.70	20.21	0.11	62	0.69	21.44	0.12
	LS78	NDTI	NA	304	0.67	21.71	0.12	102	0.70	20.74	0.12
	LS78	NDII7	NA	304	0.54	25.47	0.14	102	0.53	26.23	0.15
	LS78	NDII7, NDWI	24.47	304	0.69	20.94	0.12	102	0.73	19.59	0.11
	LS78	NDTI, NDCI	1.61	304	0.67	21.41	0.12	102	0.70	20.75	0.12

Table S11. Top candidate models for Biomass

Time	Sensor	Predictor Var	VIF	Train-				Test			
				N	r ²	rRMSE	RMSD	-N	r ²	rRMSE	RMSD
Green	LS7	NDWI	NA	60	0.72	21.70	37.32	20	0.78	22.52	36.96
	LS7	NDII7	NA	60	0.69	22.84	39.27	20	0.81	21.25	34.87
	LS7	EVI, NDII7	6.98	60	0.75	20.57	35.36	20	0.78	22.96	37.69
	LS7	NDII7, PSRI	4.97	60	0.73	21.08	36.25	20	0.78	22.59	37.08
	LS8	NDII7	NA	93	0.80	20.07	32.08	30	0.81	16.86	28.96
	LS8	NDWI	NA	93	0.79	20.88	33.37	30	0.83	15.87	27.26
	LS8	NDII7, MTVII	12.26	93	0.84	18.28	29.22	30	0.79	17.28	29.69
	LS8	NDII7+TCBRI	1.00	93	0.83	18.47	29.53	30	0.81	16.68	28.66
	LS78	NDII7	NA	153	0.76	21.38	35.07	50	0.81	18.50	30.89
	LS78	NDWI	NA	153	0.75	21.68	35.56	50	0.81	18.47	30.84
	LS78	NDII7, EVI	8.13	153	0.79	19.87	32.60	50	0.82	18.22	30.42
	LS78	NDII7, PSRI	5.02	153	0.78	20.62	33.82	50	0.83	17.57	29.34
Brown	LS7	NDTI	NA	78	0.71	30.46	32.67	25	0.77	24.19	26.43
	LS7	NDII7	NA	78	0.56	37.61	40.35	25	0.75	25.19	27.52
	LS7	NDTI, NCI	1.45	78	0.72	30.04	32.23	25	0.76	24.85	27.15
	LS7	NDTI, NDCI	1.16	78	0.72	30.27	32.47	25	0.77	24.57	26.84
	LS8	NDTI	NA	99	0.67	30.88	31.20	32	0.70	26.69	32.02
	LS8	NDII7	NA	99	0.51	37.79	38.18	32	0.65	29.04	34.83
	LS8	NDTI, TCGRE	1.94	99	0.67	30.78	31.11	32	0.72	26.25	31.48
	LS8	NDTI, NDWI	1.07	99	0.68	30.53	30.85	32	0.71	26.52	31.81
	LS78	NDTI	NA	177	0.69	30.73	31.80	57	0.73	25.86	29.54
	LS78	NDII7	NA	177	0.50	39.07	40.44	57	0.65	29.51	33.71
	LS78	NDTI, NCI	1.17	177	0.70	30.39	31.45	57	0.73	25.90	29.59
	LS78	NDTI, NDCI	1.05	177	0.70	30.49	31.55	57	0.72	26.08	29.79
All Year	LS7	NDTI	NA	120	0.67	29.32	40.52	40	0.76	25.94	37.26
	LS7	NDII7	NA	120	0.63	30.97	42.80	40	0.72	28.55	41.02
	LS7	NDII7, TCGRE	25.76	120	0.63	30.82	42.60	40	0.73	27.67	39.76
	LS7	NDII7, NDTI	5.25	120	0.68	28.57	39.49	40	0.79	24.43	35.09
	LS8	NDTI	NA	184	0.74	26.34	35.38	62	0.77	27.22	35.32
	LS8	NDII7	NA	184	0.74	26.13	35.10	62	0.72	29.17	37.84
	LS8	NDII7, NDWI	22.60	184	0.78	24.13	32.42	62	0.76	27.00	35.02
	LS8	NDTI, NDII7	5.43	184	0.78	24.17	32.47	62	0.77	27.17	35.24
	LS78	NDTI	NA	304	0.70	27.88	37.82	102	0.76	26.10	35.11
	LS78	NDII7	NA	304	0.69	28.43	38.57	102	0.70	29.19	39.26
	LS78	NDII7, NDTI	4.88	304	0.74	26.19	35.53	102	0.77	25.55	34.37
	LS78	NDTI, NDWI	2.57	304	0.74	26.22	35.57	102	0.77	25.76	34.65

Table S12. Paired Cover models

VarSel	VIFm	Time	Sensor	var	int	beta1	beta2	N - Train	r2	aRMSE	rRMSE	RMSD	N - Test	r2	aRMSE	rRMSE	RMSD
Cover	NA	Summer	LS7	NDII7	0.44	0.95	NA	60	0.70	0.11	16.89	0.11	20	0.7	0.11	17.39	0.11
Cover	NA	Summer	LS7	NDWI	0.64	1.31	NA	60	0.67	0.11	17.64	0.11	20	0.7	0.11	17.49	0.11
Cover	1.61	Summer	LS7	NDII7, NDCI	0.97	1.13	-1.11	60	0.74	0.1	15.63	0.1	20	0.68	0.11	17.98	0.11
Cover	1.6	Summer	LS7	NDII7, NDCI	0.98	1.13	-1.13	60	0.74	0.1	15.63	0.1	20	0.67	0.11	18	0.11
Cover	NA	Summer	LS8	NDII7	0.44	0.92	NA	60	0.74	0.1	15.62	0.1	20	0.7	0.11	17.45	0.11
Cover	NA	Summer	LS8	NDWI	0.61	1.2	NA	60	0.70	0.11	16.96	0.11	20	0.7	0.11	17.52	0.11
Cover	1.91	Summer	LS8	NDII7, NDCI	0.82	1.05	-0.77	60	0.76	0.09	15.05	0.09	20	0.7	0.11	17.25	0.11
Cover	1.91	Summer	LS8	NDII7, NDCI	0.83	1.05	-0.79	60	0.76	0.09	15.05	0.09	20	0.7	0.11	17.24	0.11
Cover	NA	Summer	LS78	NDII7	0.44	0.93	NA	120	0.72	0.1	16.28	0.1	40	0.7	0.11	17.42	0.11
Cover	NA	Summer	LS78	NDWI	0.62	1.24	NA	120	0.68	0.11	17.47	0.11	40	0.69	0.11	17.54	0.11
Cover	1.66	Summer	LS78	NDII7, NDCI	0.87	1.08	-0.9	120	0.75	0.1	15.4	0.1	40	0.69	0.11	17.58	0.11
Cover	1.66	Summer	LS78	NDII7, NDCI	0.88	1.09	-0.92	120	0.75	0.1	15.4	0.1	40	0.69	0.11	17.6	0.11
Cover	NA	Fall	LS7	NDTI	-0.09	3.83	NA	71	0.73	0.11	21.39	0.11	23	0.86	0.08	15.45	0.08
Cover	NA	Fall	LS7	NDII7	0.63	1.93	NA	71	0.53	0.14	28.02	0.14	23	0.8	0.1	19.16	0.1
Cover	1.08	Fall	LS7	NDTI, TCWET	-0.32	3.99	0	71	0.74	0.1	20.68	0.1	23	0.84	0.08	15.85	0.09
Cover	1.44	Fall	LS7	NDTI, SATVI	-0.37	4.22	0	71	0.74	0.1	20.68	0.1	23	0.84	0.08	15.93	0.09
Cover	NA	Fall	LS8	NDTI	-0.15	4.39	NA	71	0.71	0.11	22.18	0.11	23	0.83	0.09	16.23	0.09
Cover	NA	Fall	LS8	NDII7	0.56	2.02	NA	71	0.53	0.14	27.87	0.14	23	0.73	0.11	20.74	0.11
Cover	1.04	Fall	LS8	NDTI, SATVI	-0.36	4.53	0	71	0.73	0.11	21.17	0.11	23	0.79	0.1	18.22	0.1
Cover	1.04	Fall	LS8	NDTI, SATVI	-0.36	4.53	0	71	0.73	0.11	21.17	0.11	23	0.79	0.1	18.29	0.1
Cover	NA	Fall	LS78	NDTI	-0.11	4.05	NA	142	0.71	0.11	22.06	0.11	46	0.84	0.08	15.99	0.09
Cover	NA	Fall	LS78	NDII7	0.59	1.84	NA	142	0.50	0.15	28.97	0.15	46	0.71	0.12	21.96	0.12
Cover	1.03	Fall	LS78	NDTI, TCBRI	-0.32	3.93	0	142	0.73	0.11	21.15	0.11	46	0.8	0.09	17.7	0.09
Cover	1.14	Fall	LS78	NDTI, SATVI	-0.35	4.31	0	142	0.73	0.11	21.18	0.11	46	0.81	0.09	17.38	0.09
Cover	NA	All-year	LS7	NDTI	0.02	2.94	NA	121	0.67	0.12	21.8	0.12	40	0.74	0.12	20.28	0.12
Cover	NA	All-year	LS7	NDII7	0.5	0.85	NA	121	0.48	0.15	27.32	0.15	40	0.64	0.13	22.62	0.13
Cover	4.71	All-year	LS7	NDTI, NDII7	-0.06	3.43	-0.19	121	0.67	0.12	21.62	0.12	40	0.73	0.12	20.63	0.12
Cover	1.98	All-year	LS7	NDTI, EVI	0	3.5	-0.11	121	0.69	0.12	20.93	0.12	40	0.72	0.12	20.81	0.12
Cover	NA	All-year	LS8	NDTI	0	3.23	NA	121	0.7	0.12	20.82	0.12	40	0.71	0.13	21.37	0.13
Cover	NA	All-year	LS8	NDII7	0.48	0.93	NA	121	0.54	0.14	25.71	0.14	40	0.62	0.14	23.26	0.14
Cover	25.56	All-year	LS8	NDII7, NDWI	-0.05	3.6	-3.63	121	0.72	0.11	19.95	0.11	40	0.77	0.11	18.35	0.11
Cover	1.49	All-year	LS8	NDTI, NDCI	0.13	3.51	-0.38	121	0.71	0.11	20.42	0.11	40	0.7	0.13	21.44	0.13
Cover	NA	All-year	LS78	NDTI	0.02	3.04	NA	242	0.67	0.12	21.57	0.12	80	0.72	0.12	20.66	0.12
Cover	NA	All-year	LS78	NDII7	0.49	0.88	NA	242	0.5	0.15	26.6	0.15	80	0.63	0.13	22.93	0.14
Cover	21.06	All-year	LS78	NDII7, NDWI	-0.01	3.25	-3.26	242	0.69	0.12	21.13	0.12	80	0.78	0.11	18.59	0.11
Cover	1.47	All-year	LS78	NDTI, NDCI	0.16	3.3	-0.4	242	0.69	0.12	21.18	0.12	80	0.71	0.12	20.61	0.12

Table S13. Paired Biomass models

VarSel	VIFm	Time	Sensor	Variables	int	beta1	beta2	N - Train	r2	aRMSE	rRMSE	RMSD	N - Test	r2	aRMSE	rRMSE	RMSD
Biomass	NA	Summer	LS7	NDWI	174.15	491.63	NA	60	0.72	37.01	21.70	37.32	20	0.78	36.02	22.52	36.96
Biomass	NA	Summer	LS7	NDII7	104.06	343.18	NA	60	0.69	38.94	22.84	39.27	20	0.81	33.99	21.25	34.87
Biomass	6.98	Summer	LS7	EVI, NDII7	209.75	-131.80	585.06	60	0.75	35.06	20.57	35.36	20	0.78	36.74	22.96	37.69
Biomass	4.97	Summer	LS7	NDII7, PSRI	49.53	522.31	891.37	60	0.73	35.95	21.08	36.25	20	0.78	36.14	22.59	37.08
Biomass	NA	Summer	LS8	NDII7	102.49	338.71	NA	60	0.77	33.70	19.77	33.99	20	0.84	30.30	18.94	31.09
Biomass	NA	Summer	LS8	NDWI	163.88	457.27	NA	60	0.76	34.13	20.02	34.42	20	0.81	32.53	20.33	33.37
Biomass	4.95	Summer	LS8	NDII7, TCWET	272.09	174.71	0.08	60	0.81	30.22	17.72	30.47	20	0.83	31.70	19.82	32.52
Biomass	4.90	Summer	LS8	NDII7, TCWET	271.13	176.22	0.08	60	0.81	30.22	17.72	30.47	20	0.83	31.70	19.82	32.52
Biomass	NA	Summer	LS78	NDII7	103.22	341.00	NA	120	0.73	36.44	21.37	36.59	40	0.82	32.15	20.10	32.56
Biomass	NA	Summer	LS78	NDWI	169.12	469.49	NA	120	0.73	36.04	21.14	36.19	40	0.79	34.51	21.57	34.95
Biomass	7.24	Summer	LS78	NDII7, EVI	203.61	565.57	-122.77	120	0.78	32.88	19.28	33.02	40	0.80	34.63	21.65	35.07
Biomass	4.68	Summer	LS78	NDII7, PSRI	62.19	482.69	704.18	120	0.76	34.07	19.98	34.21	40	0.79	34.87	21.80	35.31
Biomass	NA	Fall	LS7	NDTI	-56.518	1040.92	NA	71	0.69	31.80	30.27	32.03	23	0.76	27.50	27.86	28.12
Biomass	NA	Fall	LS7	NDII7	140.759	518.646	NA	71	0.50	40.37	38.42	40.66	23	0.73	29.58	29.96	30.24
Biomass	4.335002283	Fall	LS7	NDII7, NDWI	-122.75	1122.95	-1374.309	71	0.70	31.02	29.52	31.24	23	0.75	28.59	28.97	29.24
Biomass	1.539369489	Fall	LS7	NDTI, NDWI	-114.78	1136.29	-196.2459	71	0.70	31.19	29.68	31.41	23	0.75	28.57	28.94	29.21
Biomass	NA	Fall	LS8	NDTI	-72.488	1192.72	NA	71	0.68	32.39	30.82	32.62	23	0.73	30.61	31.01	31.30
Biomass	NA	Fall	LS8	NDII7	120.496	538.874	NA	71	0.49	40.52	38.56	40.81	23	0.75	29.18	29.56	29.83
Biomass	4.954856962	Fall	LS8	NDTI, NDII7	-104.28	1384.63	-112.8741	71	0.68	32.15	30.60	32.38	23	0.71	31.67	32.09	32.38
Biomass	1.635589463	Fall	LS8	NDTI, NDWI	-104.77	1269.13	-118.7969	71	0.68	32.14	30.59	32.37	23	0.71	31.70	32.12	32.41
Biomass	NA	Fall	LS78	NDTI	-62.021	1099.22	NA	142	0.68	32.45	30.88	32.57	46	0.74	29.06	29.44	29.38
Biomass	NA	Fall	LS78	NDII7	129.156	495.262	NA	142	0.46	41.73	39.72	41.88	46	0.68	31.73	32.15	32.08
Biomass	1.299048691	Fall	LS78	NDTI, NCI	-136.85	1028.81	166.89926	142	0.69	31.96	30.42	32.08	46	0.72	30.70	31.11	31.04
Biomass	1.126359901	Fall	LS78	NDTI, NDCI	-104.73	1066.83	118.78475	142	0.68	32.19	30.64	32.30	46	0.73	29.88	30.27	30.21
Biomass	NA	All_year	LS7	NDTI	-31.366	906.524	NA	121	0.64	39.68	29.51	39.84	40	0.81	40.58	28.32	41.09
Biomass	NA	All_year	LS7	NDII7	115.081	292.015	NA	121	0.57	43.24	32.16	43.41	40	0.84	38.34	26.76	38.83
Biomass	18.07249153	All_year	LS7	NDII7, TCGRE	146.671	508.608	-0.082362	121	0.59	42.20	31.40	42.38	40	0.85	39.59	27.63	40.09
Biomass	3.408371766	All_year	LS7	NDII7, PSRI	65.892	451.056	428.41855	121	0.65	39.36	29.28	39.52	40	0.87	32.88	22.95	33.30
Biomass	NA	All_year	LS8	NDTI	-39.482	1010.45	NA	121	0.69	36.92	27.46	37.07	40	0.83	36.94	25.78	37.41
Biomass	NA	All_year	LS8	NDII7	107.448	317.912	NA	121	0.63	40.12	29.84	40.29	40	0.86	34.70	24.22	35.14
Biomass	25.82205733	All_year	LS8	NDII7, NDWI	-2.3962	867.473	-749.1708	121	0.71	35.53	26.43	35.68	40	0.88	36.45	25.45	36.92
Biomass	5.291258272	All_year	LS8	NDTI, NDII7	0.11765	729.562	102.4031	121	0.70	36.17	26.91	36.32	40	0.86	33.34	23.27	33.77
Biomass	NA	All_year	LS78	NDTI	-33.051	943.251	NA	242	0.66	38.77	28.84	38.85	80	0.82	39.19	27.35	39.43
Biomass	NA	All_year	LS78	NDII7	111.424	302.586	NA	242	0.60	41.86	31.14	41.94	80	0.85	37.08	25.88	37.31
Biomass	4.534550138	All_year	LS78	NDII7, NDTI	8.2787	105.494	665.44902	242	0.67	37.85	28.16	37.93	80	0.86	34.91	24.37	35.14
Biomass	2.384696	All_year	LS78	NDTI, NDWI	5.922948	777.8204	97.18696	242	0.67	37.94	28.22	38.02	80	0.85	34.94	24.39	35.16

Figure S3. Scatter plots between in-field estimates of cover and biomass with select vegetation indices (NDTI, NDII7, NDVI) using Landsat 7 data.

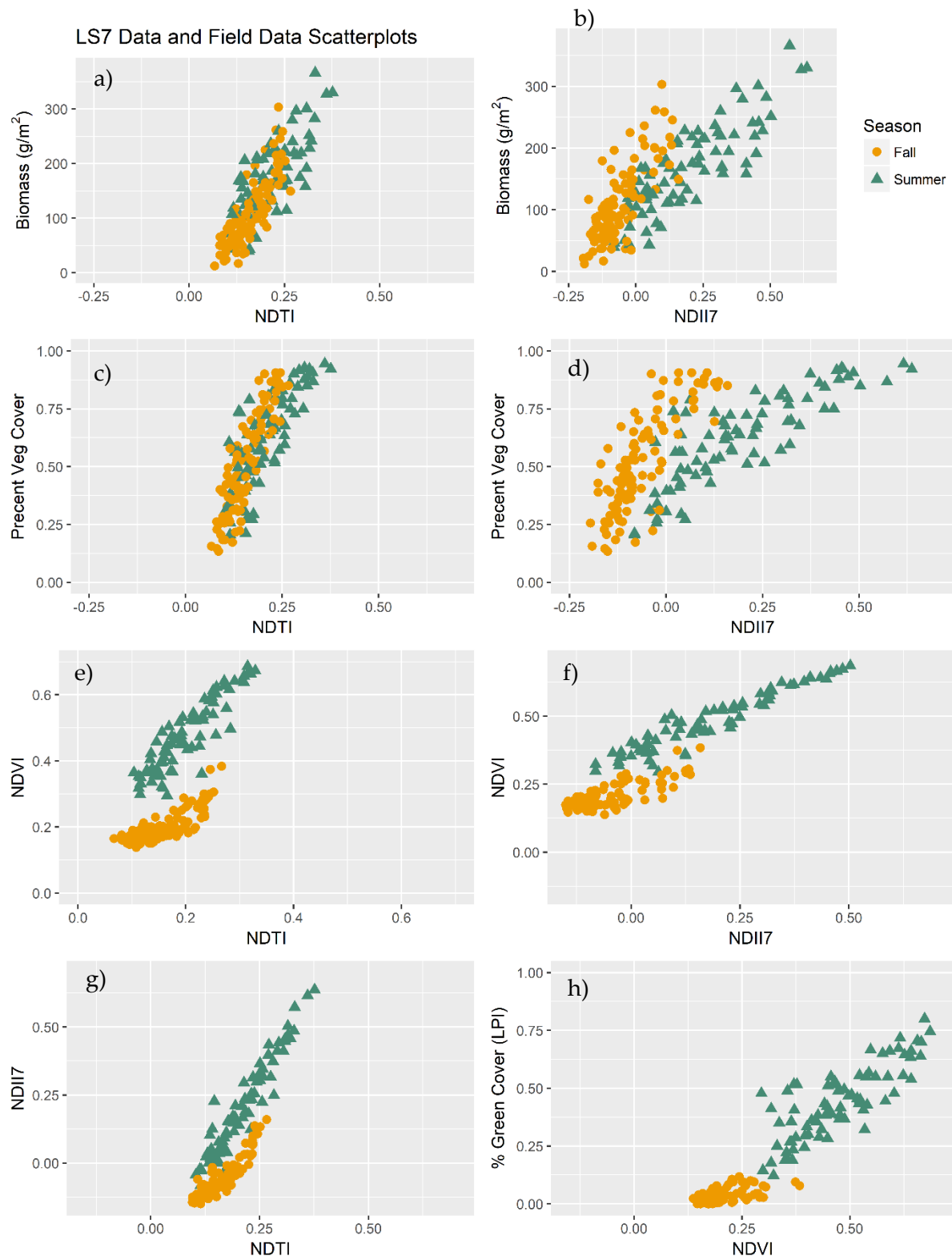


Figure S4. Scatter plots between in-field estimates of cover and biomass with select vegetation indices (NDTI, NDII7, NDVI) using Landsat 8 data.

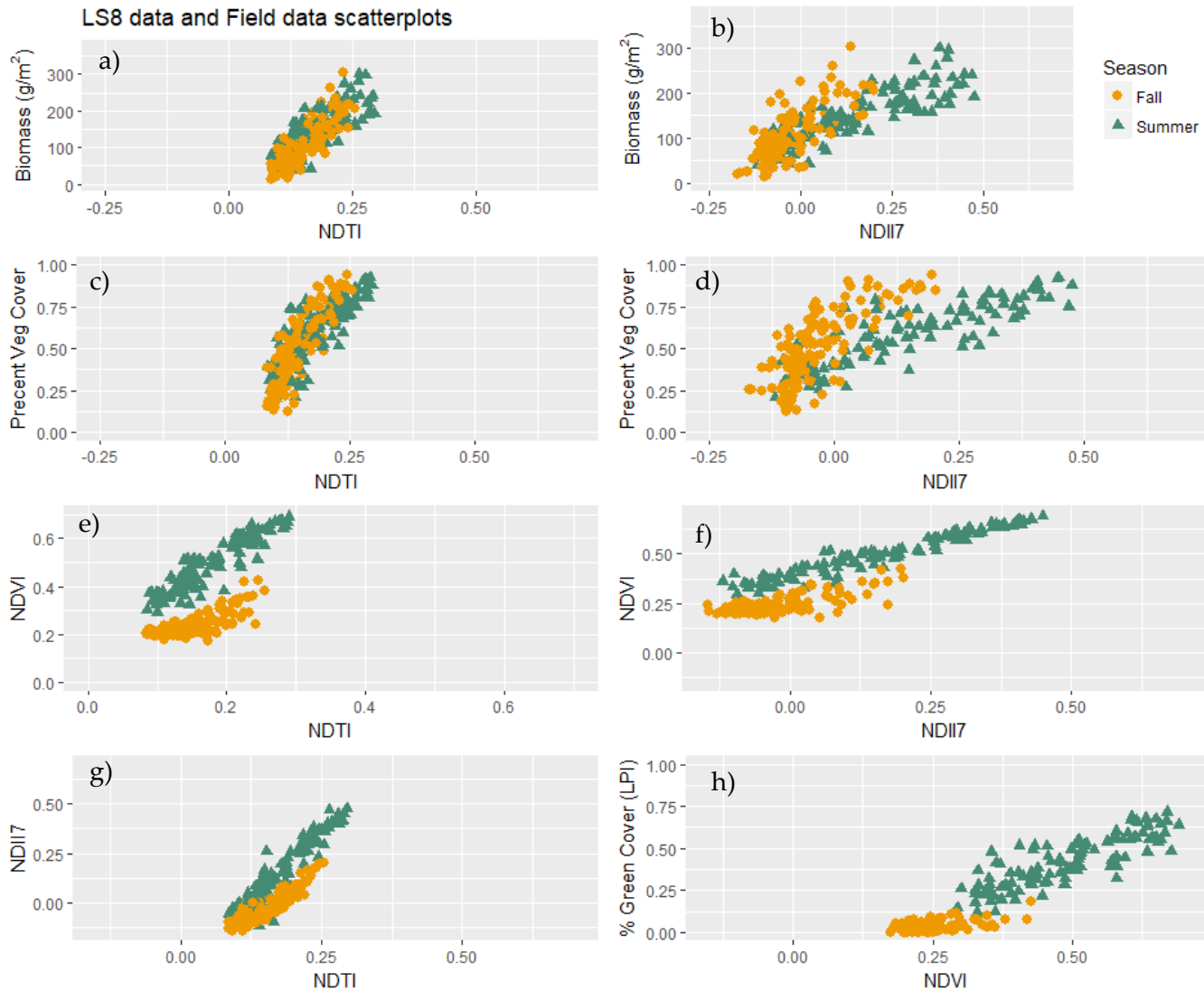


Figure S5. Scatter plots between in-field estimates of cover and biomass with select vegetation indices (NDTI, NDII7, NDVI) using Landsat 7 and Landsat 8 data.

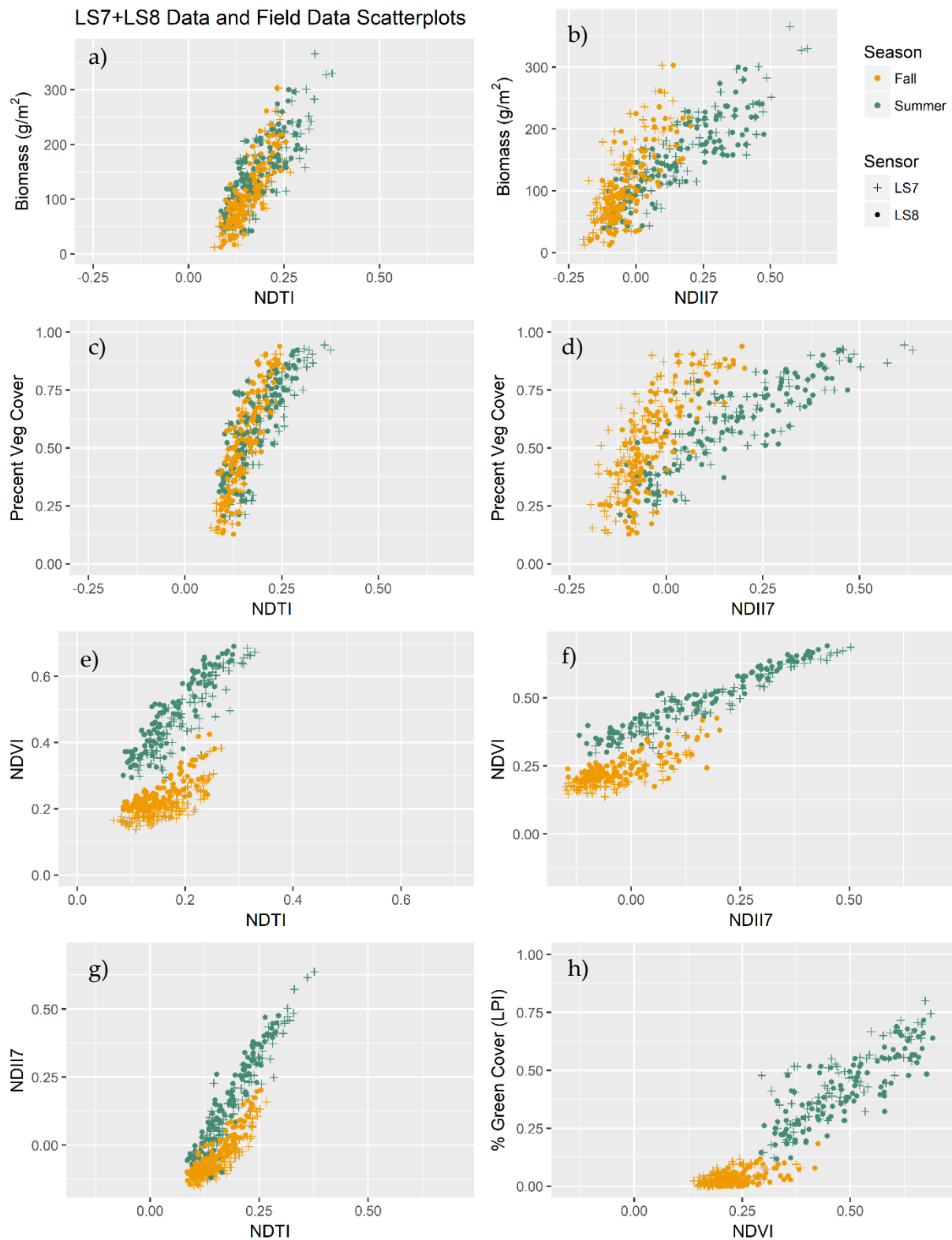


Table S14. Table of Median and Mean pixel differences in Biomass across scene pairs across all model combinations and the associated vegetation index (NDII7 for Green, NDTI for Brown).

Time	Scenes Compared	Statistic	LS8SLS7M LS7SLS7M	LS8SLS8M LS7SLS7M	LS8SLS78M LS7SLS7M	LS8SLS7M LS7SLS8M	LS8SLS8M LS7SLS8M	LS8SLS78M LS7SLS8M	LS8SLS7M LS7SLS78M	LS8SLS8M LS7SLS78M	LS8SLS78M LS7SLS78M	LS8VI- LS7VI
Green	Jun. 28-29 2013	Median	2.31	0.78	1.35	3.82	2.29	2.87	3.26	1.73	2.31	0.61
		Mean	2.59	1.14	0.89	4.06	2.61	-6.33	3.51	2.04	2.55	3.09
	Jun. 23-24 2014	Median	1.26	-0.35	0.29	2.87	1.26	1.90	2.23	0.62	1.26	2.5
		Mean	0.93	-0.64	-0.03	2.50	0.93	1.54	1.89	0.32	0.93	8.25
	Jun. 10-11 2015	Median	-1.13	-2.73	-2.09	0.48	-1.12	-0.49	-0.16	-1.76	-1.12	-1.6
		Mean	-1.91	-3.59	-2.80	-0.31	-1.88	-1.22	-0.68	-2.47	-1.87	1.09
	Jun. 26-27 2015	Median	4.14	2.63	3.19	5.62	4.11	4.67	5.08	3.57	4.14	1.99
		Mean	4.27	2.77	3.32	5.73	4.23	4.78	5.21	3.70	4.26	-25.25
	Jun. 20-21 2016	Median	2.91	1.29	1.94	4.51	2.89	3.54	3.87	2.26	2.90	5.87
		Mean	3.00	1.39	2.03	4.58	2.98	3.62	3.96	2.35	2.99	5.45
	Jun. 23-24 2017	Median	1.99	0.34	1.01	3.63	1.98	2.66	2.97	1.31	1.99	3.95
		Mean	2.14	0.51	1.17	3.76	2.13	2.79	3.11	1.48	2.14	7.71
	All Scene Averages	Avg Median	1.91	0.33	0.95	3.49	1.90	2.52	2.88	1.29	1.91	2.22
		Std Median	1.62	1.65	1.63	1.59	1.61	1.59	1.61	1.64	1.62	2.37
		Avg Mean	1.84	0.26	0.76	3.39	1.83	0.86	2.83	1.06	1.57	0.06
		Std Mean	1.95	2.00	1.90	1.91	1.93	3.72	1.86	1.94	1.93	11.59
Brown	Sep. 11-12 2014	Median	-6.68	-4.54	-5.09	-8.01	-5.88	-6.43	-7.39	-5.25	-5.80	-3.8
		Mean	-6.55	-3.55	-4.79	-8.18	-5.56	-6.32	-6.26	-5.11	-5.73	-3.67
	Sep. 19-20 2014	Median	1.19	3.20	2.53	-0.15	1.86	1.19	0.51	2.52	1.84	1.28
		Means	1.93	3.55	3.01	0.47	2.06	2.59	0.83	2.72	2.62	1.57
	Oct. 16-17 2015	Median	-2.88	-0.67	-1.16	-4.21	-2.00	-2.49	-3.70	-1.47	-1.97	-1.23
		Mean	-2.10	0.21	0.15	-3.35	-0.63	-1.93	-3.25	-0.54	-1.08	-0.99
	Sep. 24-25 2016	Median	-3.35	-1.30	-1.93	-4.69	-2.64	-3.27	-4.02	-1.97	-2.61	-1.76
		Mean	-3.10	-0.57	-1.22	-3.91	-1.70	-2.61	-3.46	-1.25	-1.83	-1.28
	Aug. 18- 19 2017	Median	-1.20	0.71	-0.05	-2.54	-0.63	-1.39	-1.77	0.14	-0.62	-0.44
		Mean	-2.19	1.66	-0.01	2.01	-0.49	-0.81	-1.32	0.70	-0.60	-0.25
	Sep. 27-28 2017	Median	-2.08	-0.13	-0.85	-3.42	-1.47	-2.19	-2.68	-0.73	-1.45	-1.02
		Mean	-1.63	0.29	-0.38	-6.72	-0.94	-1.65	-2.27	3.74	-1.17	-0.84
	All Scene Averages	Avg Median	-2.50	-0.45	-1.09	-3.84	-1.79	-2.43	-3.18	-1.13	-1.77	-1.16
		Std Median	2.38	2.32	2.27	2.37	2.32	2.27	2.40	2.34	2.29	1.52
		Avg Mean	-2.28	0.26	-0.54	-3.28	-1.21	-1.79	-2.62	0.04	-1.30	-0.91
		Std Mean	2.49	2.16	2.31	3.61	2.26	2.63	2.16	2.88	2.45	1.55

Table S15. Table of Median and Mean differences in Cover between scene pairs across all model combinations and the associated vegetation index (NDII7 for Green, NDTI for Brown).

Time	Scenes Compared	Stat	LS8SL57M LS7SL57M	LS8SL58M LS7SL57M	LS8SL578M LS7SL57M	LS8SL57M LS7SL58M	LS8SL58M LS7SL58M	LS8SL578M LS7SL58M	LS8SL57M LS7SL578M	LS8SL58M LS7SL578M	LS8SL578M LS7SL578M	LS8VI- LS7VI
Green	Jun. 28-29	Median	0.87	0.79	1.04	1.68	1.60	1.85	1.43	1.35	1.60	0.61
	2013	Mean	0.91	0.84	1.09	1.73	1.66	1.91	1.48	1.41	1.66	3.09
	Jun. 23-24	Median	0.34	0.16	0.41	1.12	0.94	1.20	0.86	0.69	0.94	2.5
	2014	Mean	0.04	-0.10	0.15	0.83	0.69	0.94	0.58	0.43	0.69	8.25
	Jun. 10-11	Median	-1.46	-1.62	-1.36	-0.67	-0.84	-0.58	-0.93	-1.09	-0.84	-1.6
	2015	Mean	-1.89	-2.04	-1.79	-1.11	-1.26	-1.00	-1.36	-1.51	-1.26	1.09
	Jun. 26-27	Median	2.06	2.00	2.25	2.88	2.82	3.07	2.64	2.57	2.82	1.99
	2015	Mean	2.00	1.93	2.18	2.82	2.75	3.00	2.57	2.50	2.75	-25.25
	Jun. 20-21	Median	1.57	1.38	1.64	2.35	2.17	2.42	2.10	1.91	2.17	5.87
	2016	Mean	1.58	1.40	1.66	2.37	2.19	2.44	2.11	1.93	2.19	5.45
	Jun. 23-24	Median	0.99	0.76	1.02	1.76	1.53	1.79	1.50	1.27	1.53	3.95
	2017	Mean	1.02	0.81	1.07	1.80	1.59	1.84	1.54	1.33	1.59	7.71
	All Scene Averages	Avg Median	0.62	0.49	0.71	1.30	1.17	1.39	1.09	0.96	1.17	2.22
		Std Median	1.07	1.07	1.09	1.17	1.16	1.20	1.13	1.13	1.16	2.59
		Avg Mean	0.52	0.40	0.62	1.21	1.09	1.30	0.99	0.87	1.09	0.06
		Std Mean	1.20	1.20	1.21	1.28	1.27	1.31	1.25	1.25	1.27	12.69
Brown	Sep. 11-12	Median	-5.18	-3.87	-4.13	-5.87	-4.56	-4.82	-5.57	-4.26	-4.52	-3.8
	2014	Mean	-4.28	-3.87	-4.09	-6.11	-3.96	-4.02	-6.59	-9.75	-4.51	-3.67
	Sep. 19-20	Median	0.93	2.21	1.88	0.22	1.51	1.18	0.54	1.82	1.49	1.28
	2014	Mean	1.64	2.90	2.46	0.62	2.13	1.61	1.00	2.16	2.28	1.57
	Oct. 16-17	Median	-2.20	-0.86	-1.09	-2.84	-1.50	-1.73	-2.59	-1.26	-1.49	-1.23
	2015	Mean	-1.81	-0.47	-0.68	-2.42	-1.08	-1.29	-2.21	-0.87	-1.08	-0.99
	Sep. 24-25	Median	-2.67	-1.38	-1.68	-3.38	-2.09	-2.39	-3.06	-1.76	-2.07	-1.76
	2016	Mean	-1.98	-0.83	-1.28	-2.89	-1.48	-1.76	-2.17	-1.26	-2.11	-1.28
	Aug. 18-19	Median	-1.00	0.26	-0.12	-1.76	-0.50	-0.89	-1.38	-0.12	-0.50	-0.44
	2017	Mean	-0.74	1.23	0.51	-1.43	-0.35	-0.72	-1.03	-0.45	-0.15	-0.25
	Sep. 27-28	Median	-1.71	-0.44	-0.80	-2.46	-1.19	-1.55	-2.09	-0.82	-1.18	-1.02
	2017	Mean	-1.30	-0.07	-0.66	-2.19	-0.84	-1.26	-1.86	-0.51	-0.71	-0.84
	All Scene Averages	Avg Median	-1.69	-0.58	-0.85	-2.30	-1.19	-1.46	-2.02	-0.91	-1.18	-1.16
		Std Median	1.84	1.71	1.70	1.93	1.75	1.76	1.89	1.73	1.73	1.66
		Avg Mean	-1.21	-0.16	-0.54	-2.06	-0.80	-1.06	-1.84	-1.53	-0.90	-0.91
		Std Mean	1.70	1.91	1.84	2.04	1.69	1.59	2.23	3.51	1.93	1.69

Figure S6. Scatter plots of simple and polynomial linear regressions using the summer, fall, and all-year cover data for both Landsat7 and Landsat 8.

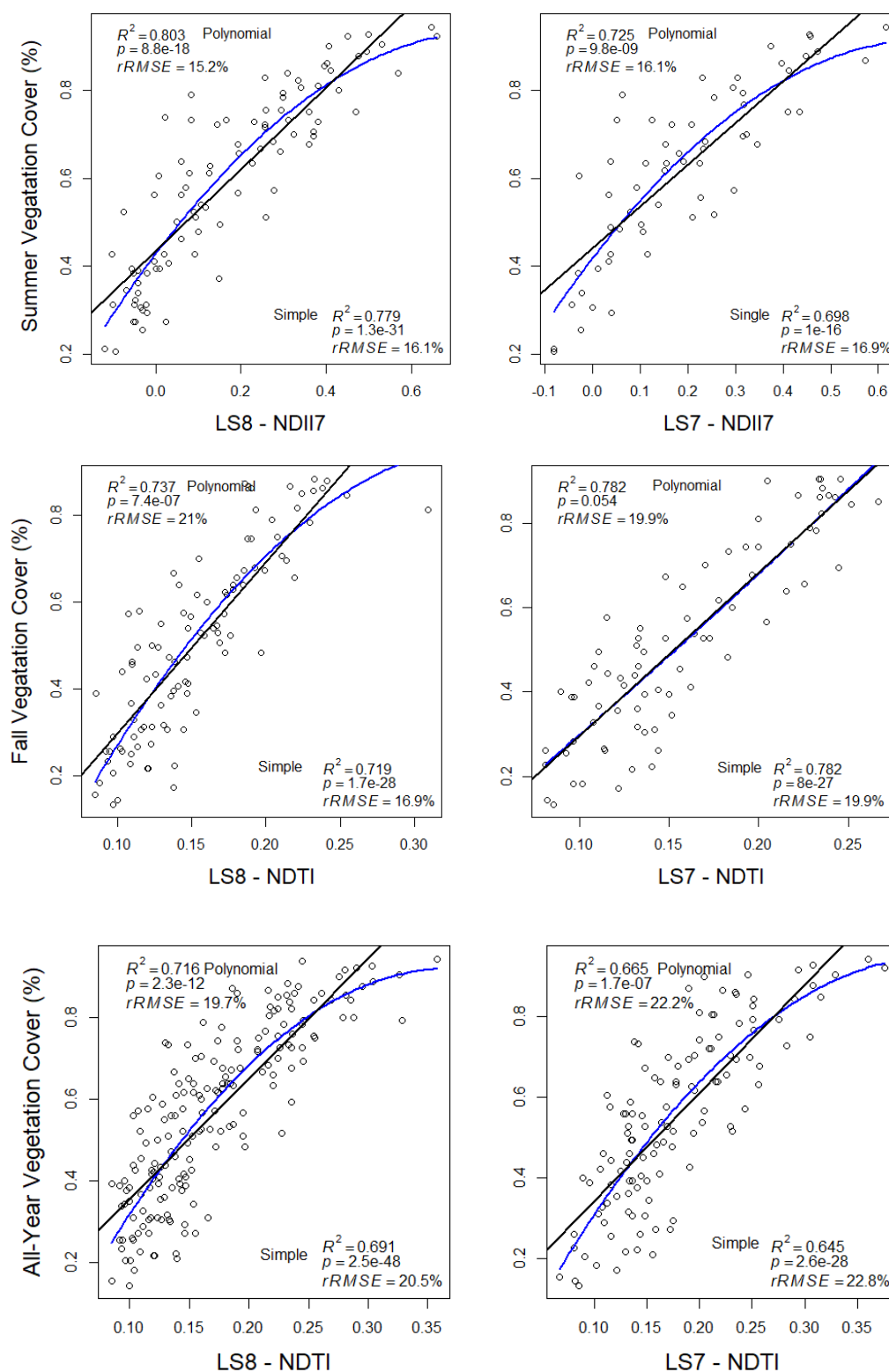


Figure S16. Model fit statistics for simple and polynomial linear regressions using the summer and fall cover data.

Metric	Time	Sensor	Model	Veg Index	Training				Lillie-test	Testing			
					N	R ²	rRMSE	RMSD		N	R ²	rRMSE	RMSD
Cover	Summer	LS7	Simple	NDII7	60	0.70	16.89	0.106	0.89	20	0.70	17.39	0.111
	Summer	LS7	Polynomial	NDII7	60	0.72	16.12	0.101	0.47	20	0.70	17.03	0.108
	Summer	LS8	Simple	NDII7	93	0.78	16.07	0.097	0.60	30	0.75	13.00	0.085
	Summer	LS8	Polynomial	NDII7	60	0.80	15.20	0.091	0.48	30	0.77	11.97	0.078
	Fall	LS7	Simple	NDTI	78	0.78	19.87	0.104	0.48	26	0.81	17.07	0.090
	Fall	LS7	Polynomial	NDTI	78	0.78	19.85	0.104	0.48	26	0.81	17.15	0.091
	Fall	LS8	Simple	NDTI	99	0.72	21.73	0.110	0.51	32	0.72	22.71	0.125
	Fall	LS8	Polynomial	NDTI	99	0.74	21.02	0.106	0.84	32	0.72	22.16	0.122
	All-Year	LS7	Simple	NDTI	120	0.65	22.84	0.12	0.64	40	0.72	21.00	0.121
	All-Year	LS7	Polynomial	NDTI	120	0.67	22.18	0.12	0.93	40	0.75	20.50	0.118
	All-Year	LS8	Simple	NDTI	184	0.69	20.55	0.12	0.61	62	0.70	21.02	0.115
	All-Year	LS8	Polynomial	NDTI	184	0.72	19.70	0.11	0.89	62	0.74	18.97	0.104