2023

Drone Imagery For Potato Trials In Tulelake, CA

Sixten drone images taken throughout the growing season were acquired from the Southwest and Western Region potato trials at the Intermountain Research and Extension Center during 2023.

Image analysis results are summarized in this report.

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RESEARCH REPORT
Number 207, 2023

Drone Imagery From 2023 Southwest and Western Region Potato Trials In Tulelake, CA

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Prepared Report

A total of 16 drone multispectral images were collected using DJI Mavic 3M from the study field that contained three different potato variety trials (Russet, Red and Chip) at different crop growth stages. All raw images were processed through the Pix4D software for image stitching, then all analyses were performed through ArcGIS pro software. The purpose of this report is to give an example for drone multispectral analysis for potato variety trials.

More details about the potato trials can be found in IREC research report number 205, 2023.

Drone Flights Details

Location: Intermountain Research and Extension Center, Tulelake, CA

Planting Date: May 19th

Harvest Date: September 26th

Flight Altitude: 59 Feet

Frontal Overlap: 80%

Side Overlap: 70%

Forward Speed: 3.5 mph

Ground Sampling Distance: 0.83 cm/pixel (0.33 inch/pixel)

Drone images dates and days after planting (DAF):

I	Date	DAF
1	06-06-2023	18
2	06-09-2023	21
3	06-12-2023	24
4	06-16-2023	28
5	06-23-2023	35
6	07-06-2023	48
7	07-14-2023	56
8	07-17-2023	59
9	07-21-2023	63
10	07-25-2023	67
11	07-28-2023	70
12	08-01-2023	74
13	08-04-2023	77
14	08-08-2023	81
15	08-14-2023	87
16	08-17-2023	90

Drone Image Analysis

Images were analyzed using ArcGIS pro software as follows:

1- Relocation for all images using ground control points to adjust images location for more precise and consistent analysis.

2- Creating rectangular polygons with 5 ft width and 15 ft length centered into each potato variety plot.

3- Extracting spectral data from each variety from all images and calculating NDVI, GNDVI, NDRE using the following equations:

GNDVI = (G-NIR) / (G+NIR)

NDVI = (R-NIR) / (R+NIR)

NDRE = (RE-NIR) / (RE+NIR)

Where G is the green, R is the red, RE is the red-edge and NIR is the near infrared reflectance values.

4- Calculating the crop coverage area from early growth stages till row closure by applying the following steps on each image:

A- Calculating NDVI and classifying pixels based on values where only NDVI>0.5 pixels were considered as vegetation.

B- Converting the classified image from raster to polygon format.

C- Clipping vegetation polygons from each variety box and calculating the total area of vegetation to calculate the crop coverage percentage. See figure 1 for example of one variety from one image.

Results of this analysis had three outcomes as follows:

1- Archived images for each variety at different crop stages.
2- Measurements of vegetation coverage area.
3- Time series for three vegetation indices at different crop growth stages.

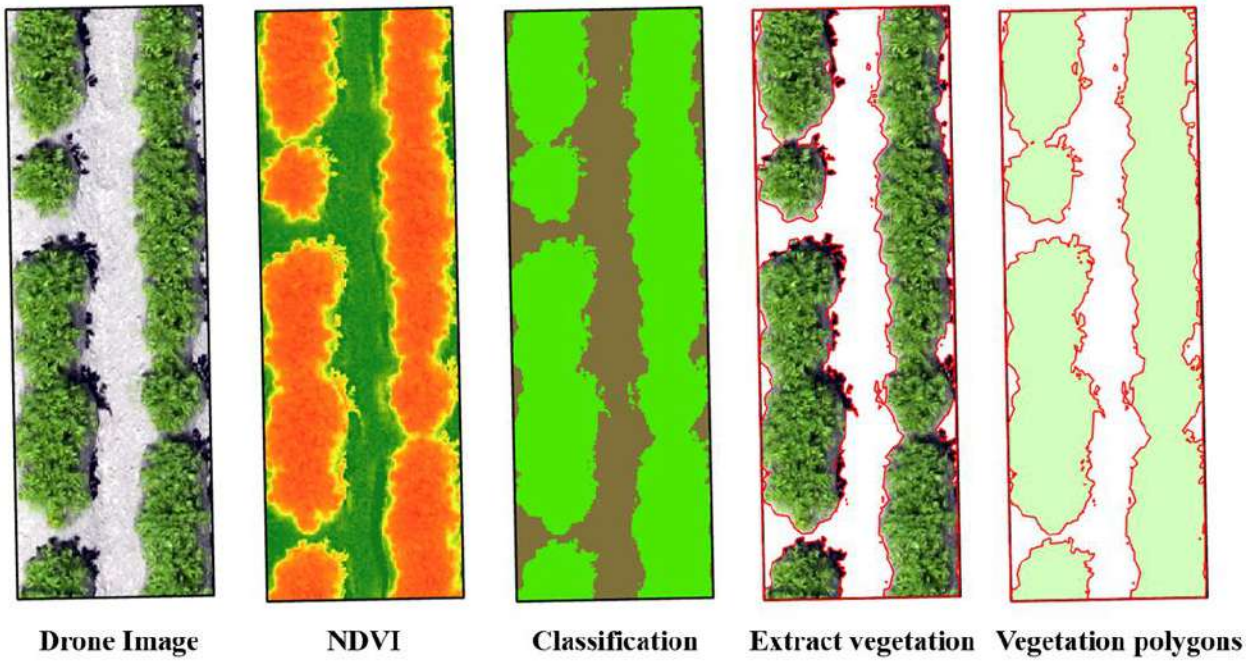

Figure 1: Example of measuring crop coverage area from a drone image acquired on 7-6-2023.

Vegetation Coverage Area

Vegetation coverage area from a 5ft × 15ft box in the center of each plot was used to calculate the percentage of vegetation coverage area. Complete row closure occured when the percentage value reached 95%. Tables 2, 3 and 4 shows the percentage of vegetation coverage area for Russet, Red and Chip varieties. This information can help growers and breeders evaluate early season vigor, seed emergence problems, potential weed competition, or early season disease.

Table 2: Vegetation coverage area percentage for Russet varieties

Clone / Variety	DAP									
	18	**21**	**24**	**28**	**35**	**48**	**56**	**59**	**63**	**67**
Clearwater Russet	0	1	6	20	74	100	99	100	100	100
Ranger Russet	1	3	14	31	81	100	100	100	100	100
Russet Burbank	2	5	19	39	99	100	100	100	100	100
A09086-1LB	2	7	24	49	97	100	100	99	100	100
A10594-4sto	1	4	17	41	94	100	100	100	100	100
A12169-5	0	2	10	23	69	99	100	100	100	100
A12305-2adg	1	4	17	38	87	100	100	100	100	100
A13036-12	3	6	18	33	70	97	99	100	100	100
AC12090-3RU	0	1	3	6	23	60	72	85	95	99
AFA5661-8	0	0	3	12	61	99	100	100	100	100
AOR11217-3	0	0	6	19	70	100	100	100	100	100
AOR13064-2	1	3	15	28	75	100	98	99	100	100
CO13003-1RU	0	0	6	19	79	100	99	100	100	100
COTX08063-2Ru	0	3	13	28	78	100	100	100	100	100
Russet Norkotah	1	4	19	36	84	100	100	100	100	100
COTX10080-2Ru	0	2	9	21	66	100	98	99	100	100
CO15016-1RUsto	0	1	4	15	66	96	97	99	100	100

Table 3: Vegetation coverage area percentage for Red varieties

Clone / Variety	DAP									
	18	**21**	**24**	**28**	**35**	**48**	**56**	**59**	**63**	**67**
Chieftain	1	4	17	29	78	98	100	100	100	100
Modoc	0	3	12	25	80	100	100	100	100	100
A08122-9RY	1	3	14	31	84	100	100	100	100	100
A11582-1R	0	1	9	22	79	100	100	100	100	100
Yukon Gold	1	3	12	27	72	99	99	99	100	100
A11573-5RYsto	1	4	18	38	86	100	100	100	100	100
AC10376-2012-1W/Y	0	1	9	28	82	100	100	98	99	98
AORTX09037-5W/Y	4	11	32	48	88	98	99	100	100	100
NDTX081451CB-1Y/Y	3	11	36	56	100	100	100	100	100	100
POR16PG34-1	0	2	12	31	87	100	100	100	100	100
Purple Majesty	0	1	5	14	57	94	96	100	100	100
COTX08365f-3P/P	0	3	13	30	90	100	100	100	100	100
POR16PG25-2	1	4	12	24	74	99	100	100	100	100
POR189G54-1	1	3	13	27	69	96	95	94	98	99
CO15084-4R	0	2	11	26	74	100	100	100	99	99

Table 4: Vegetation coverage area percentage for Chip varieties

Clone / Variety	DAP									
	18	**21**	**24**	**28**	**35**	**48**	**56**	**59**	**63**	**67**
Atlantic	3	7	23	36	71	97	97	97	99	100
Lamoka	1	4	19	39	90	100	100	100	100	100
Snowden	5	12	31	50	94	100	100	99	100	100
A13125-3C	1	6	24	49	99	100	100	100	100	100
AC13126-1Wadg	1	4	15	33	80	100	100	100	100	100
CO12235-3W	6	12	34	58	99	100	100	100	100	100
CO12293-1W	4	9	28	53	100	100	100	100	100	100
COOR13270-2	1	4	15	34	87	100	100	100	100	100
NYOR14Q9-5	0	1	9	28	87	100	100	100	100	100
NYOR14Q9-9	3	8	23	44	94	100	100	100	100	100
AC13125-5W	5	10	29	54	99	100	100	100	100	100

Vegetation Indices

Vegetation indices (VIs) describe vegetation properties such as photosynthetic activity and canopy structure. There are many VIs and calculation depends on the available measurements of spectral bands. For instance, NDVI is calculated from Red and NIR bands where Red light is mostly absorbed by the top of plant canopy. The NDVI saturates when the field is covered by healthy reflecting plant leaves therefore it is difficult to measure small vegetation changes with NDVI in fields with high biomass density. NDRE is calculated from Red-Edge and NIR bands where Red-Edge penetrates better through the canopy and gives better idea for canopy structure. NDRE complements NDVI as it is sensitive even with high density biomass. Furthermore, GNDVI is commonly used to determine water and nitrogen uptake into the plant canopy.

Timeseries analysis of Vis can help in assessing crop performance, drought stress or disease severity. Also, VIs are useful in growers fields for mapping field variability and correlating in season measurements with crop yield.

Figure 2 is an example for NDVI time series of three Russet varieties. The complete results for time series of GNDVI, NDVI and NDRE for all potato trials are available in appendix 1.

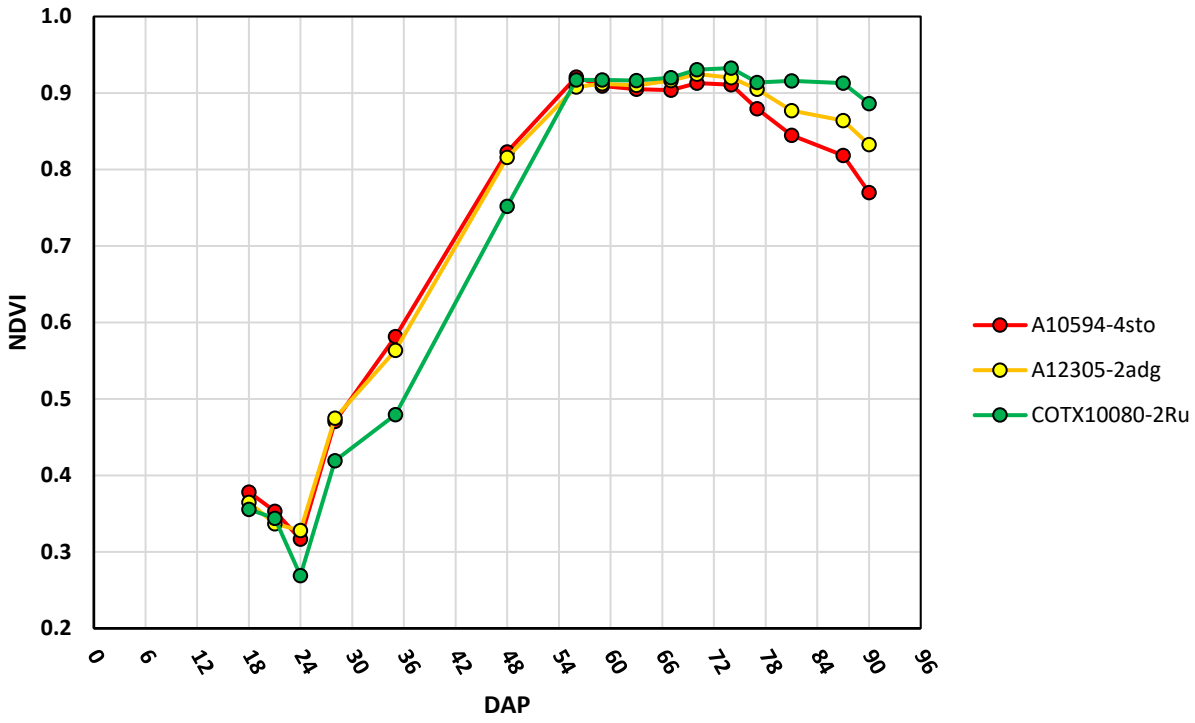

Figure 2: Example of NDVI time series for three Russet varieties.

Archived Images

Images of all varieties were compiled on one page for each drone image date to allow for convenient side by side visual comparisons. These images can easily be archived and shared with stakeholders. This could provide a better assessment approach for measuring disease severity, vine maturity, vigor, and variety tolerance to water and heat stress. In 2023, Rob Wilson evaluated early dying severity by calculating AUDPC during the season using in field observations and then reevaluated after the season by looking for disease symptoms using archived drone images. Figure 3 shows a 1:1 graph for AUDPC ratings for the Russet varieties using field observation and archived drone images. A complete set of archived images for each variety and their associated VIs are included in Appendix 2.

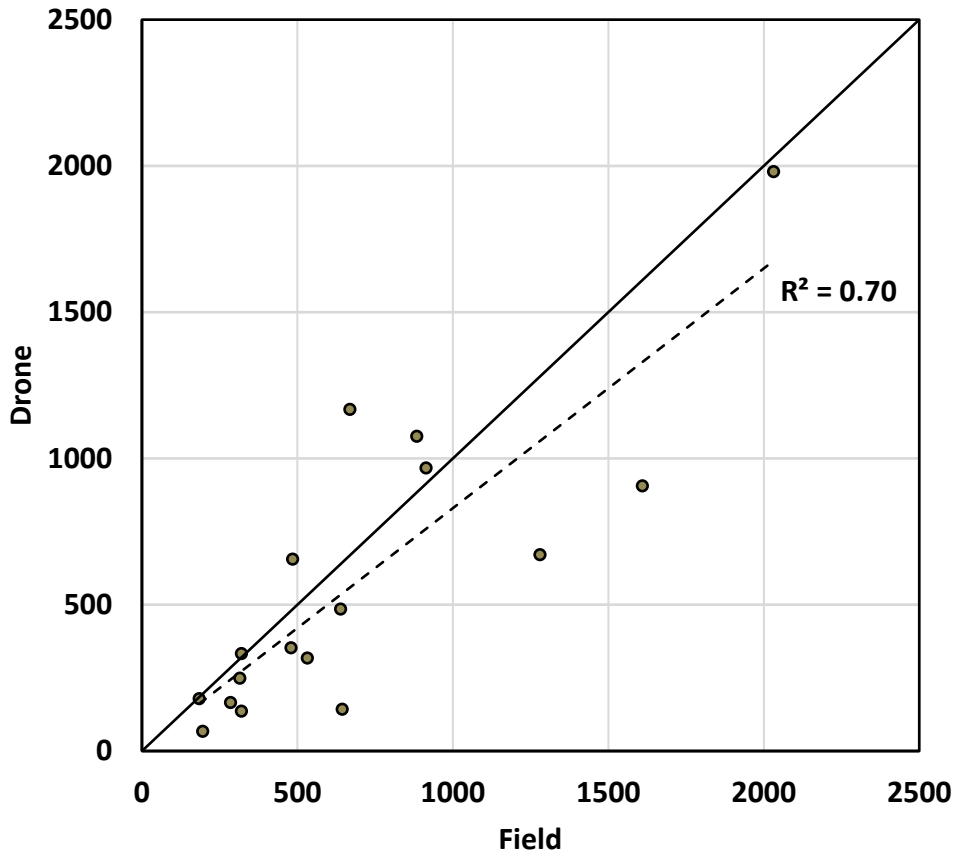

Figure 3: AUDPC ratings for the Russet trial from field vs drone images evaluations.

Appendix 1: Time series for vegetation indices

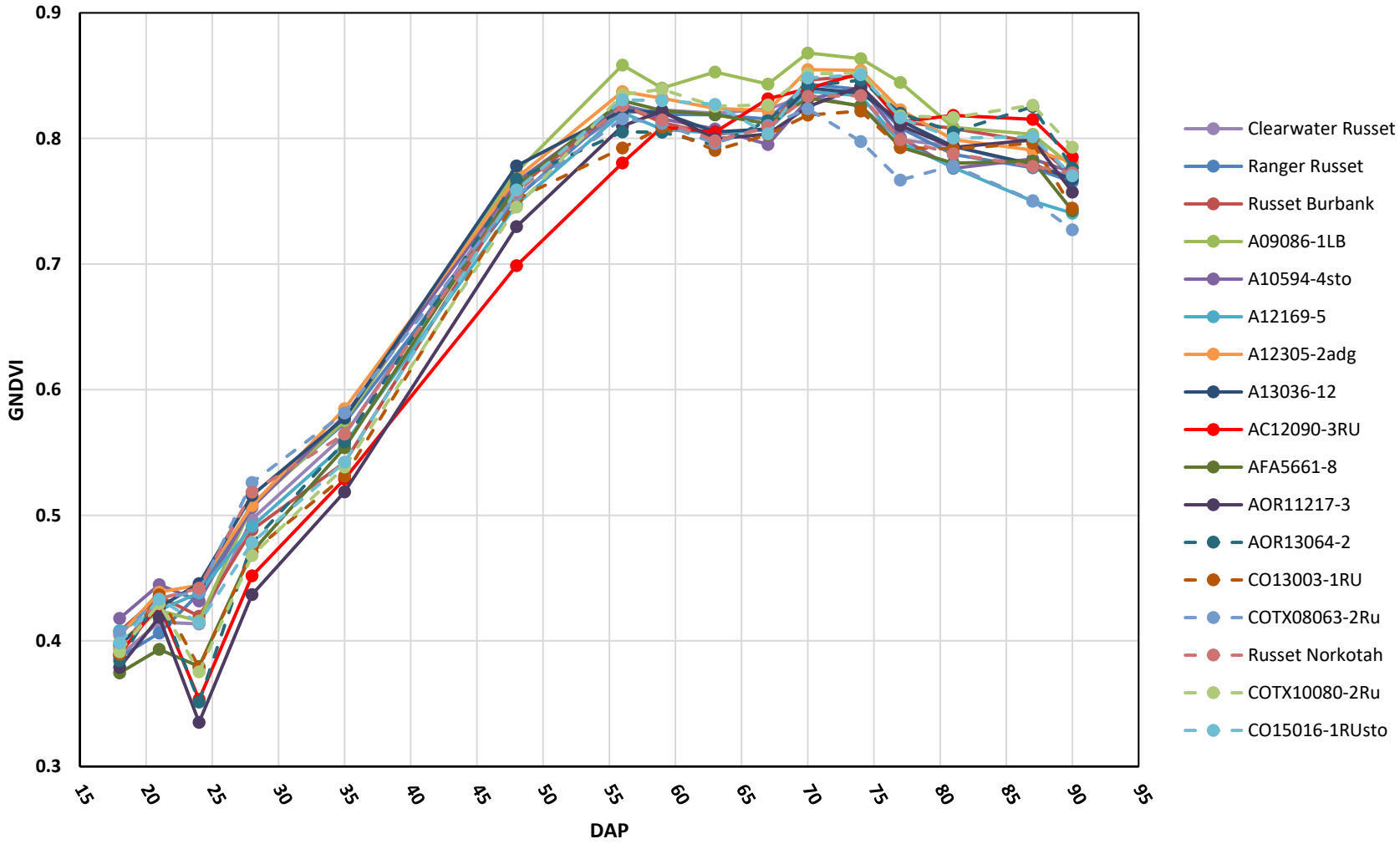

Figure 4: GNDVI time series for the Russet varieties.

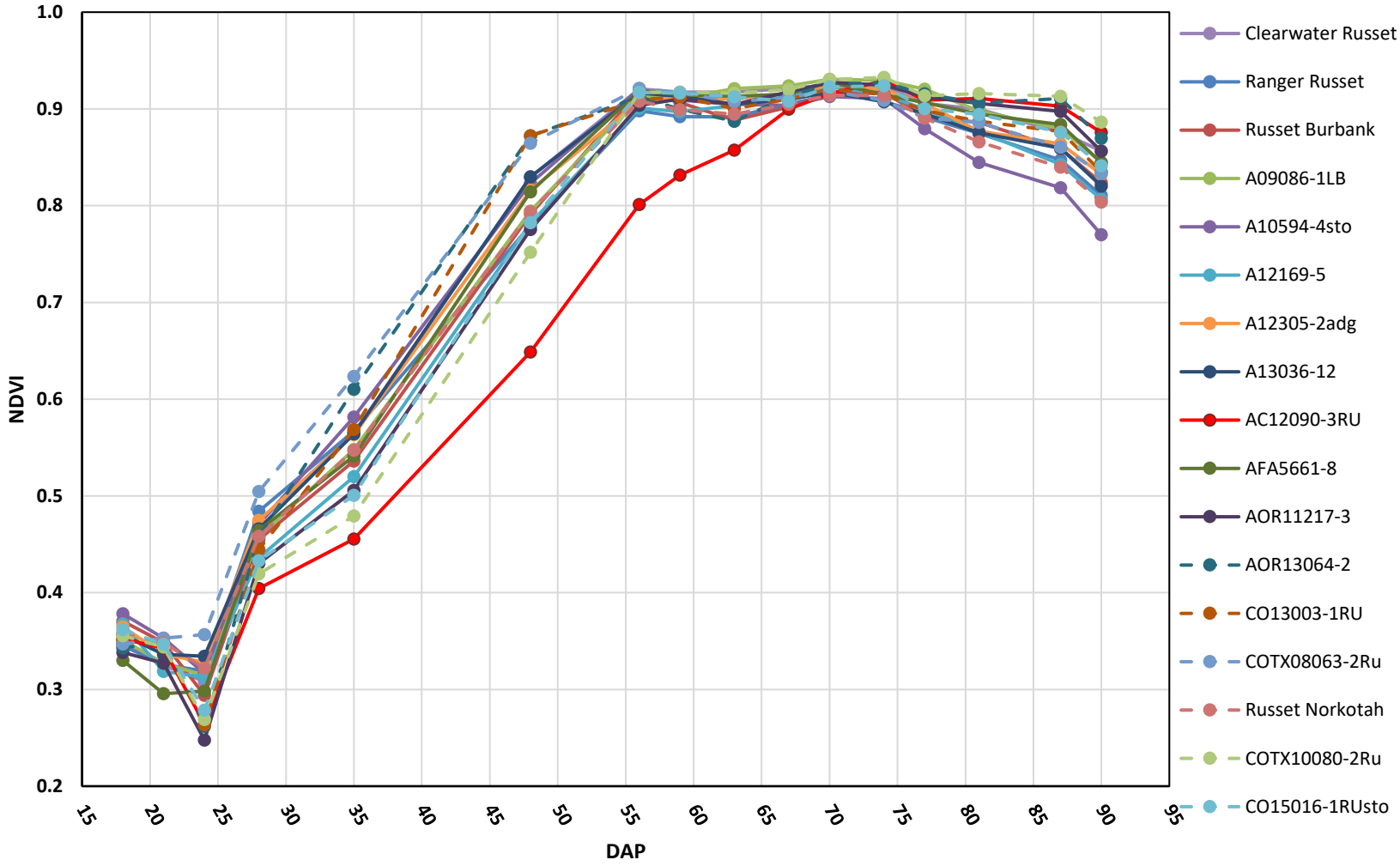

Figure 5: NDVI time series for the Russet varieties.

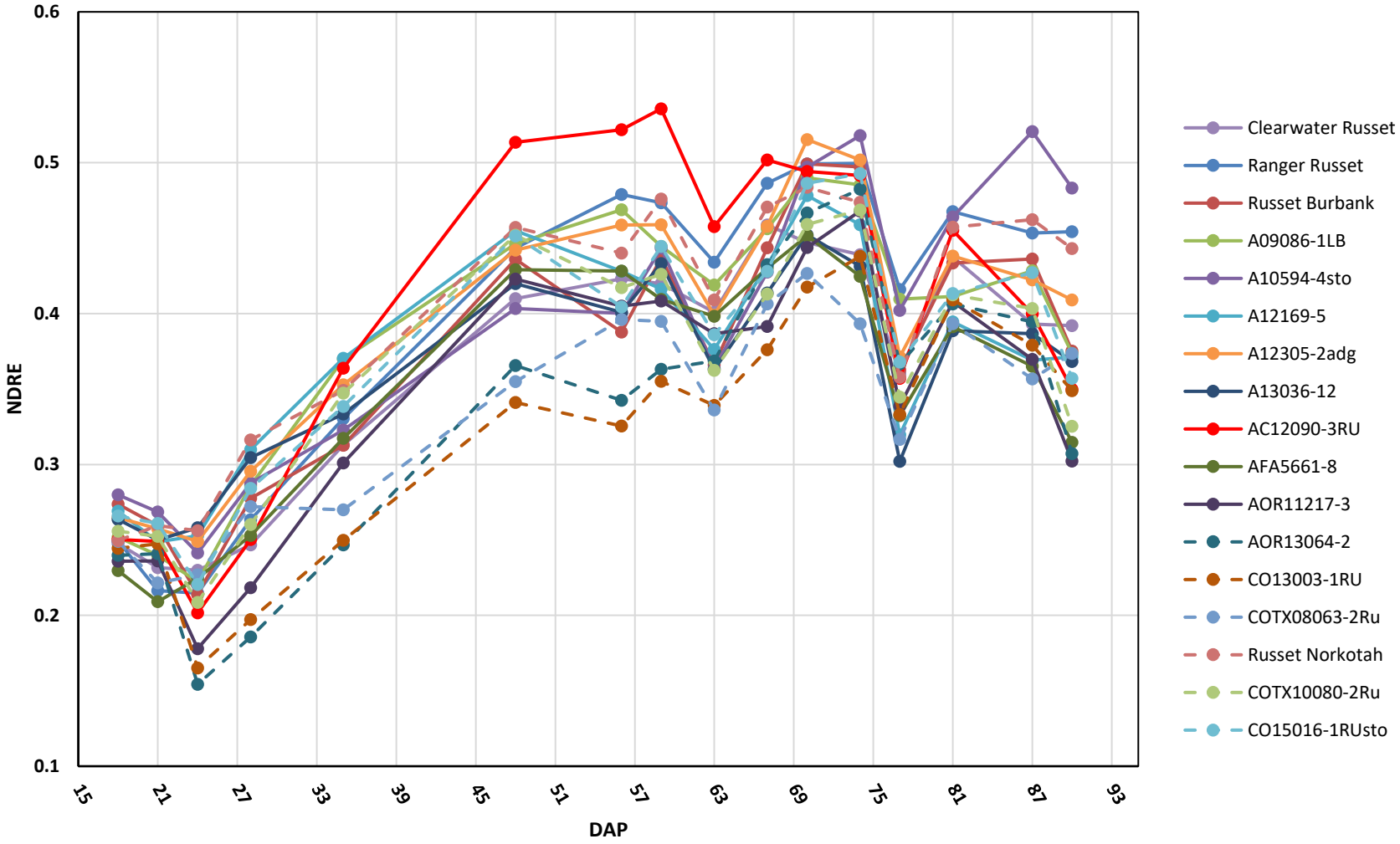

Figure 6: NDRE time series for the Russet varieties.

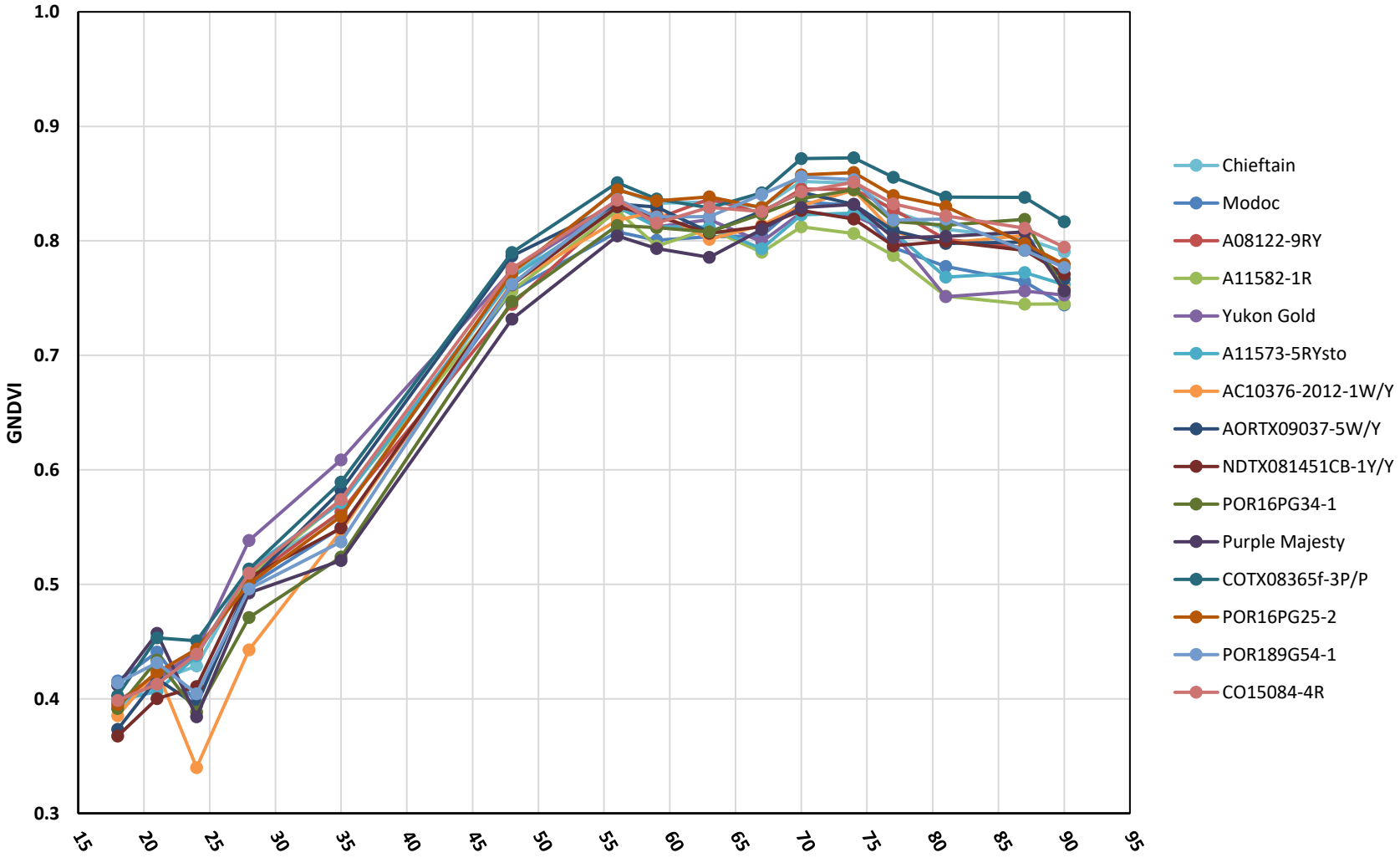

Figure 7: GNDVI time series for the Red varieties.

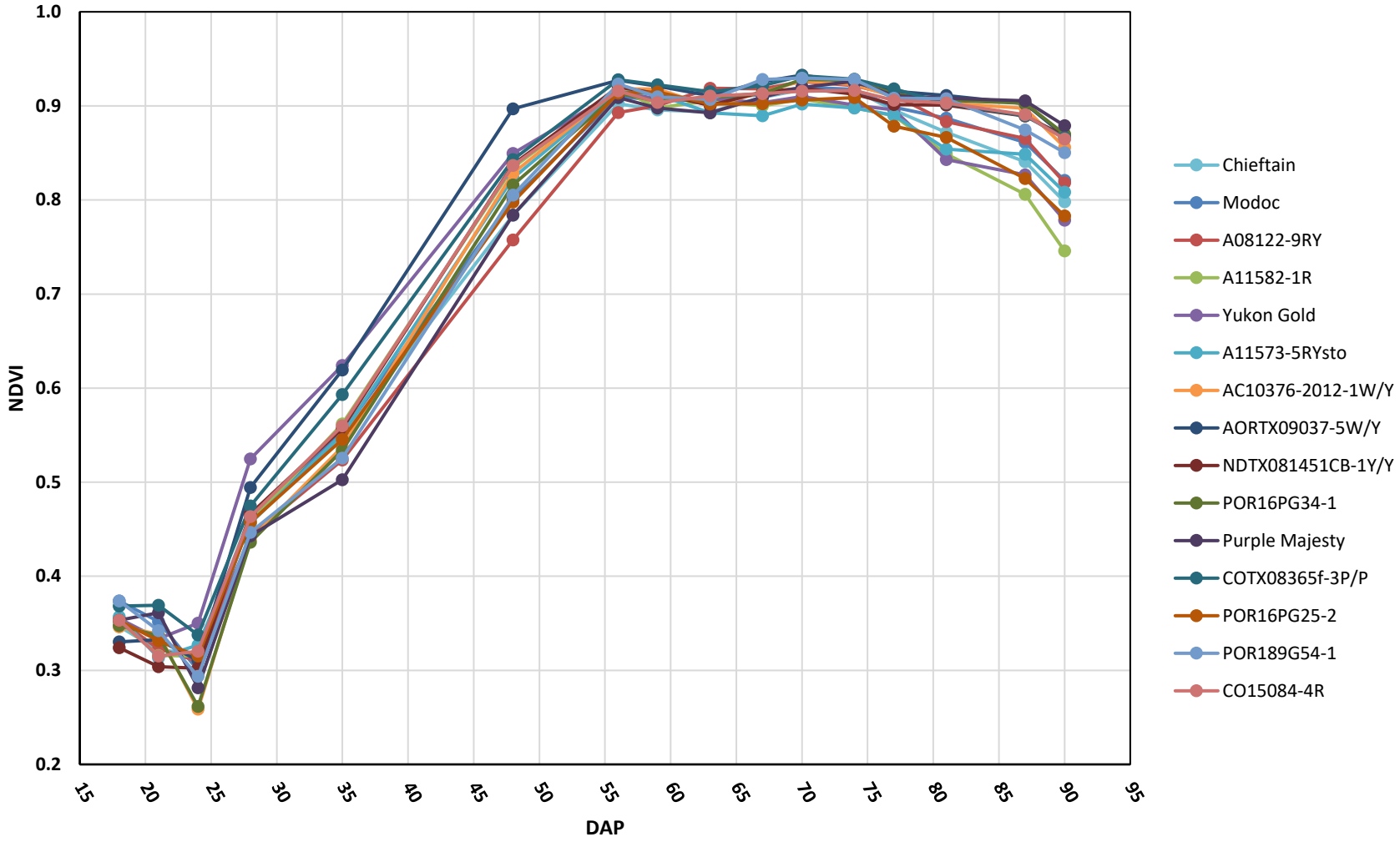

Figure 8: NDVI time series for the Red varieties.

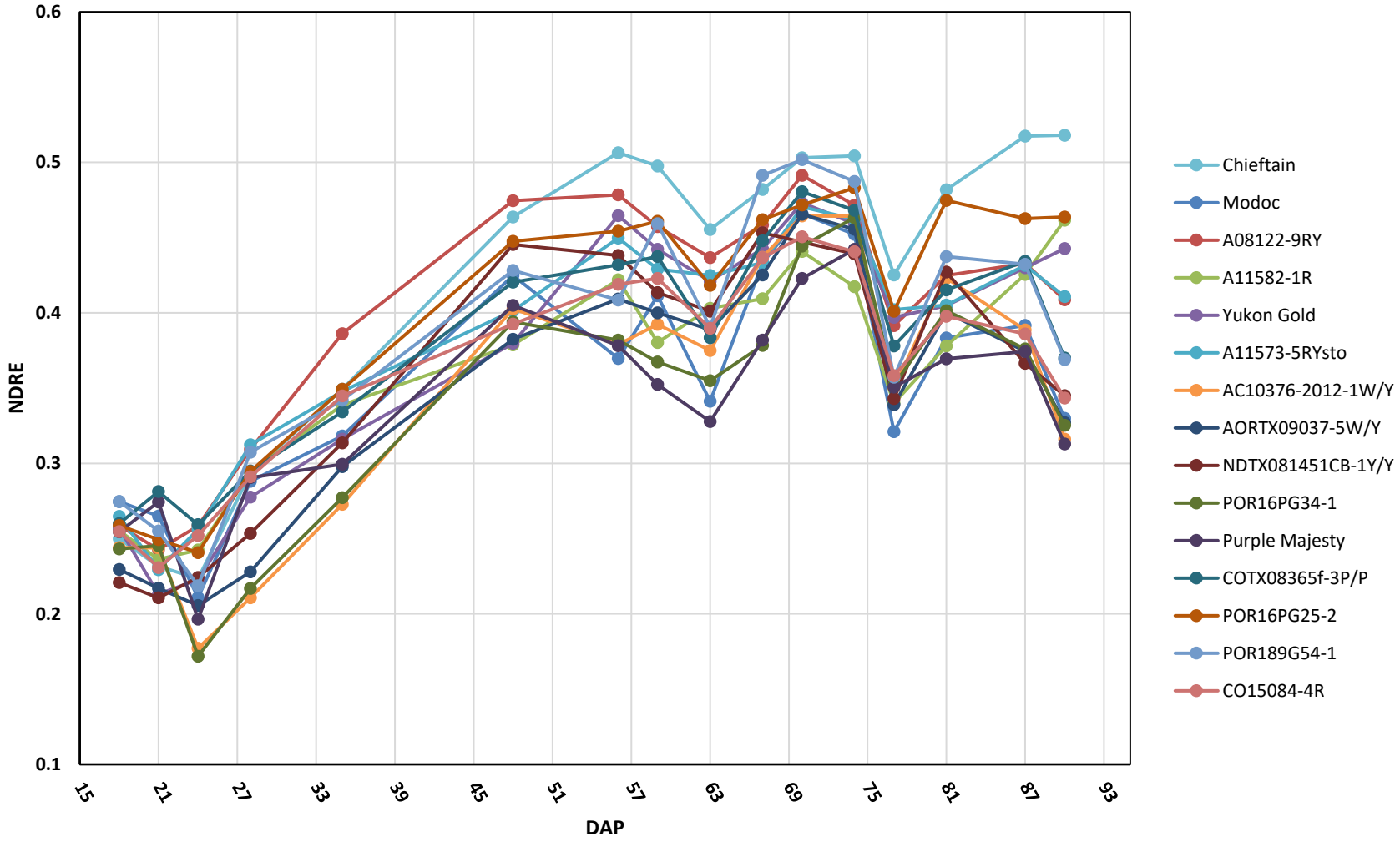

Figure 9: NDRE time series for the Red varieties.

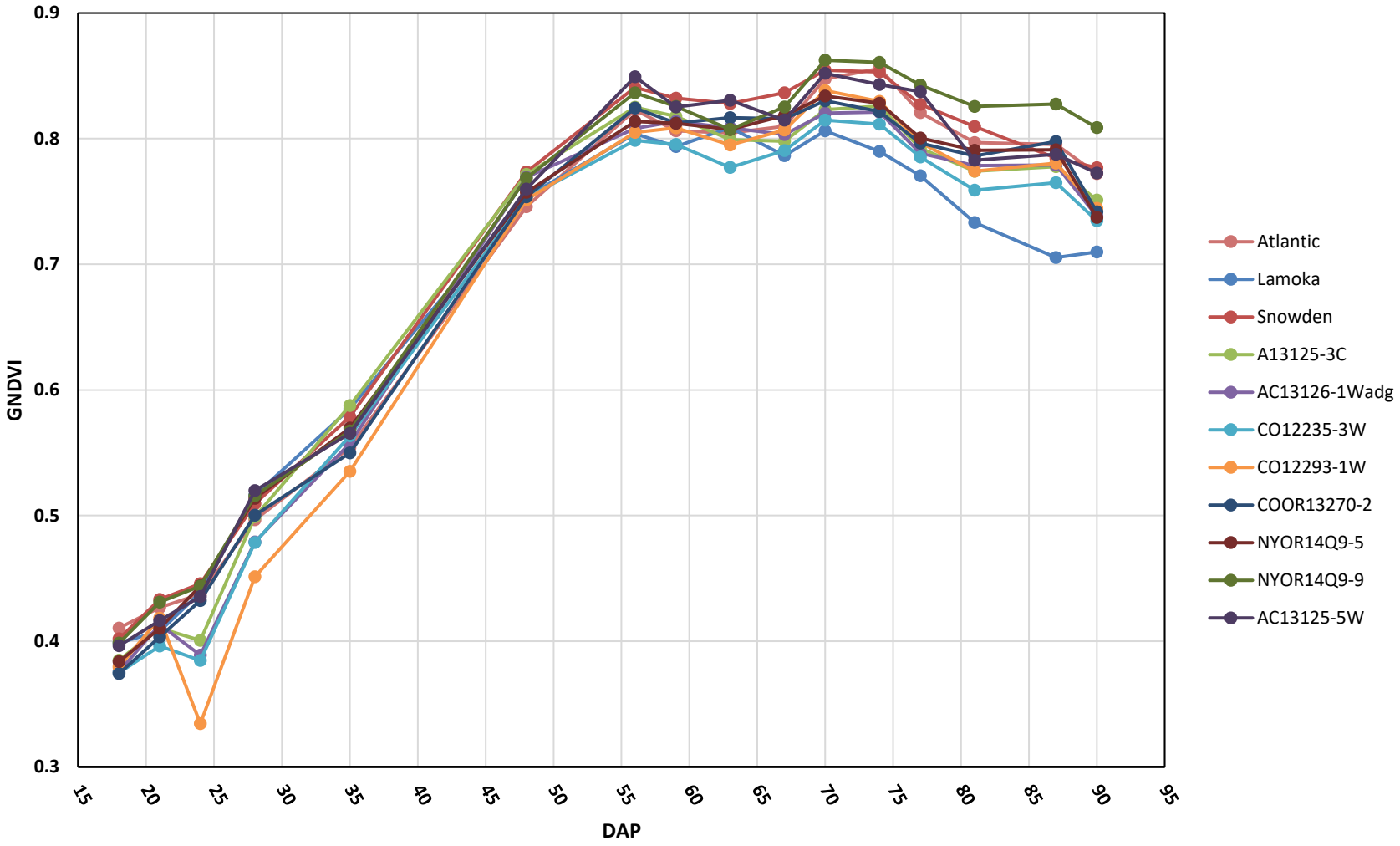

Figure 10: GNDVI time series for the Chip varieties.

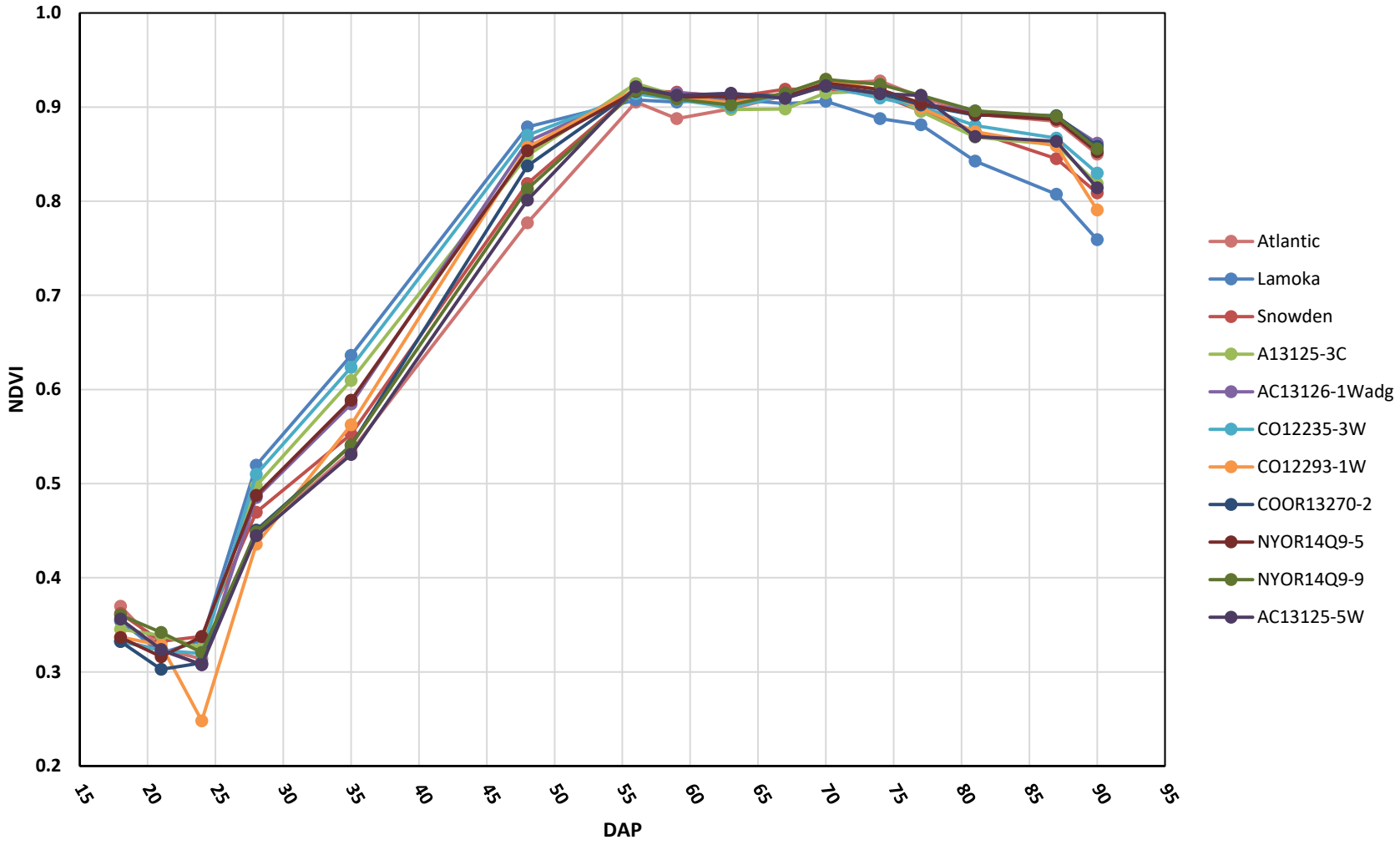

Figure 11: NDVI time series for the Chip varieties.

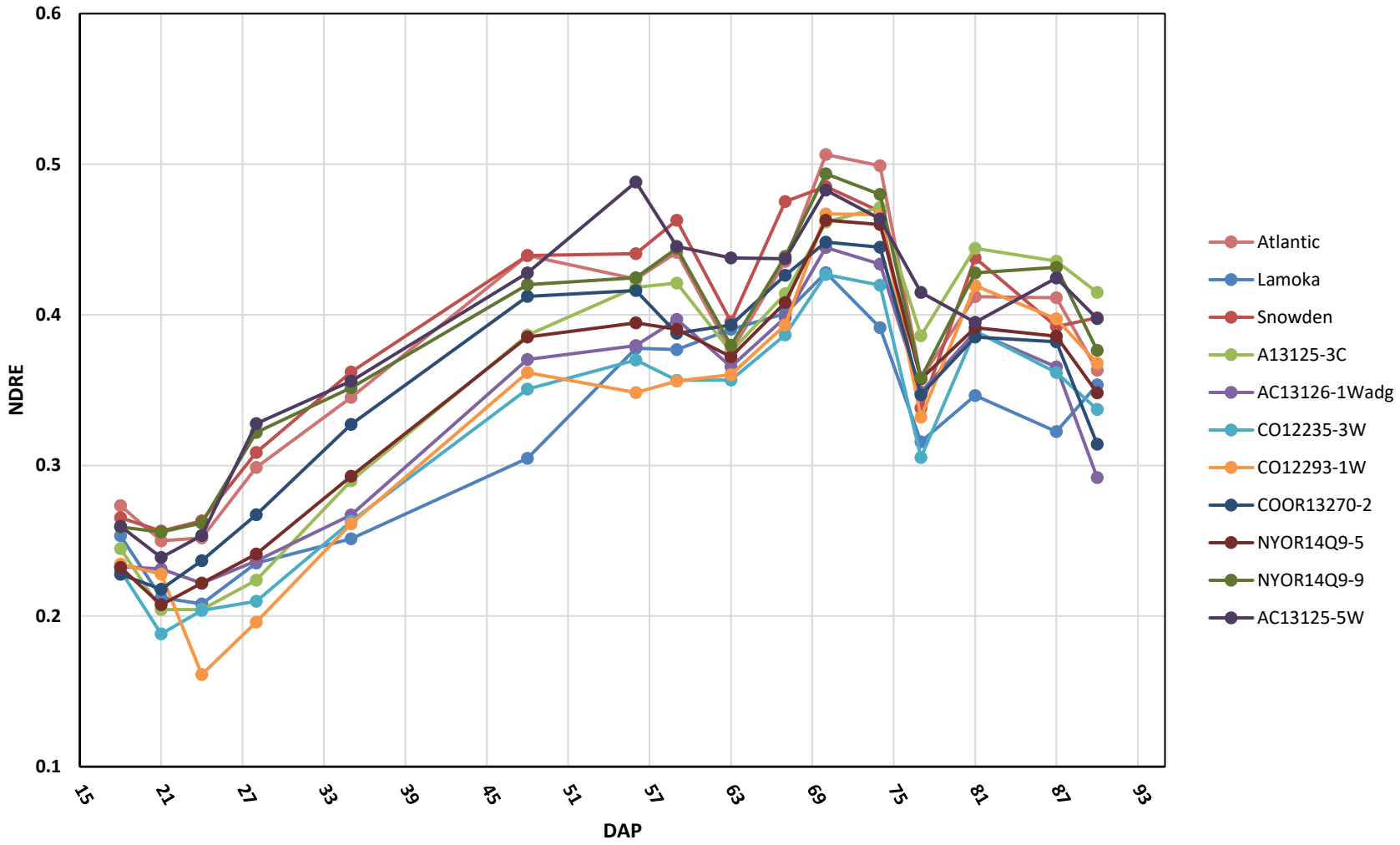

Figure 12: NDRE time series for the Chip varieties.

Appendix 2: Archived Drone Images

Russet		Red		Chip	
I	Variety	I	Variety	I	Variety
1	Clearwater Russet	1	Chieftain	1	Atlantic
2	Ranger Russet	2	Modoc	2	Lamoka
3	Russet Burbank	3	A08122-9RY	3	Snowden
4	A09086-1LB	4	A11582-1R	5	A13125-3C
5	A10594-4sto	5	Yukon Gold	6	AC13126-1Wadg
6	A12169-5	6	A11573-5RYsto	7	CO12235-3W
7	A12305-2adg	7	AC10376-2012-1W/Y	8	CO12293-1W
8	A13036-12	8	AORTX09037-5W/Y	9	COOR13270-2
9	AC12090-3RU	9	NDTX081451CB-1Y/Y	10	NYOR14Q9-5
10	AFA5661-8	10	POR16PG34-1	11	NYOR14Q9-9
11	AOR11217-3	11	Purple Majesty	12	AC13125-5W
12	AOR13064-2	12	COTX08365f-3P/P		
13	CO13003-1RU	13	POR16PG25-2		
14	COTX08063-2Ru	14	POR189G54-1		
15	Russet Norkotah	15	CO15084-4R		
16	COTX10080-2Ru				
17	CO15016-1RUsto				

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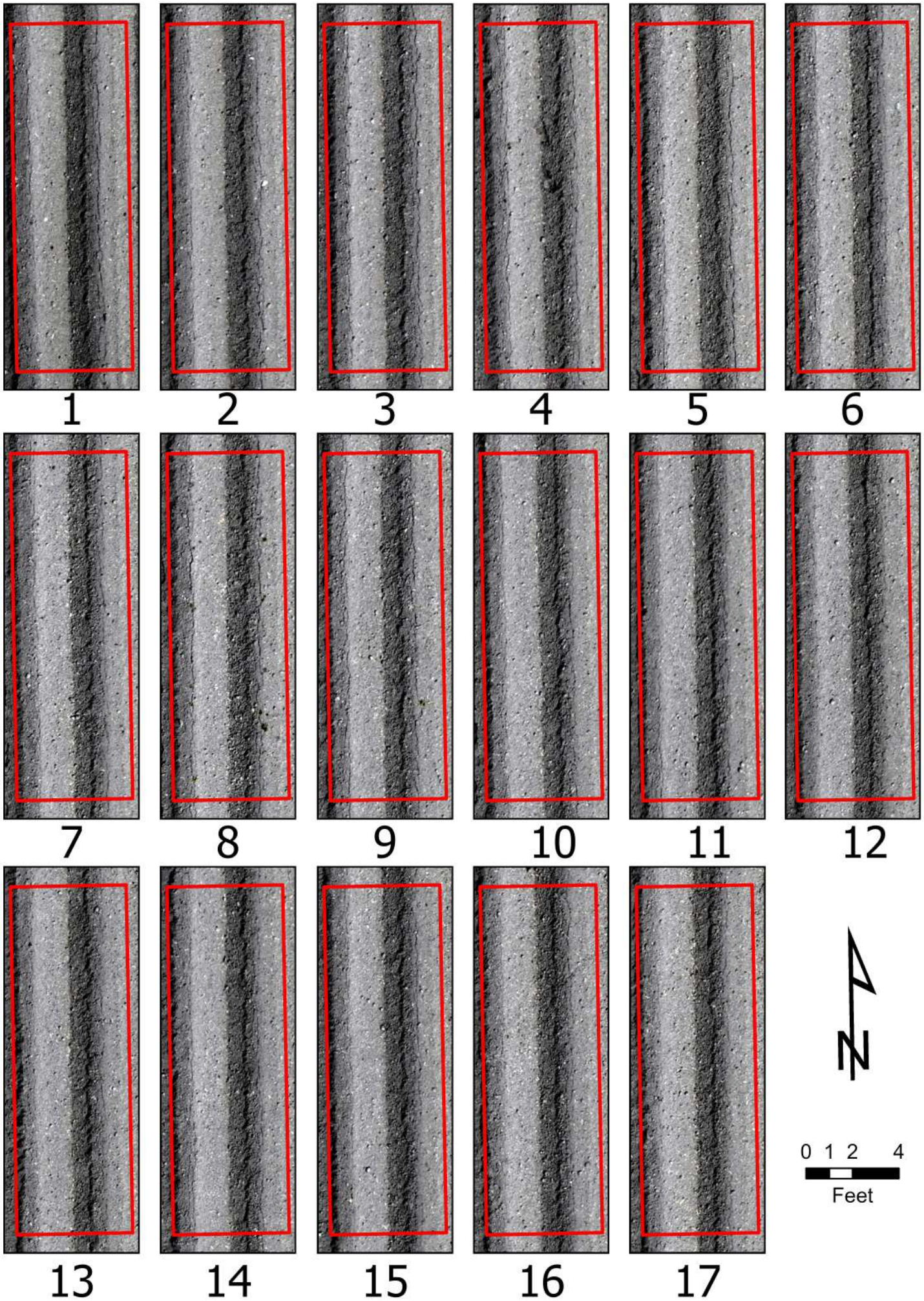

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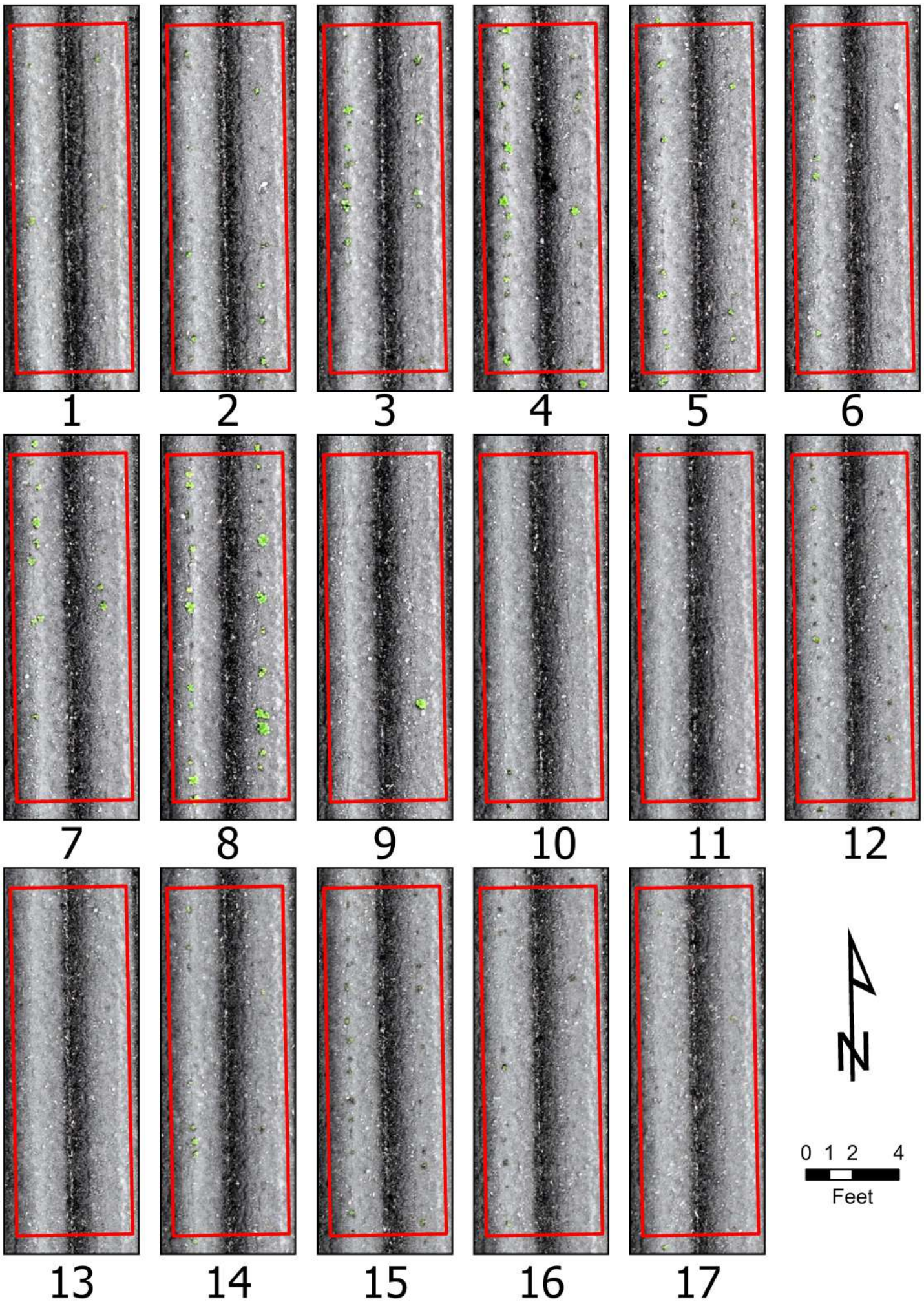

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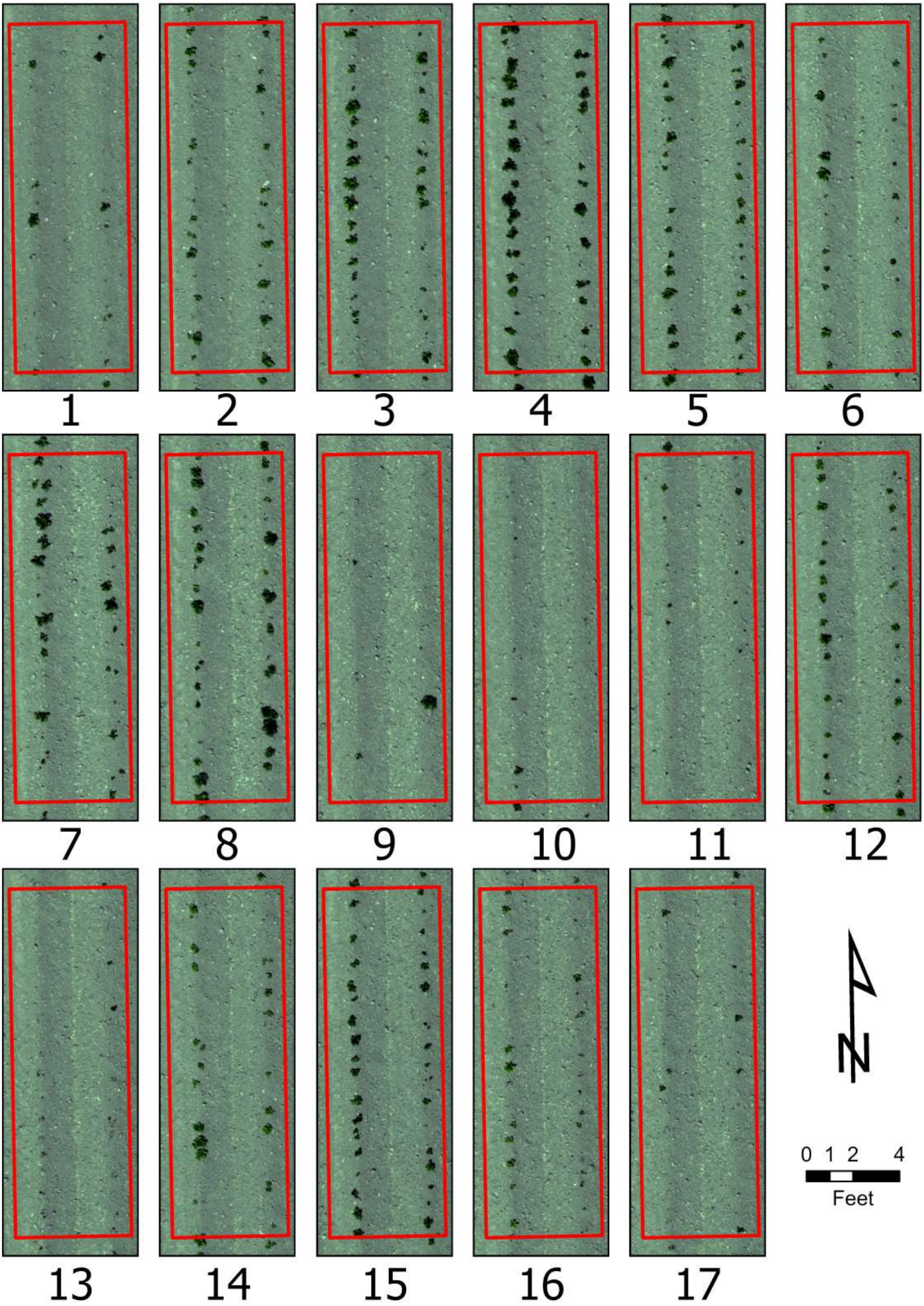

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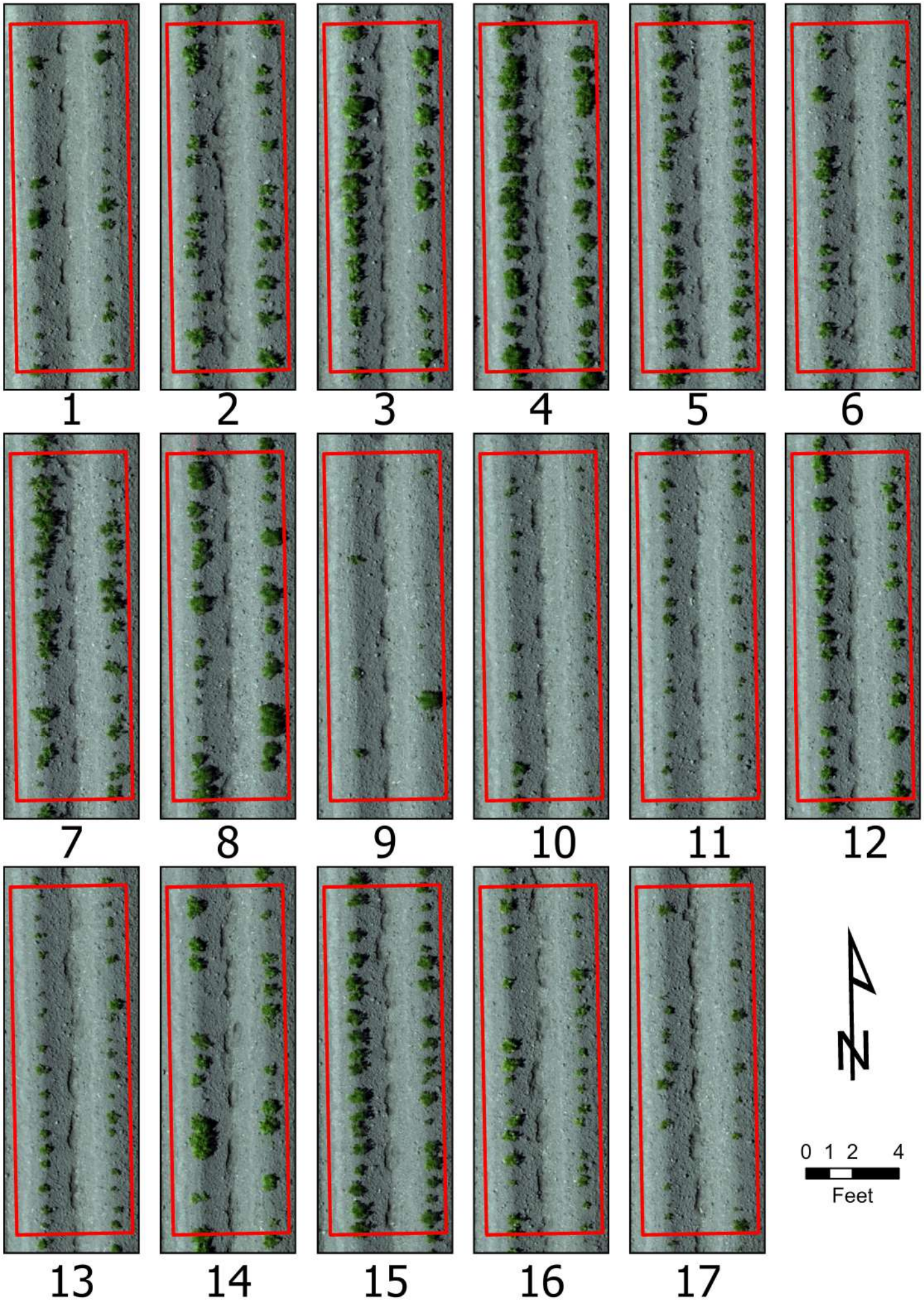

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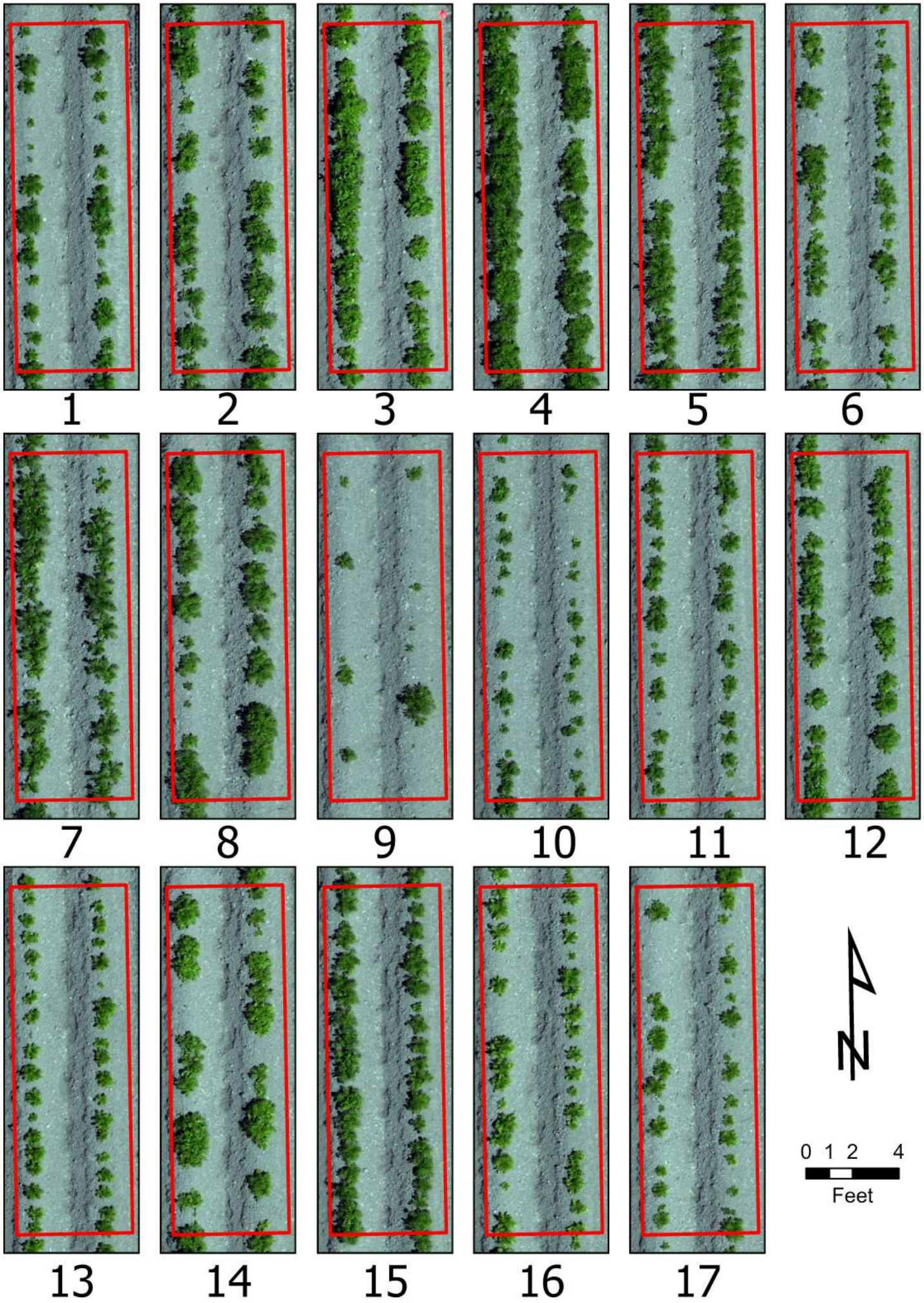

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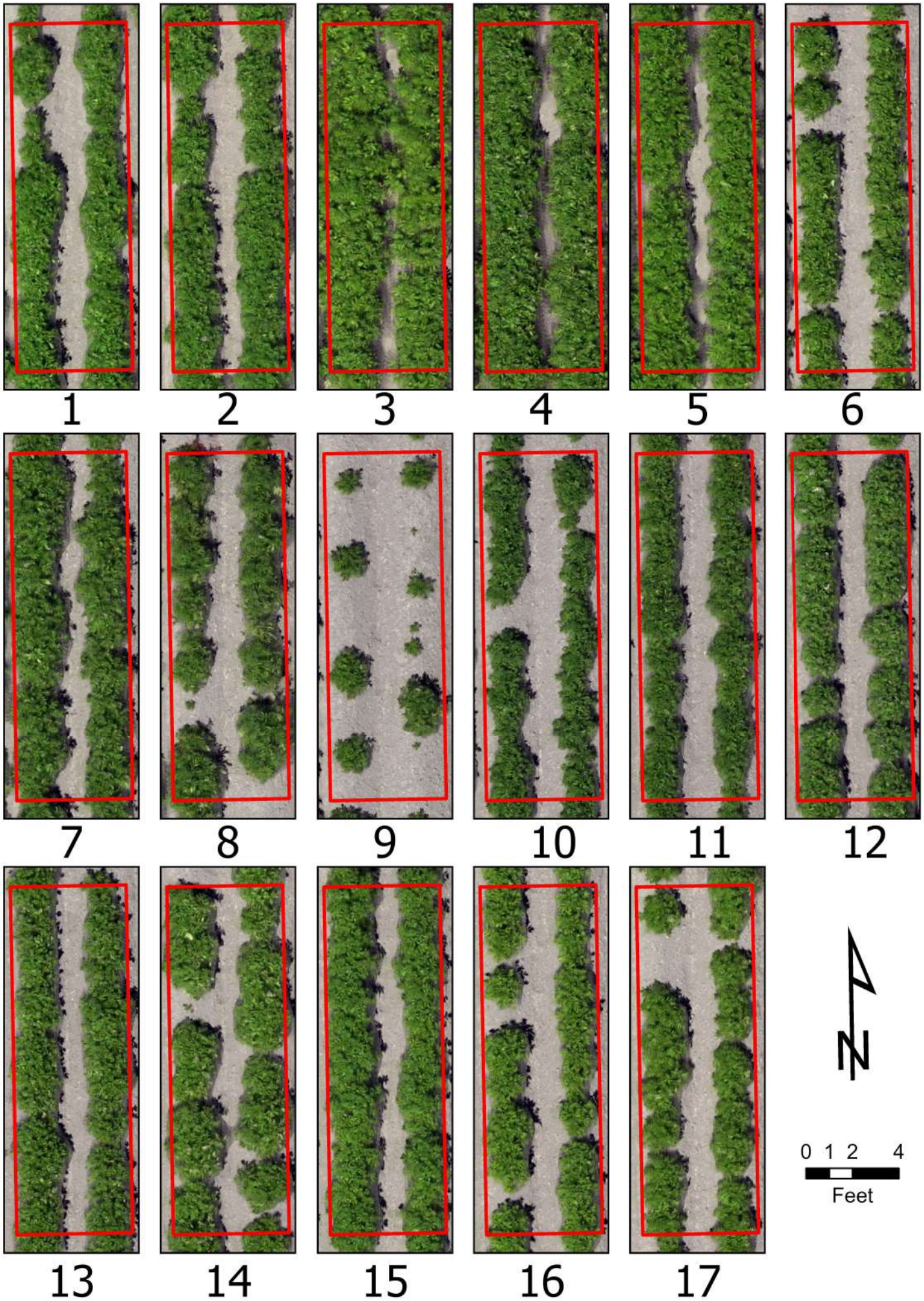

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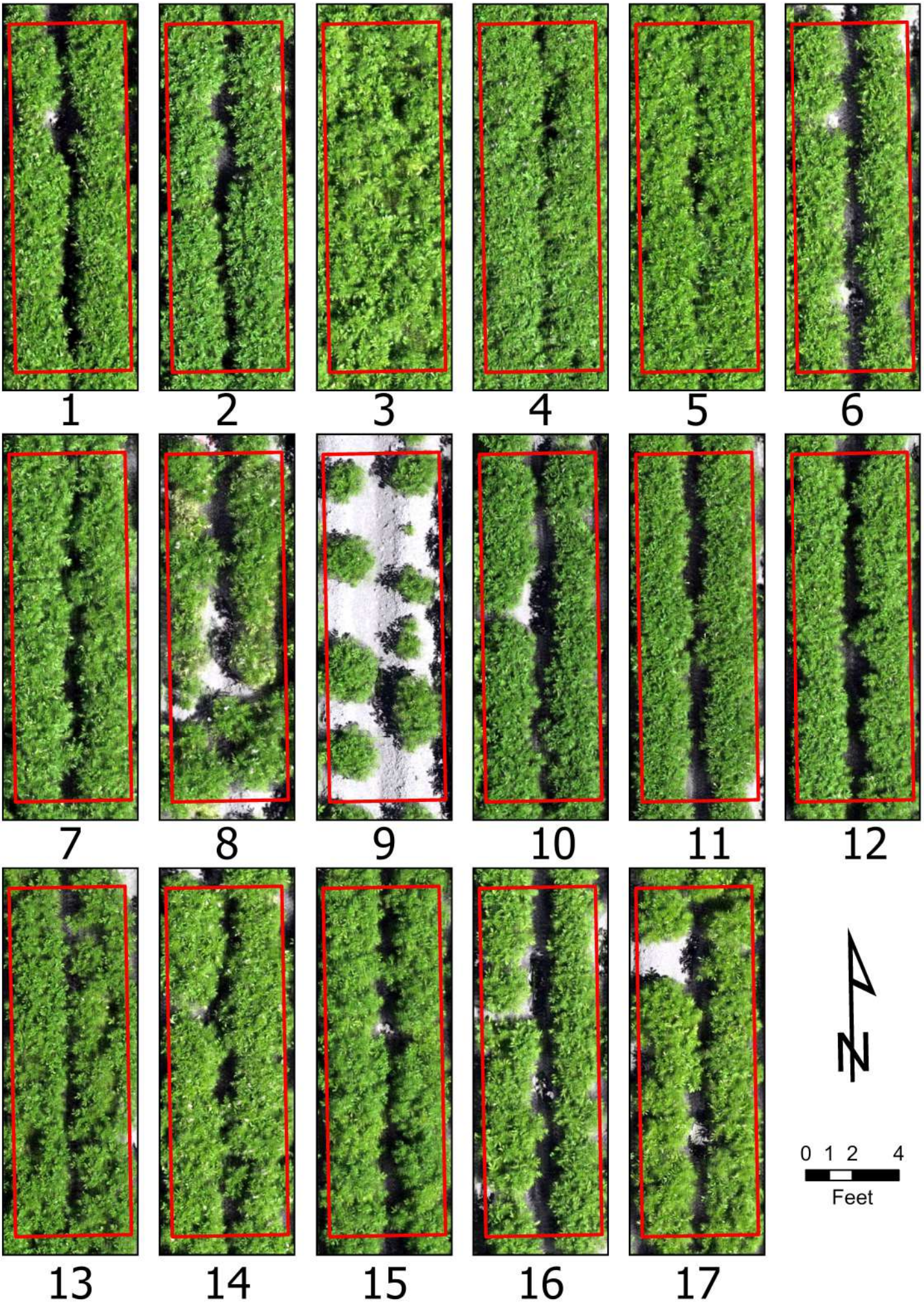

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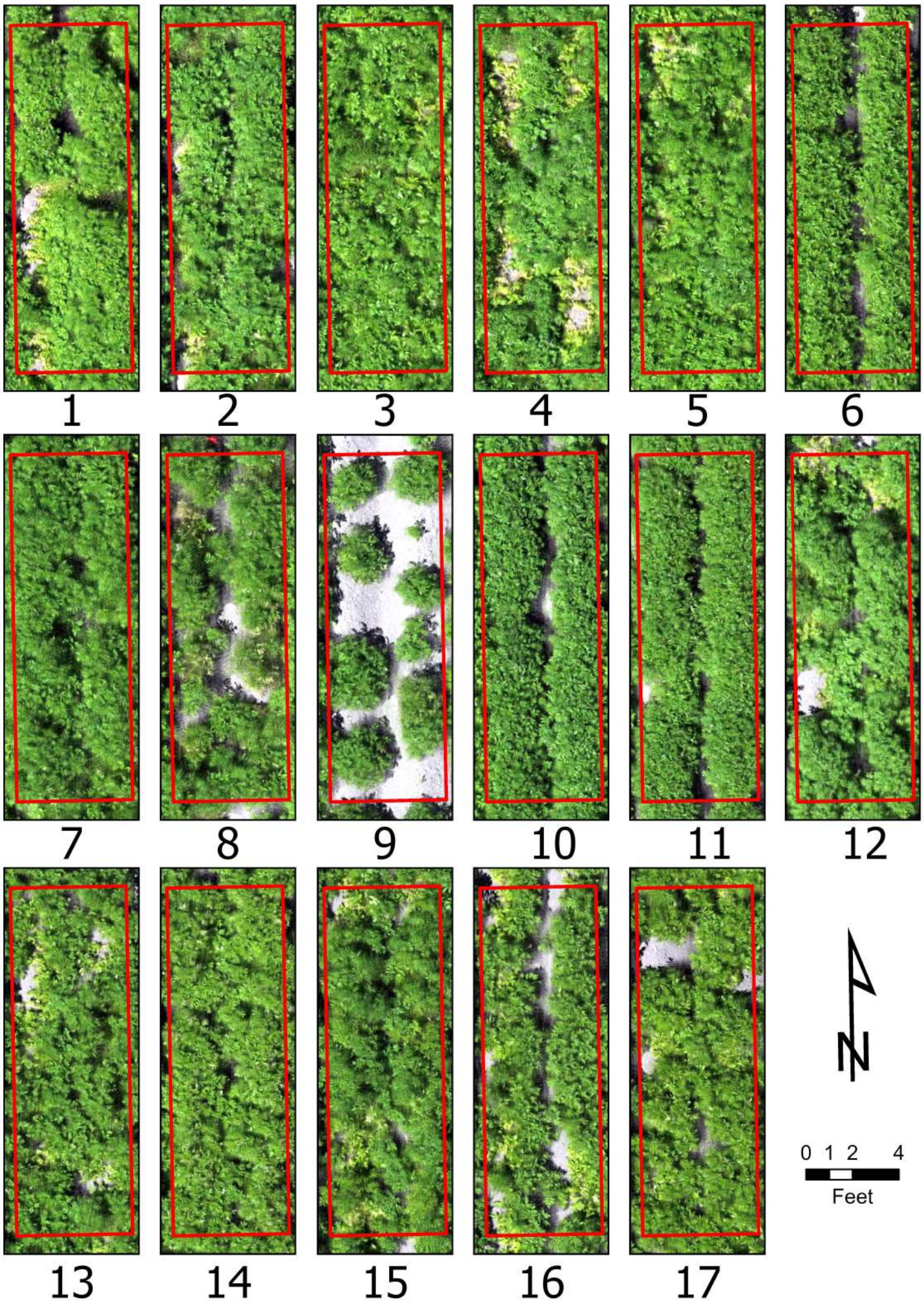

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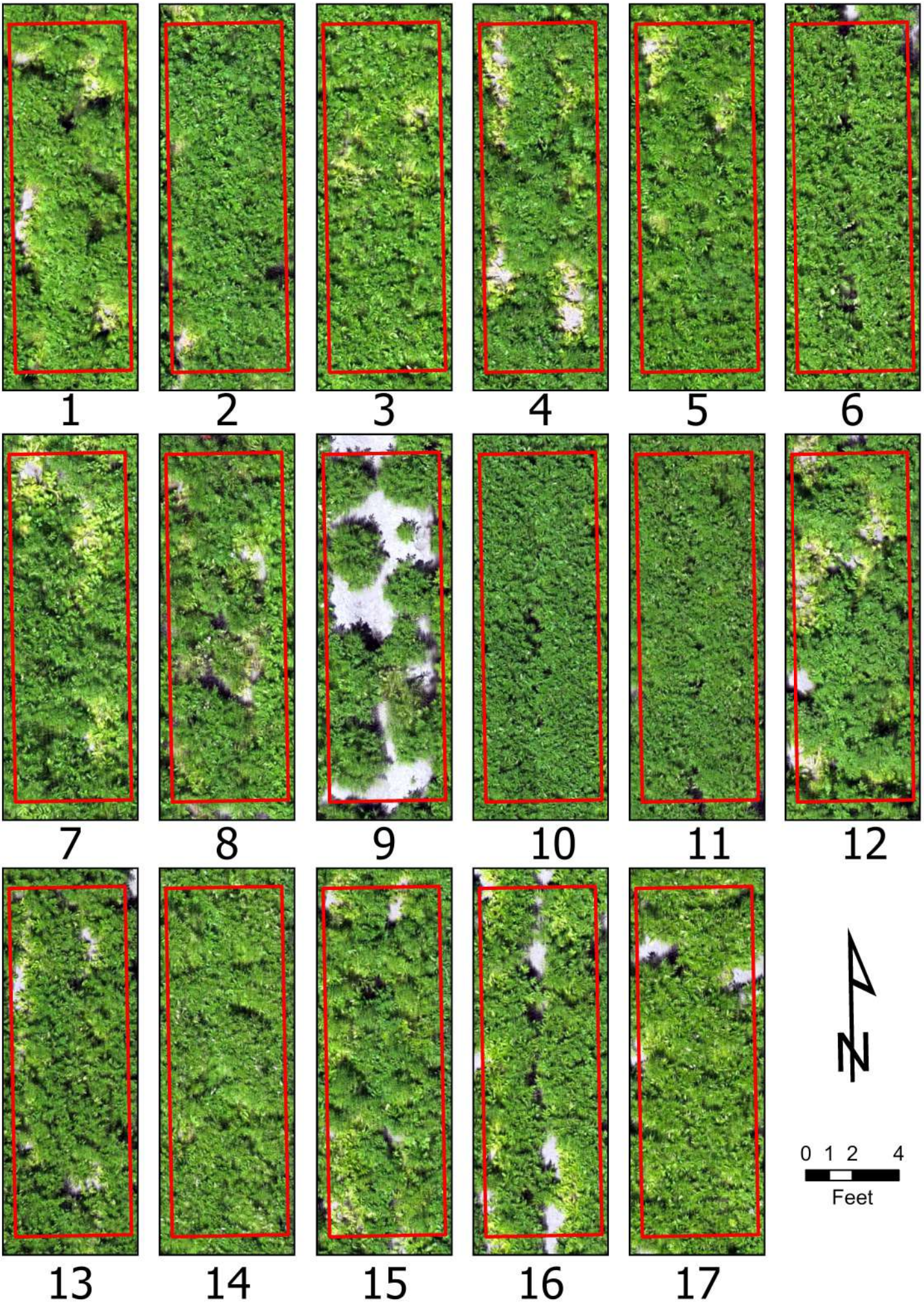

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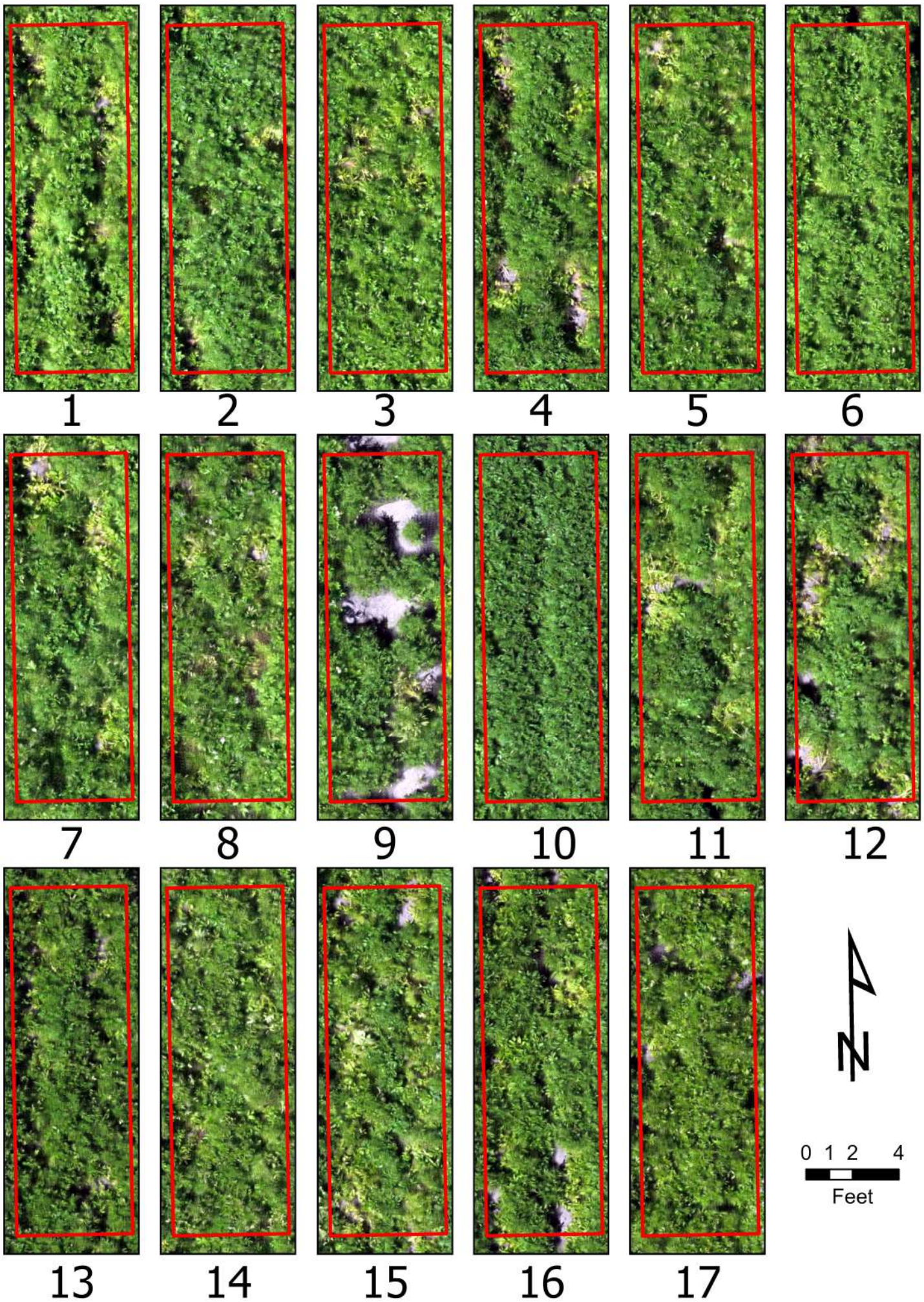

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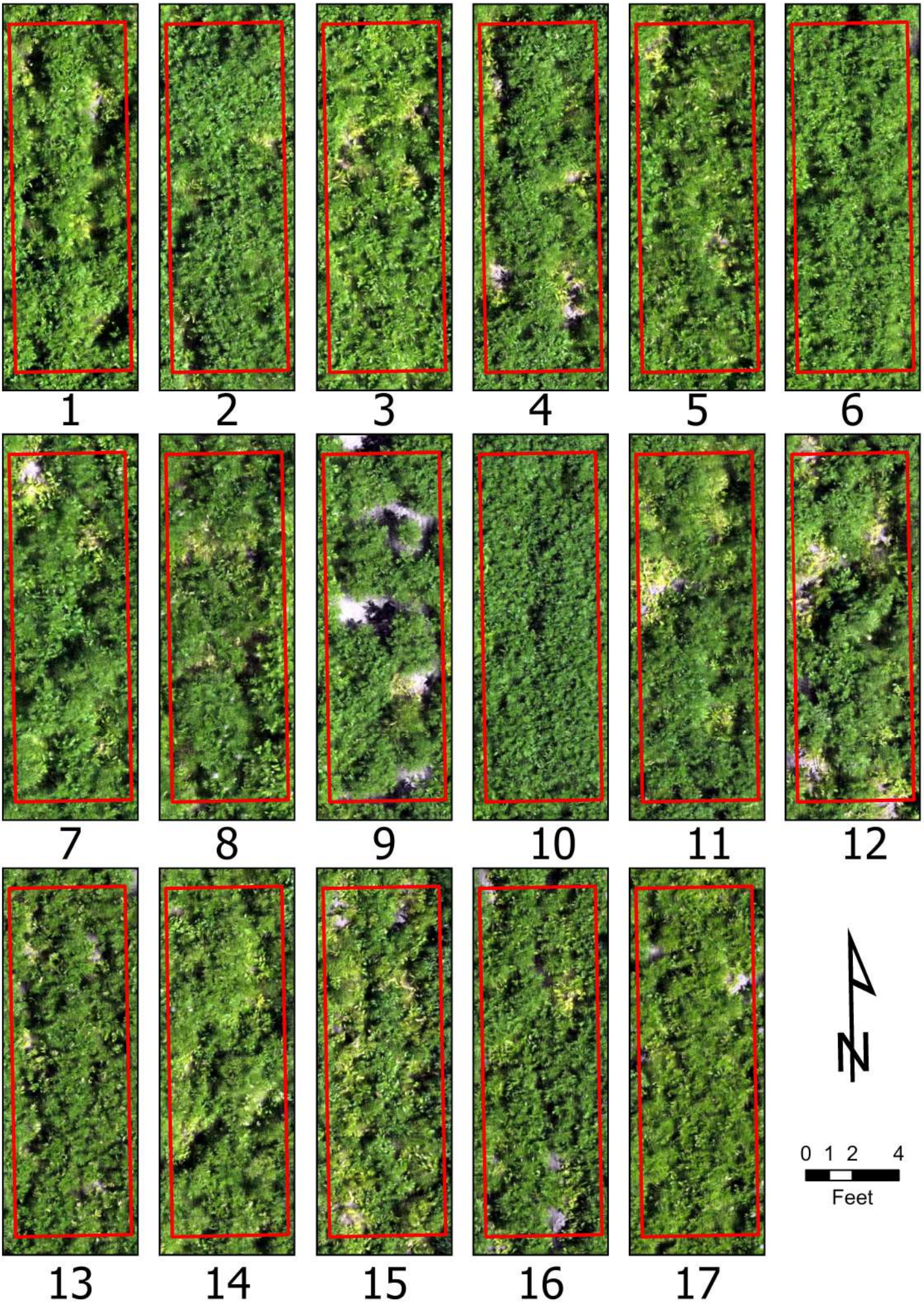

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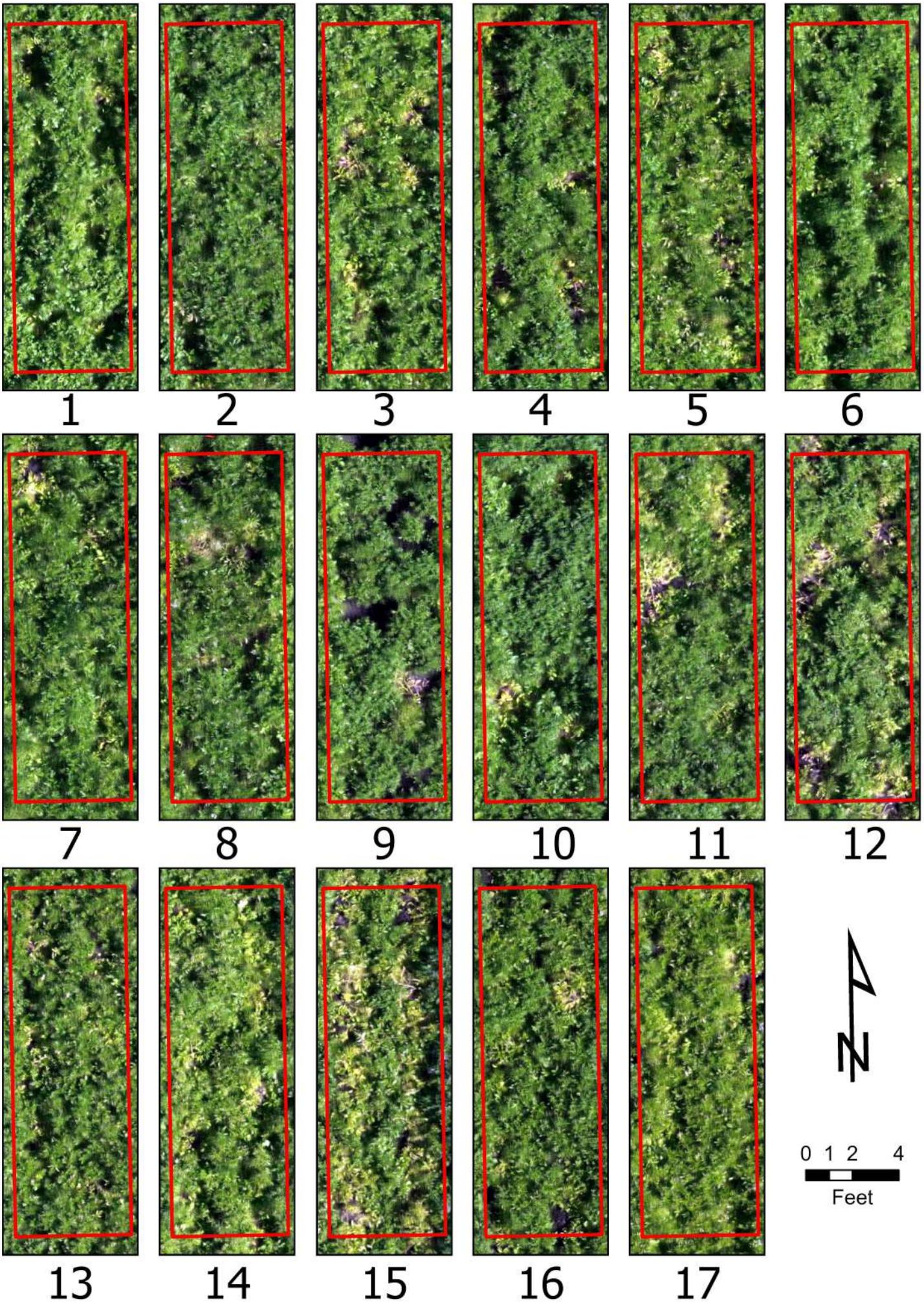

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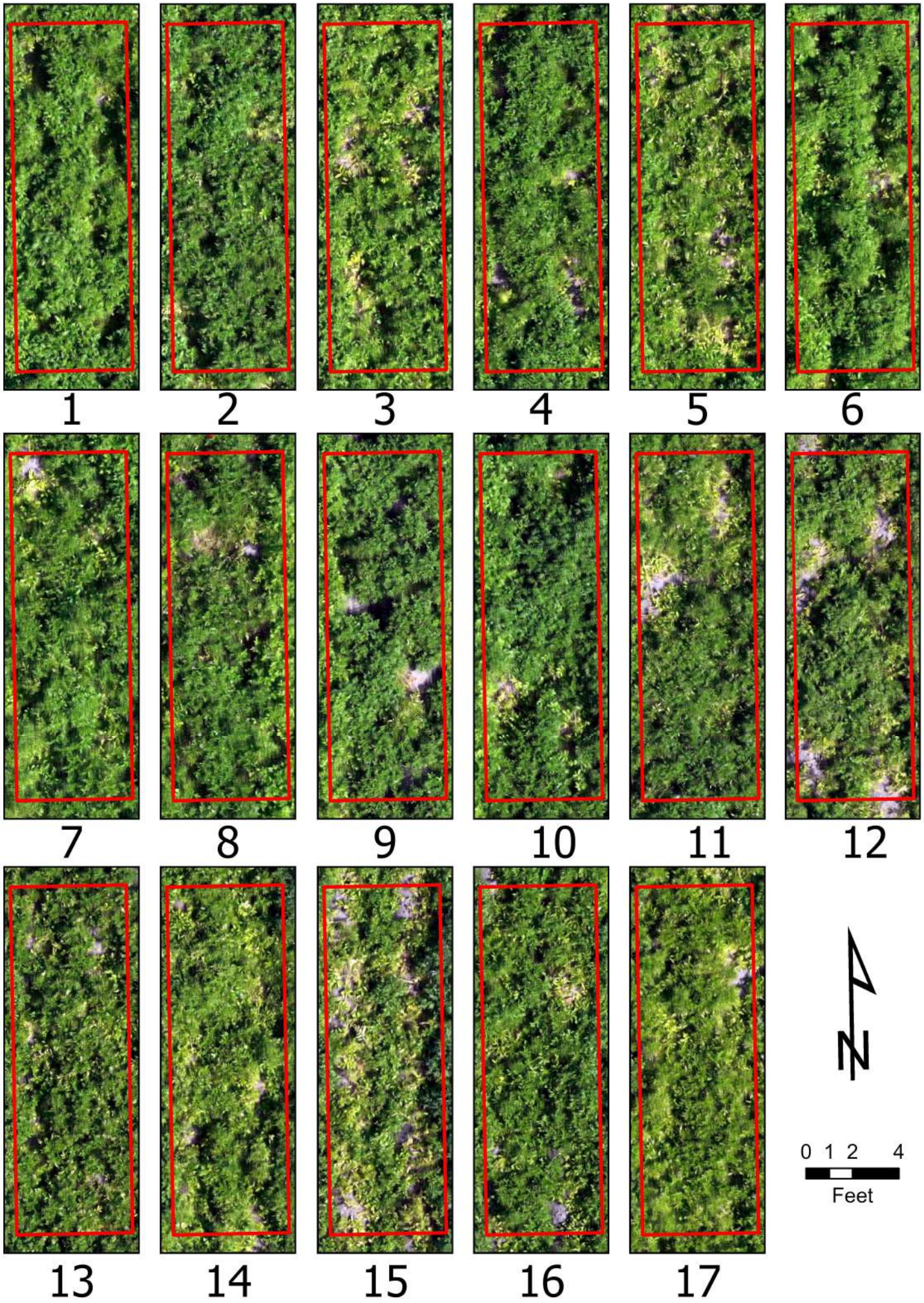

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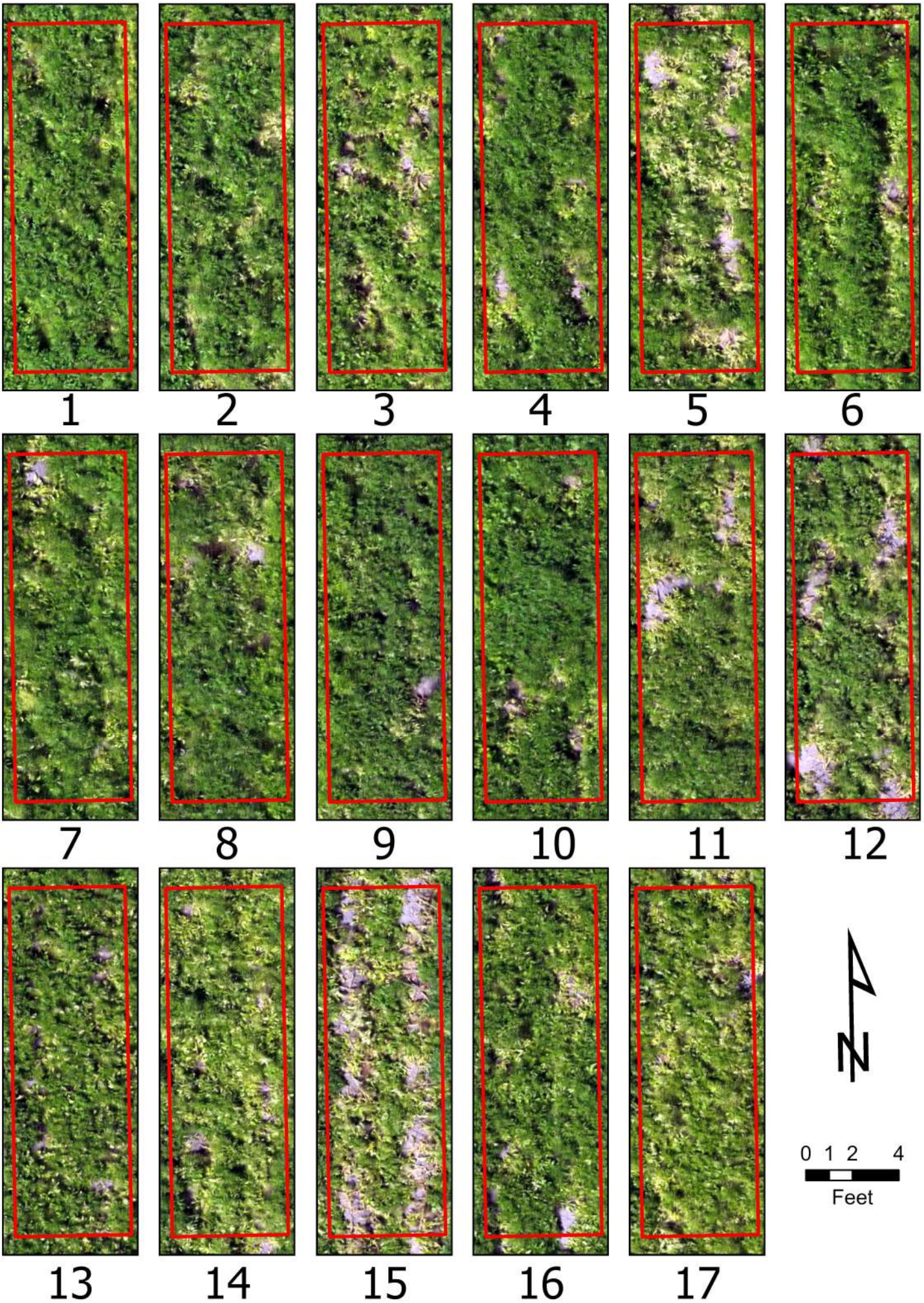

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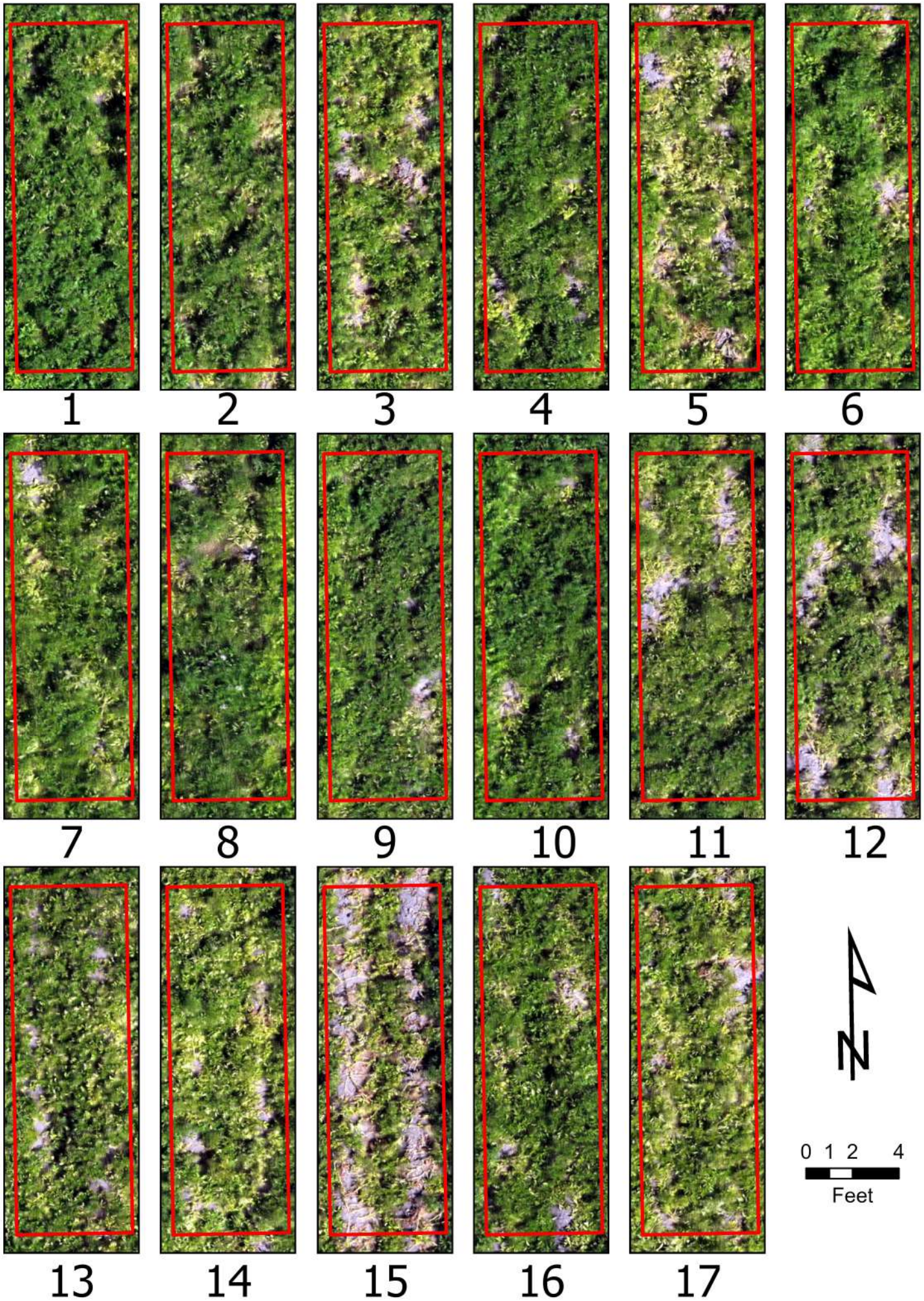

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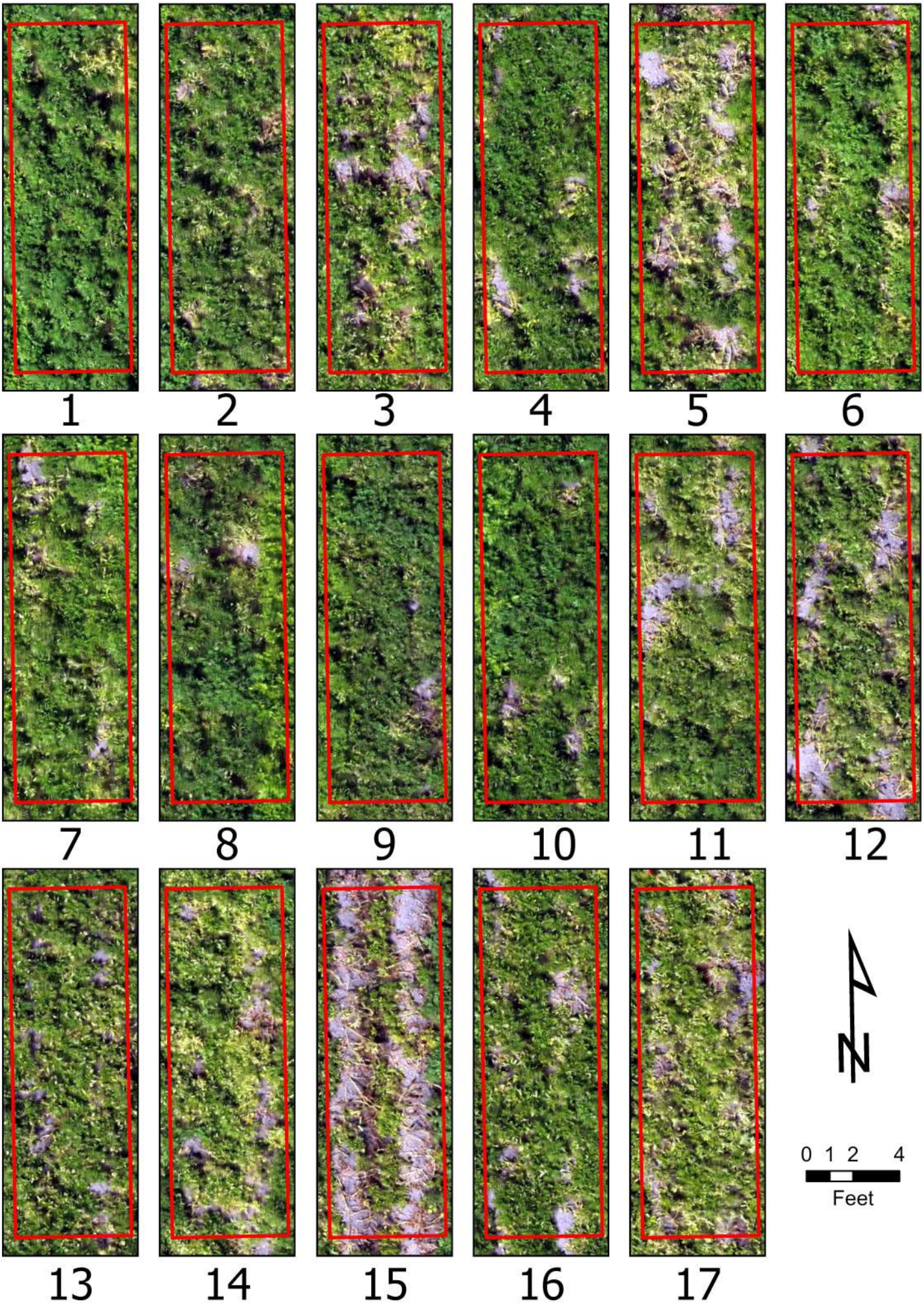

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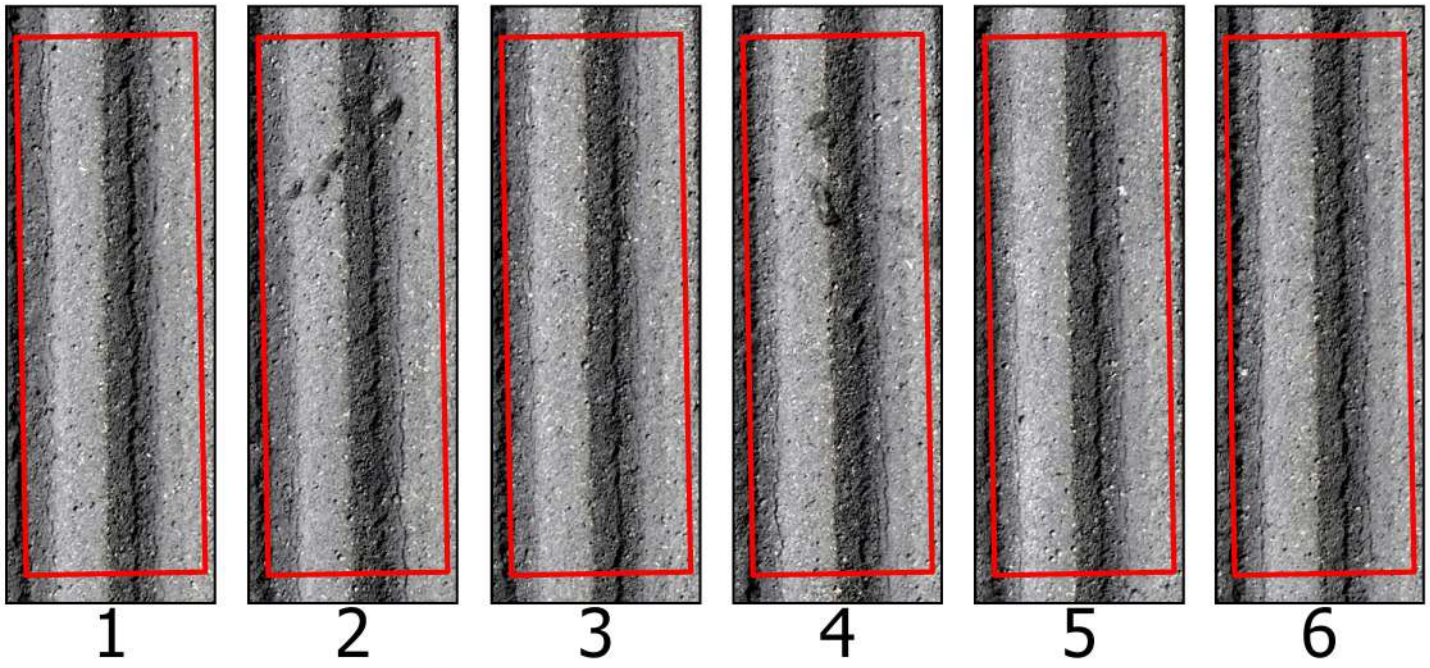

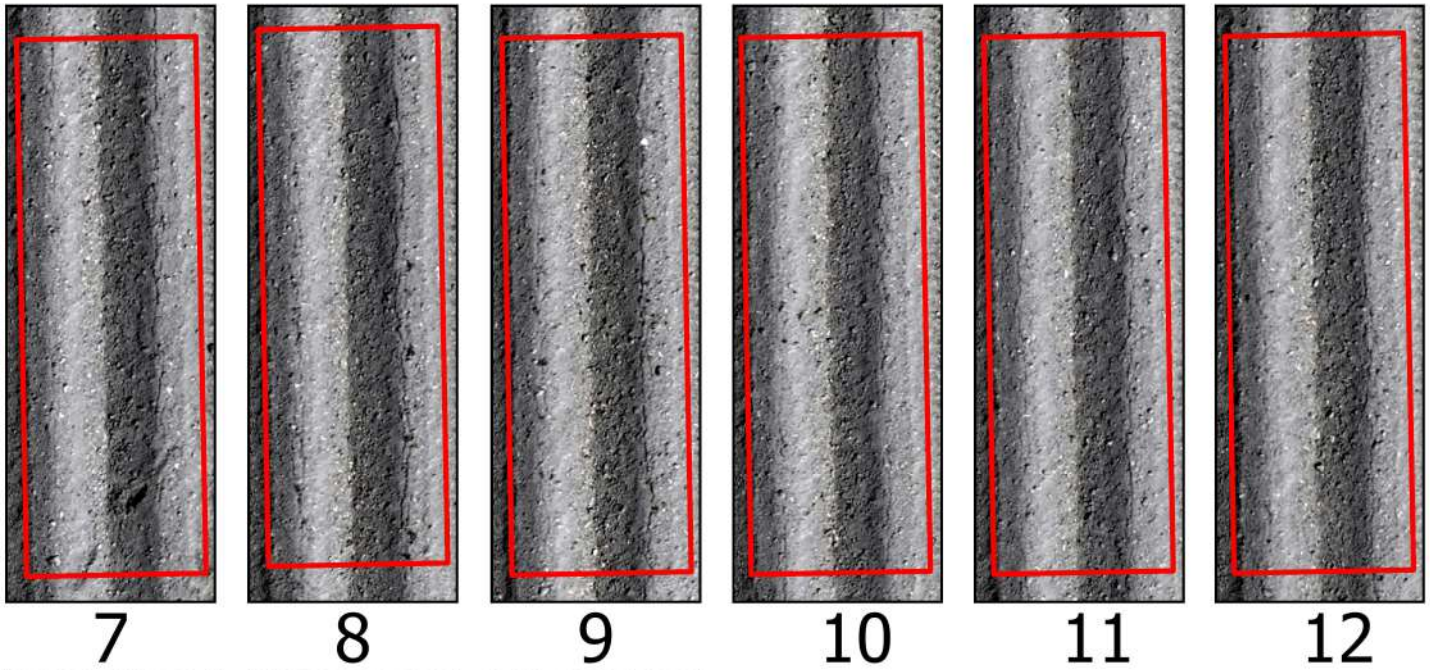

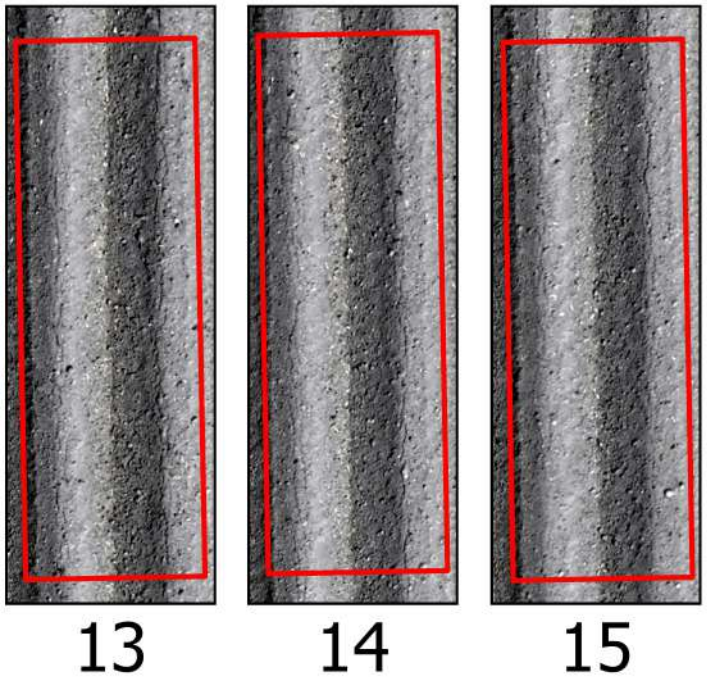

N

0 1 2 4
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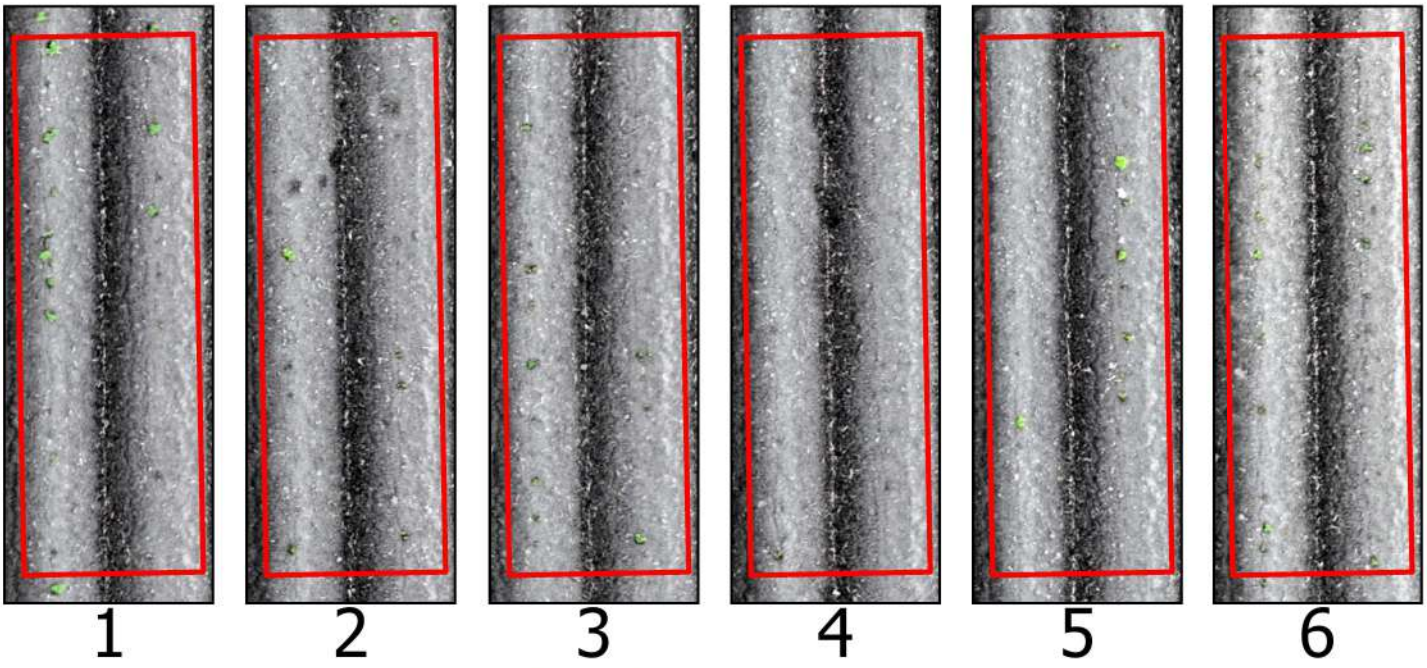

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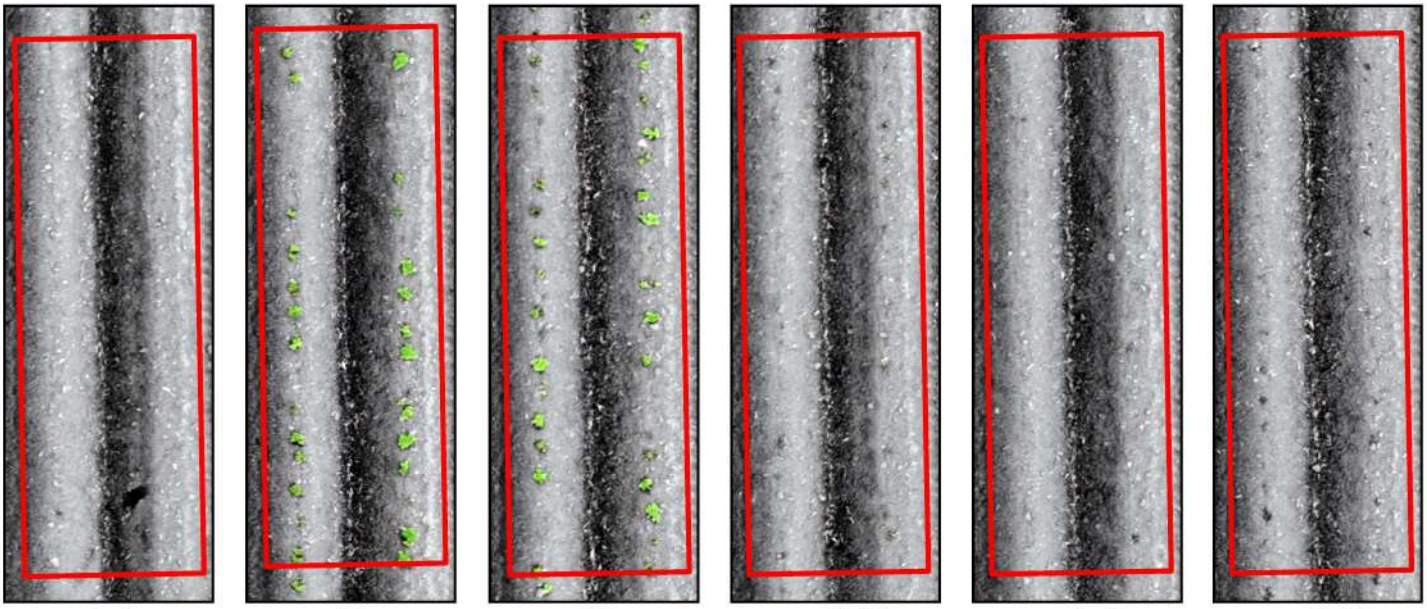
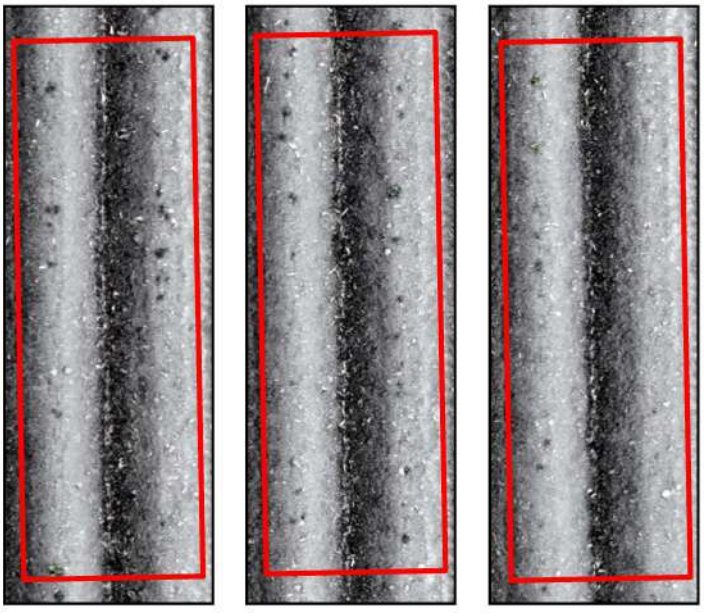


7 8 9 10 11 12



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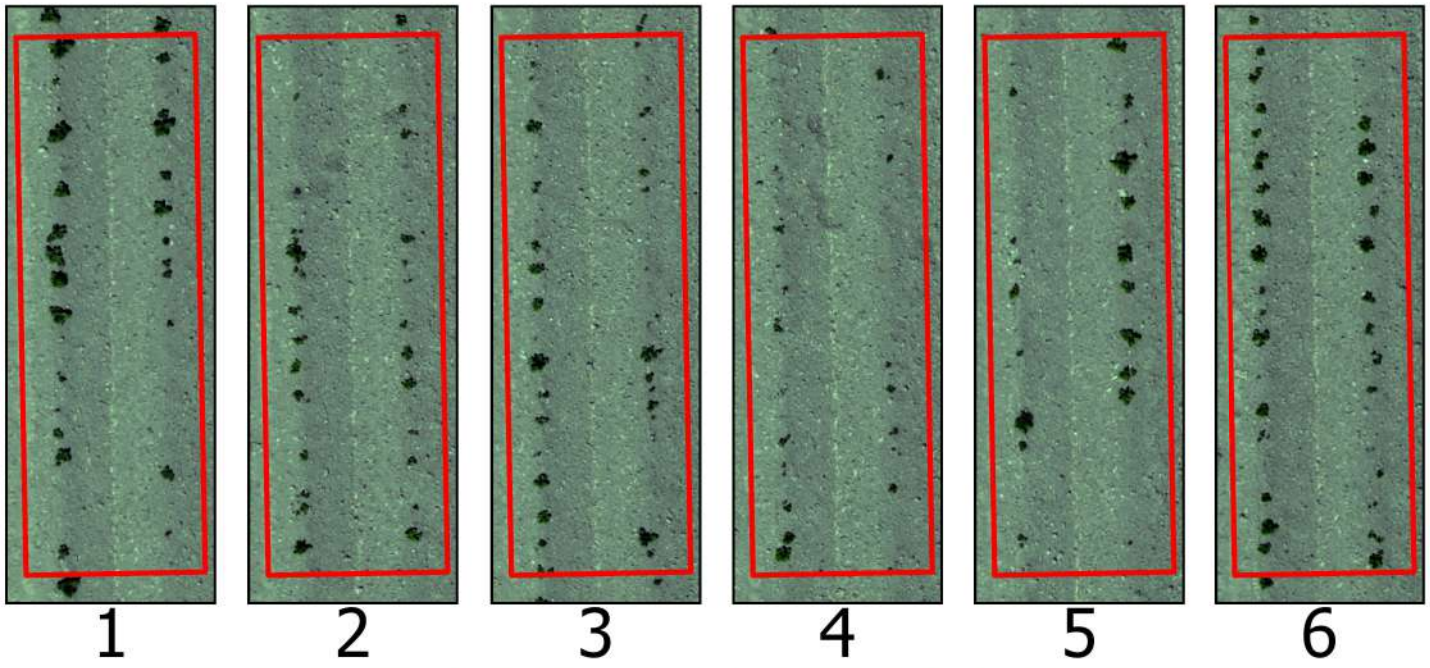

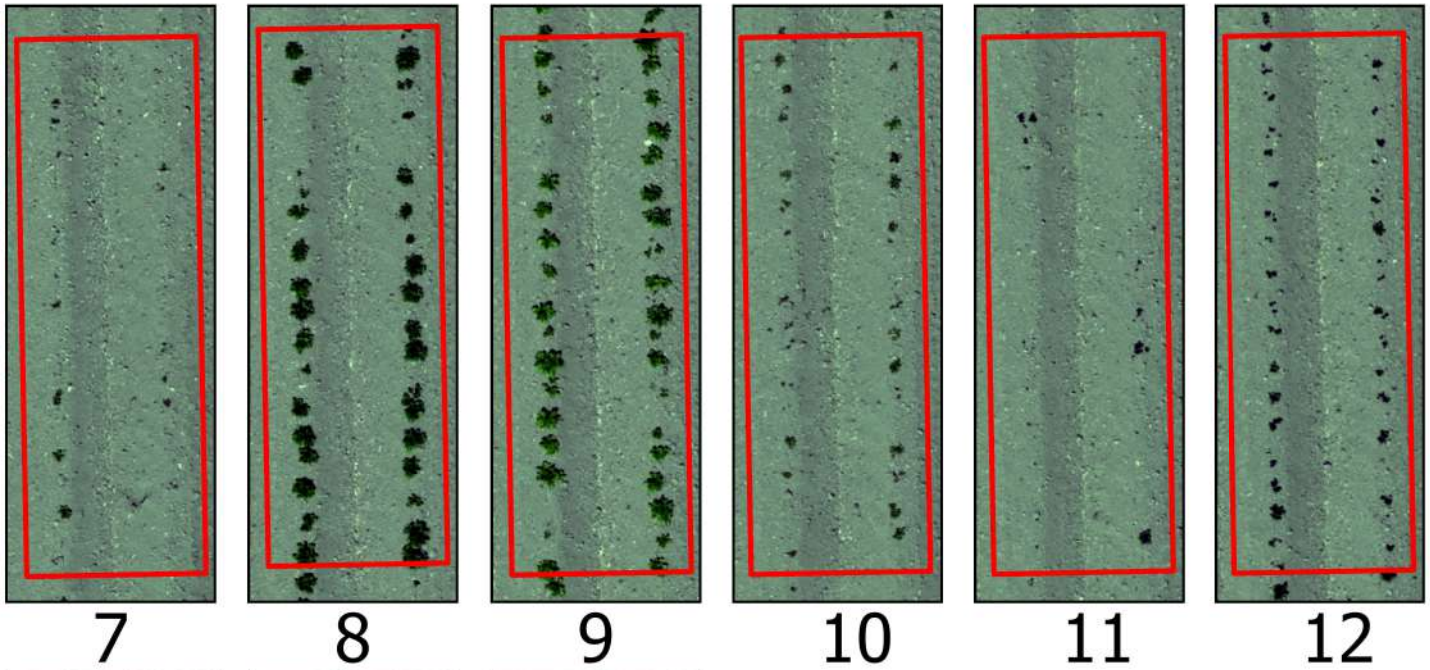

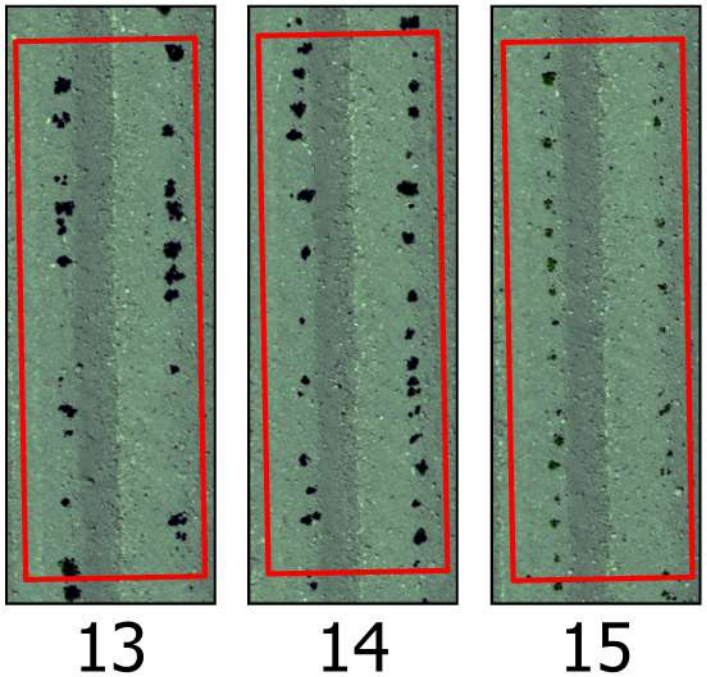

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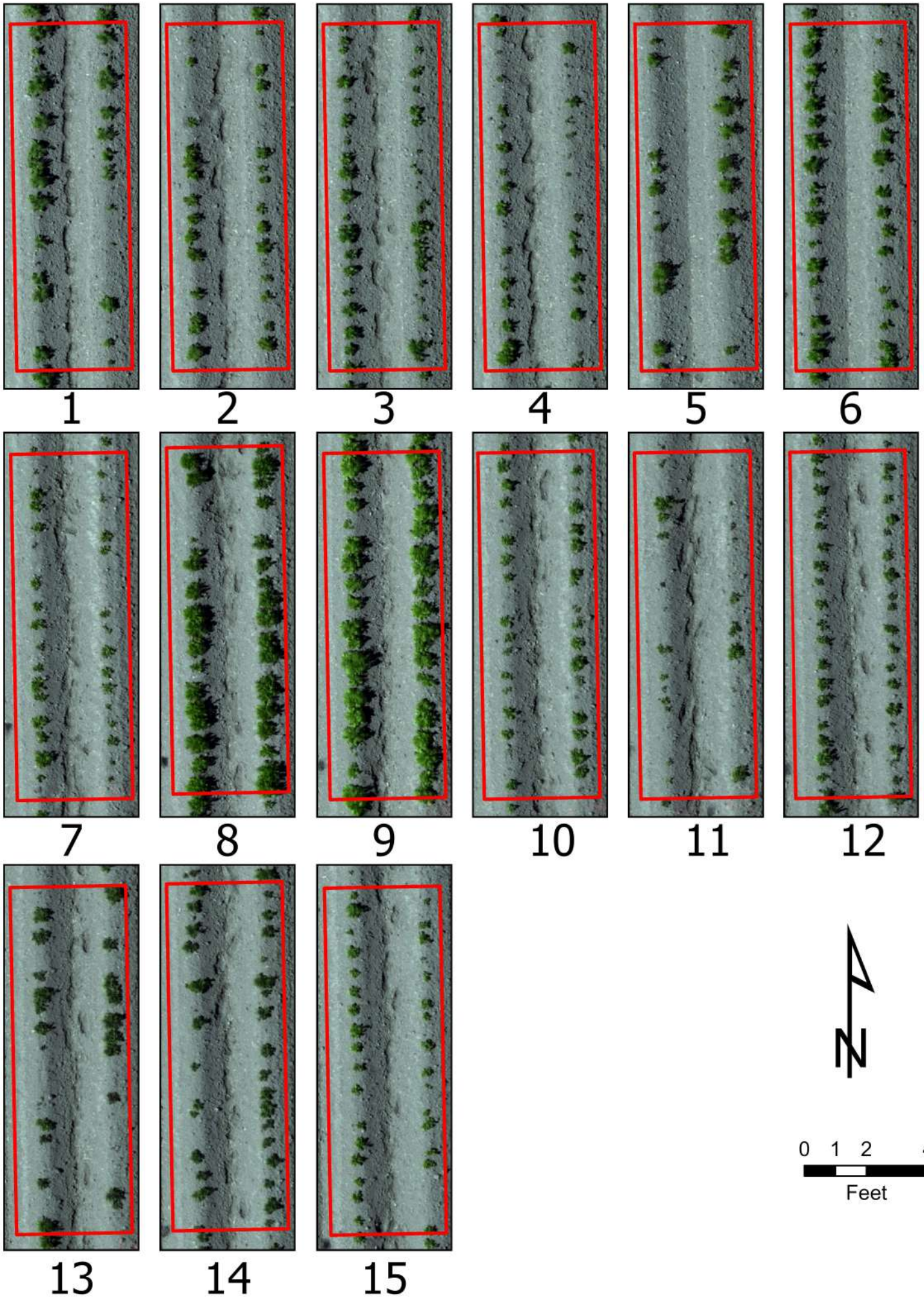

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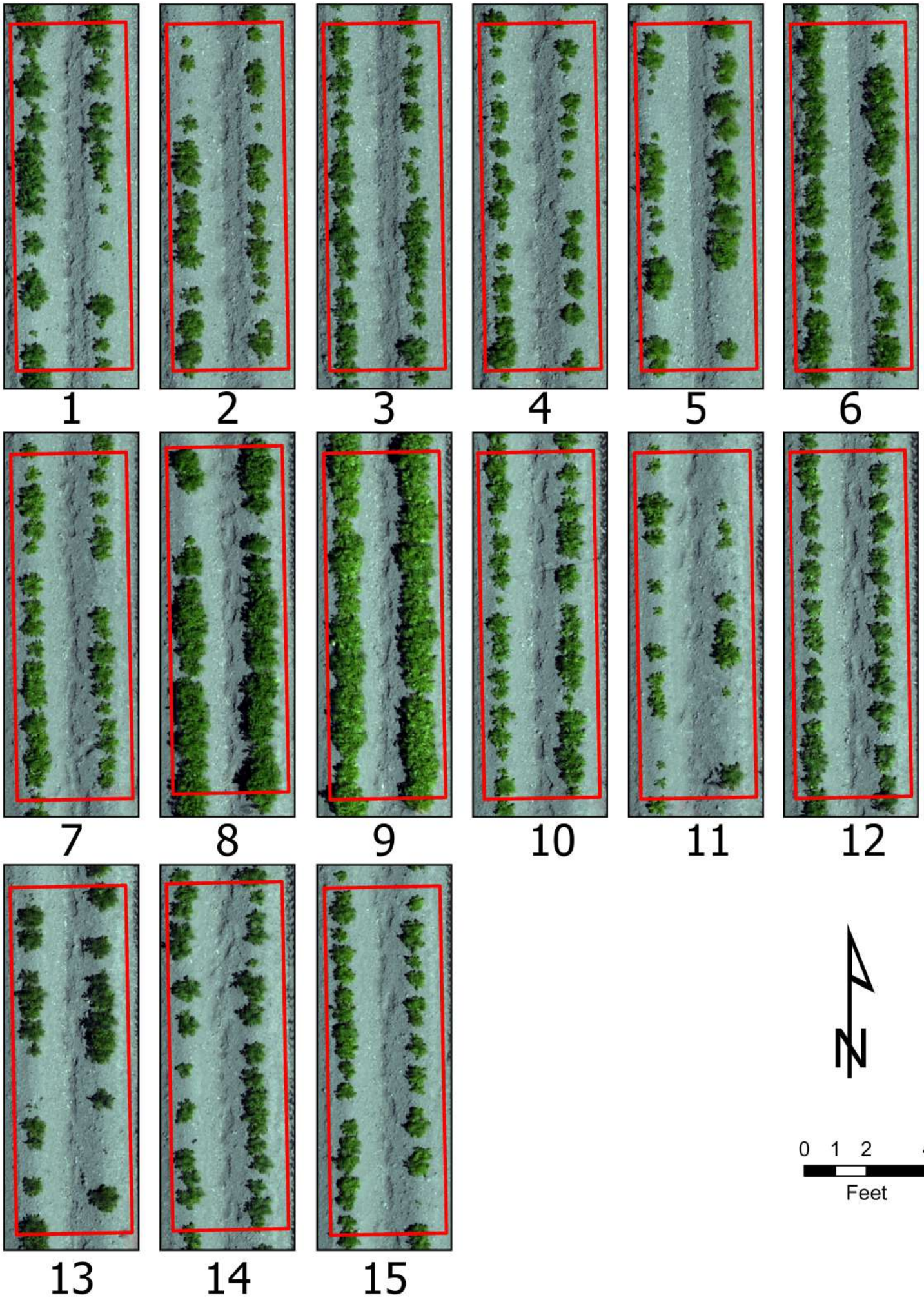

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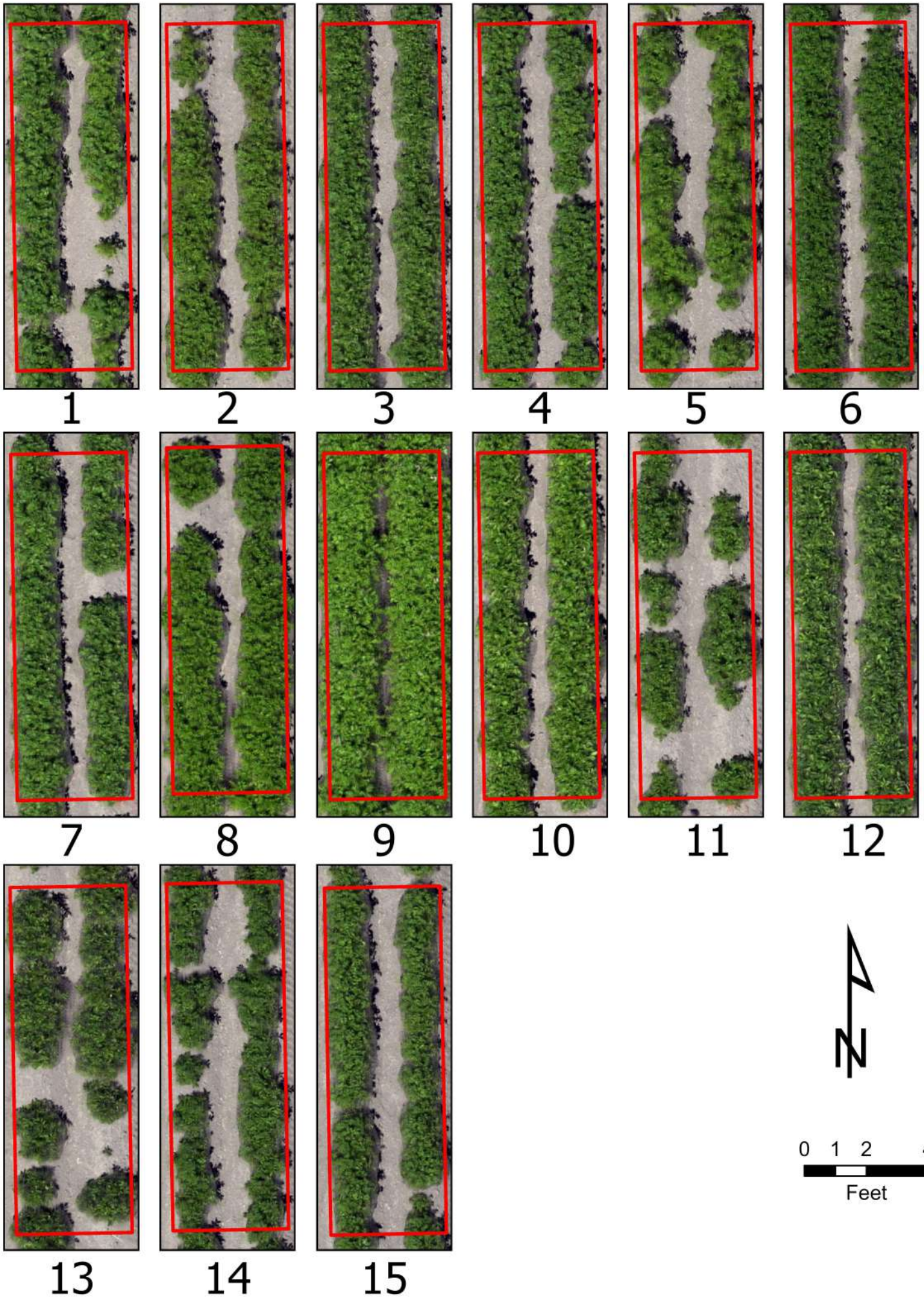

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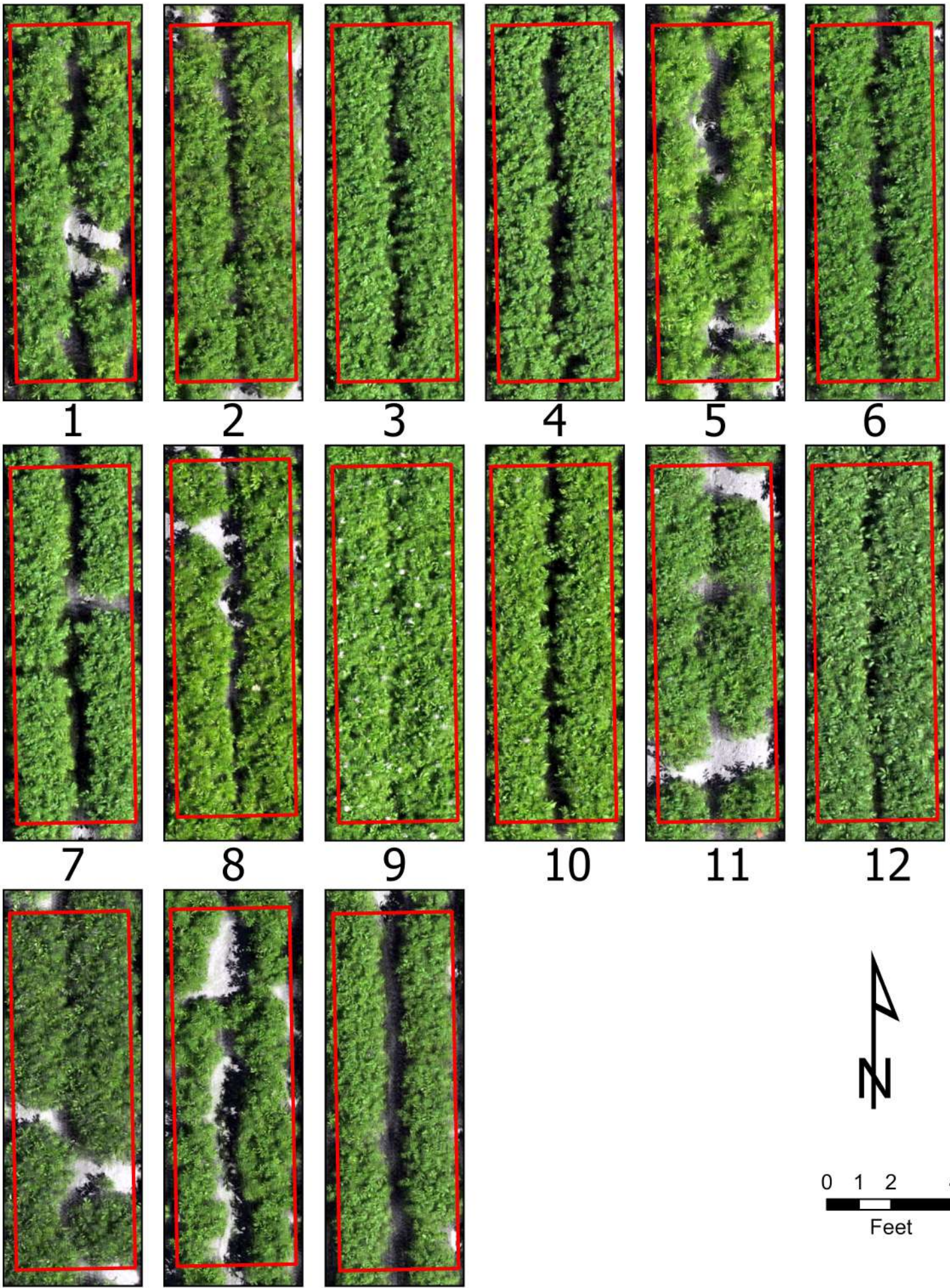

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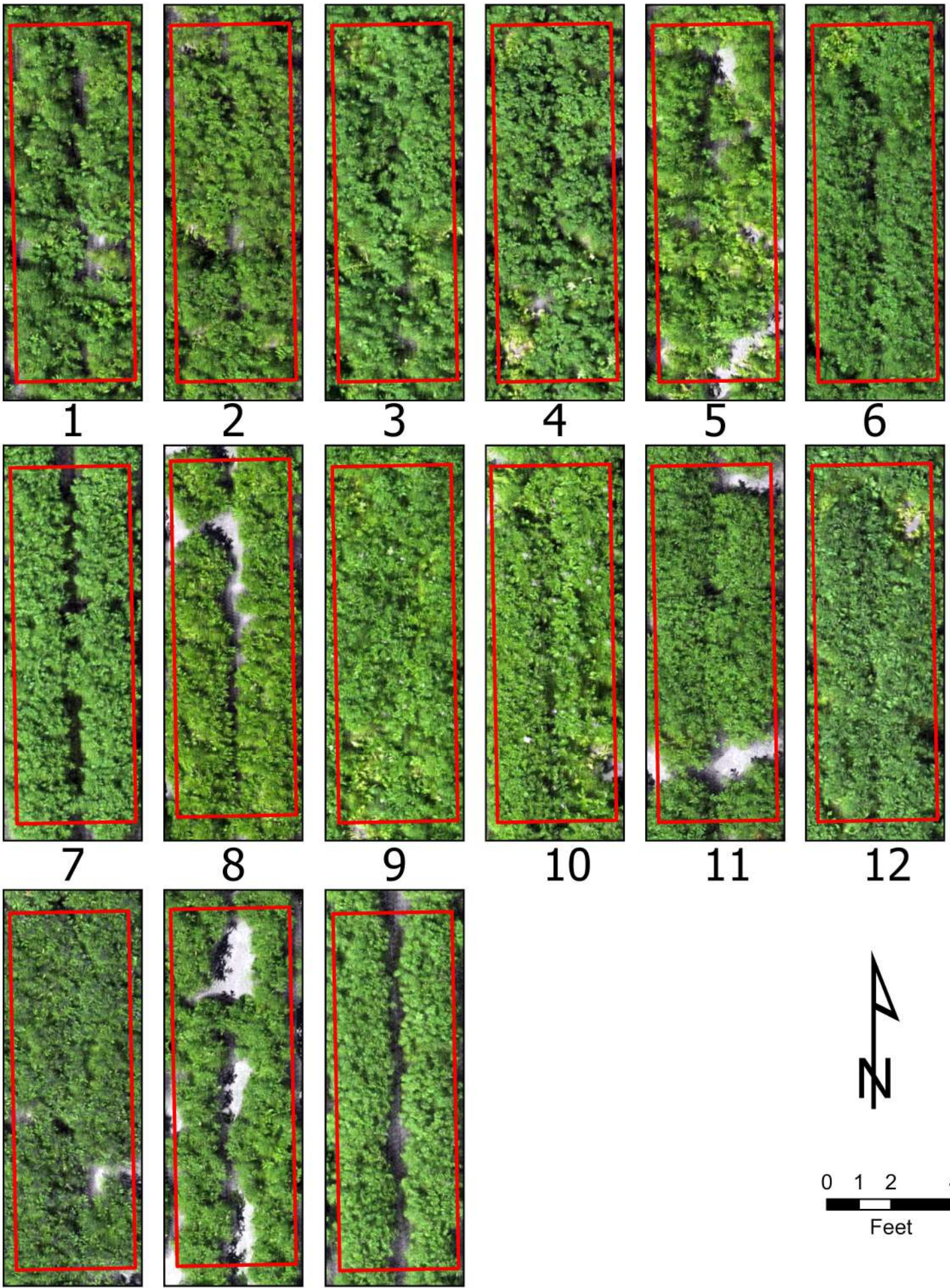

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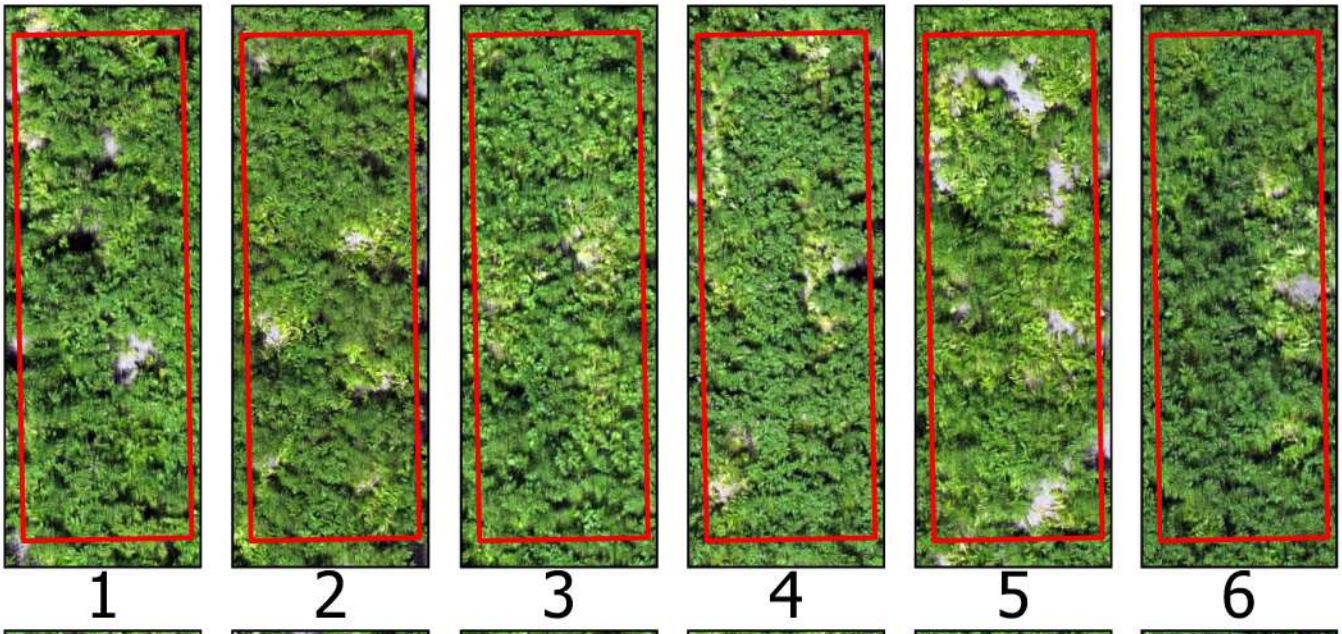

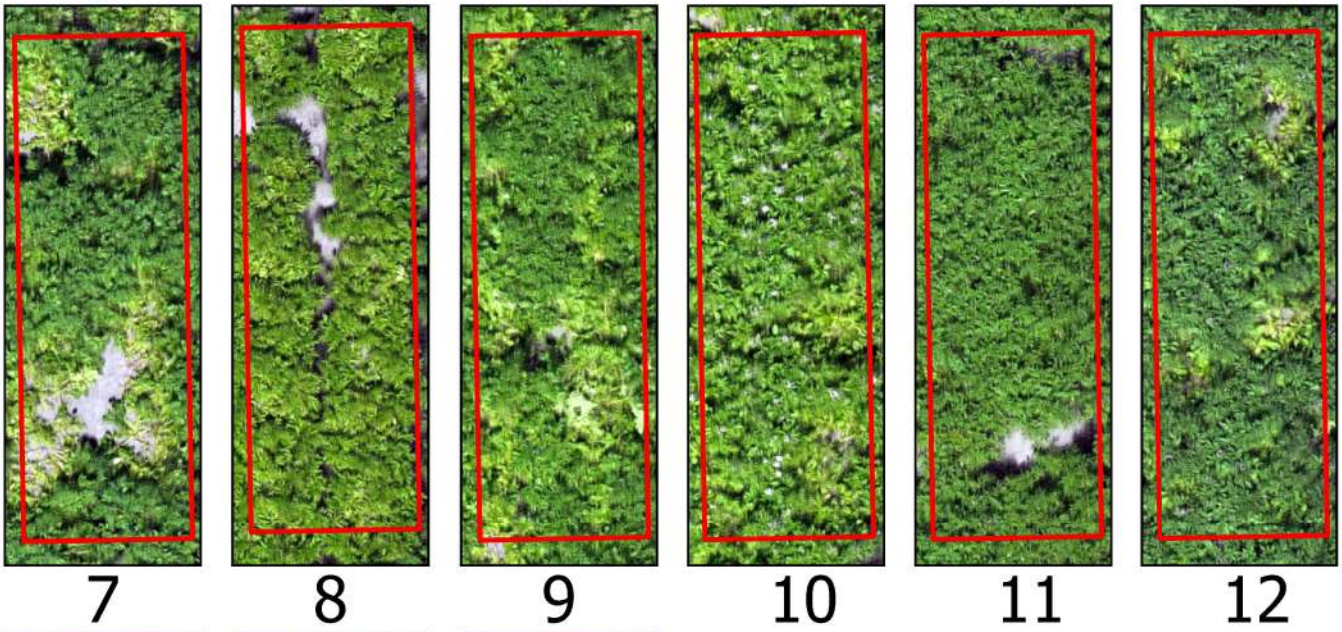

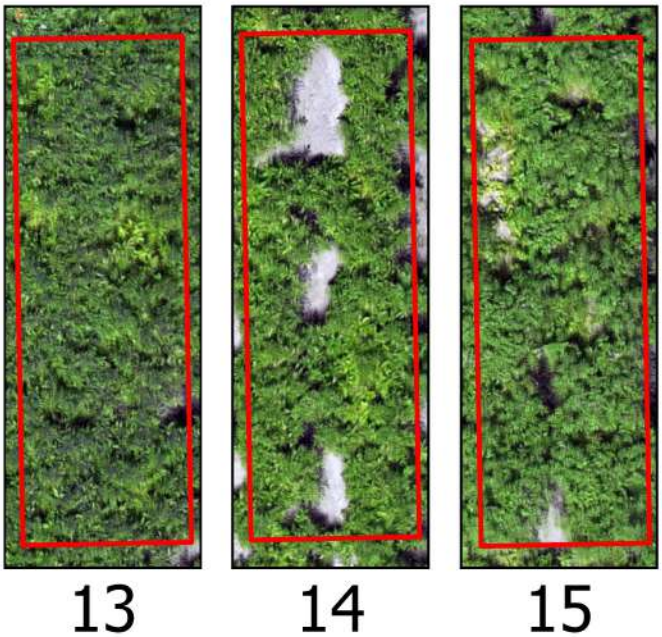

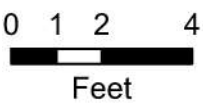

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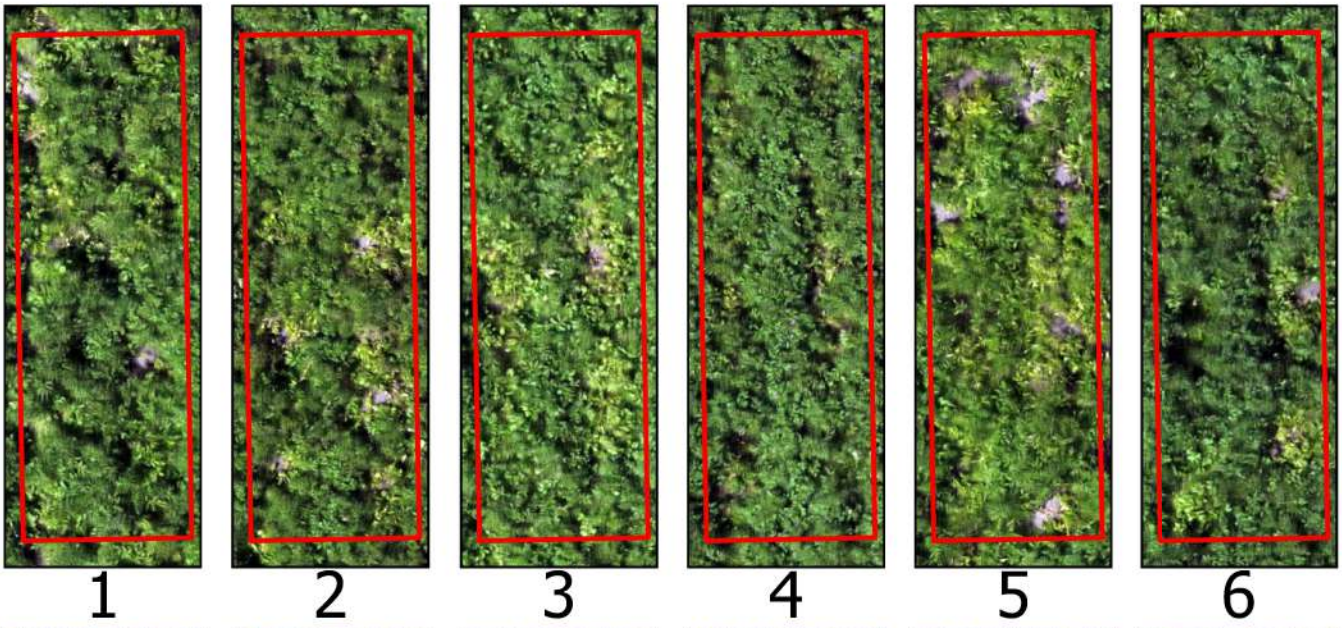

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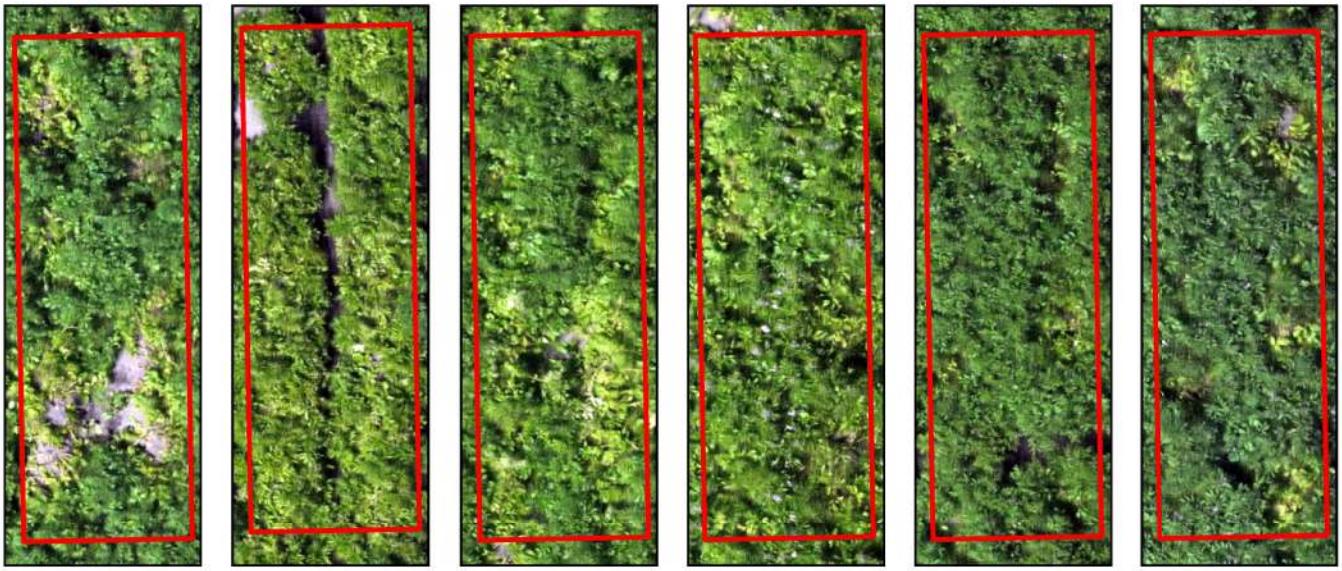

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Feet

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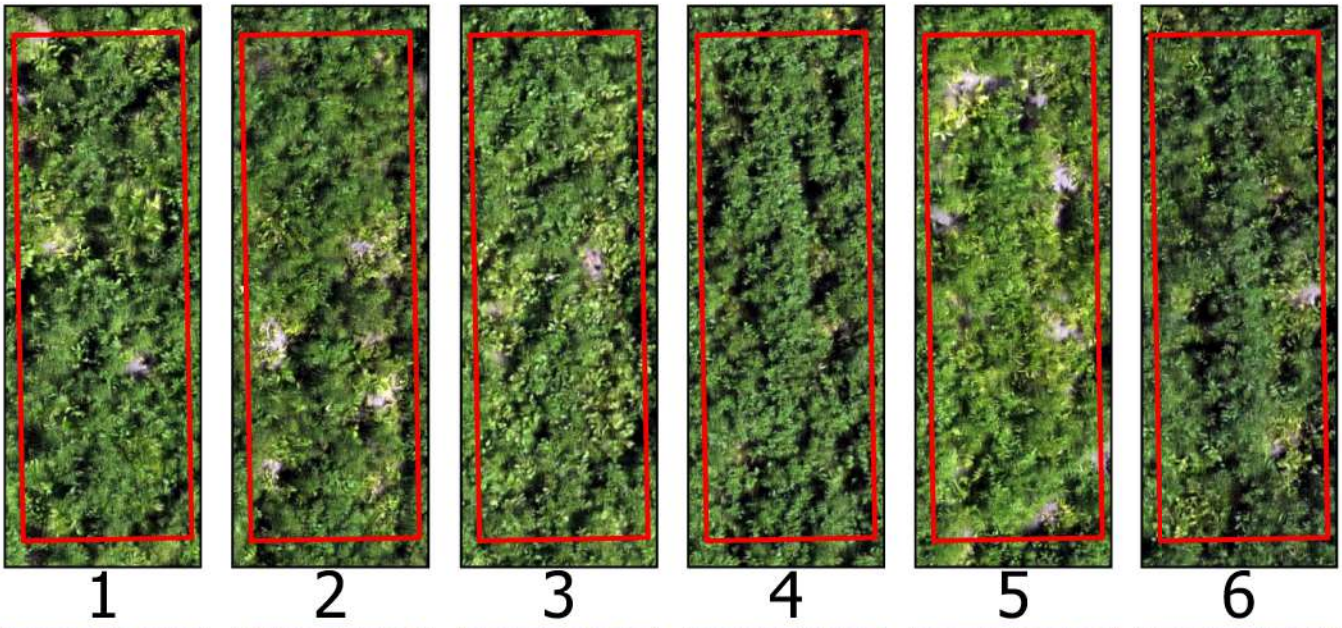

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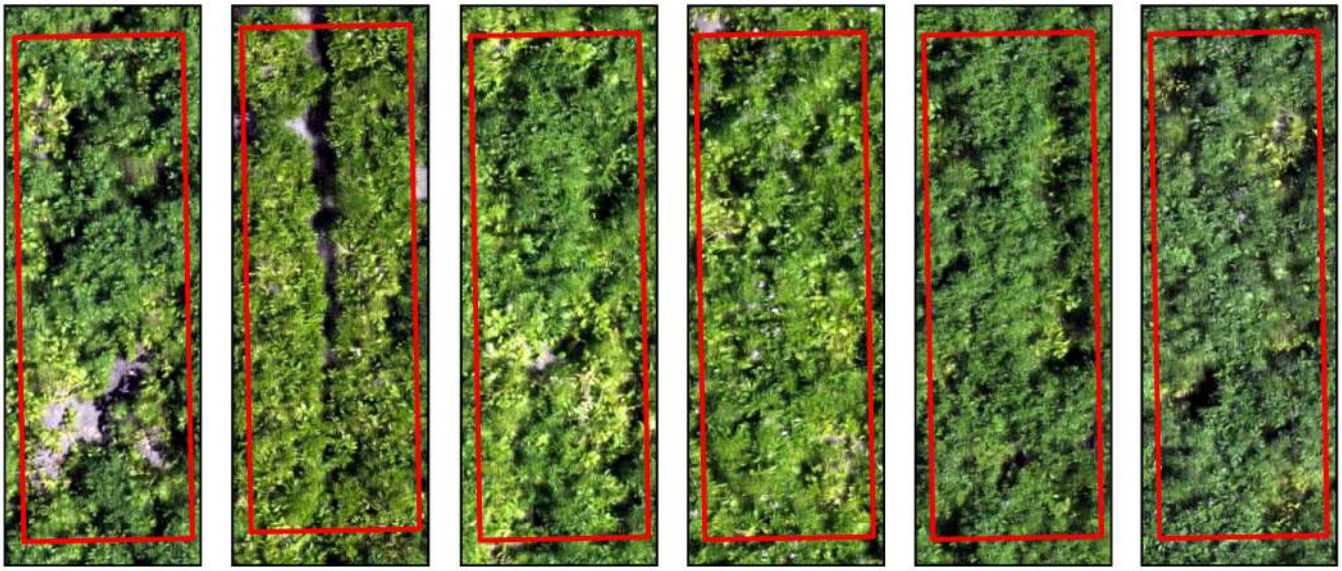

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Feet

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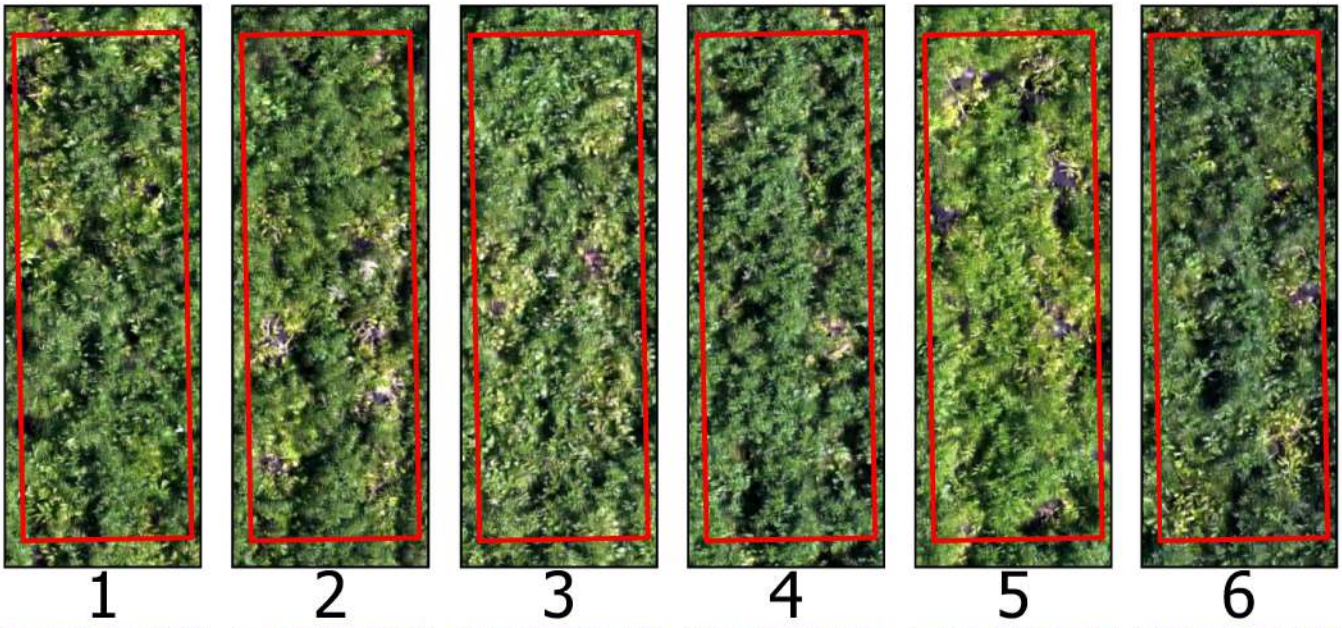

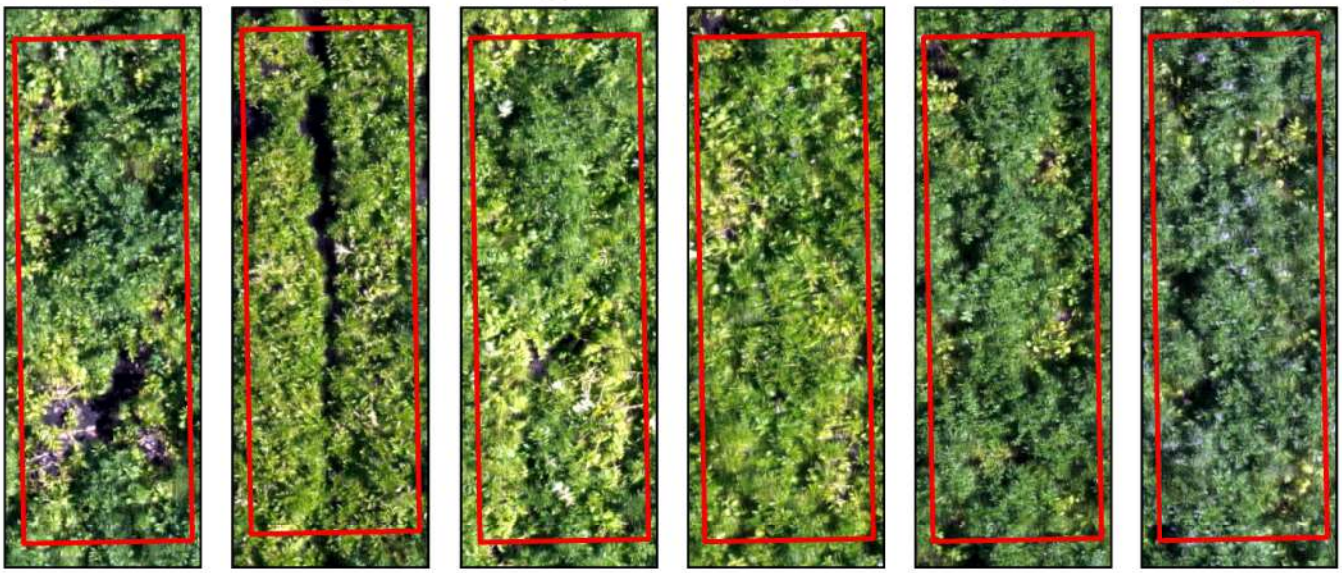

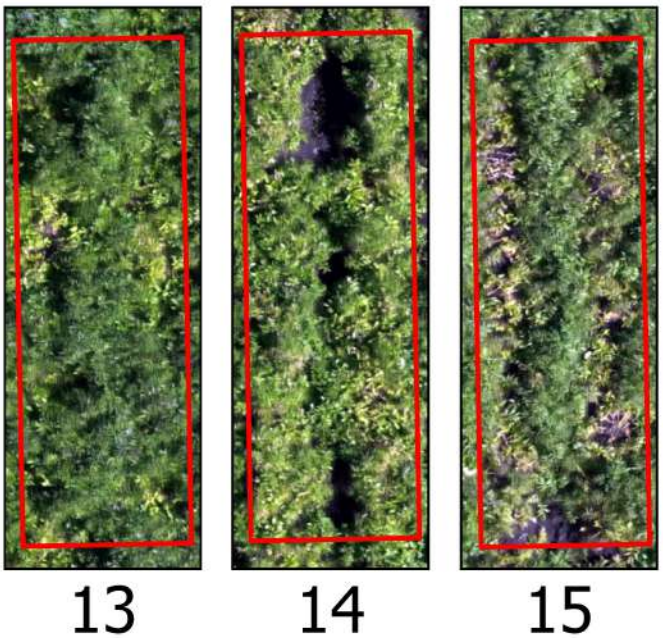

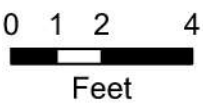

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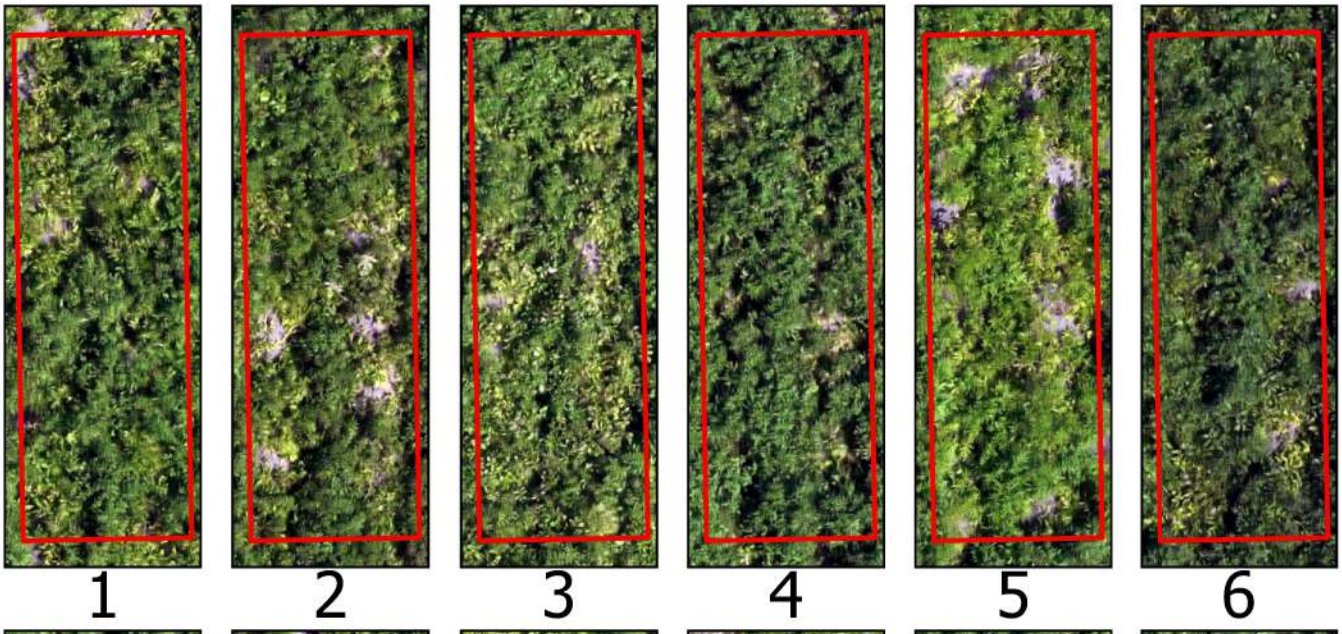

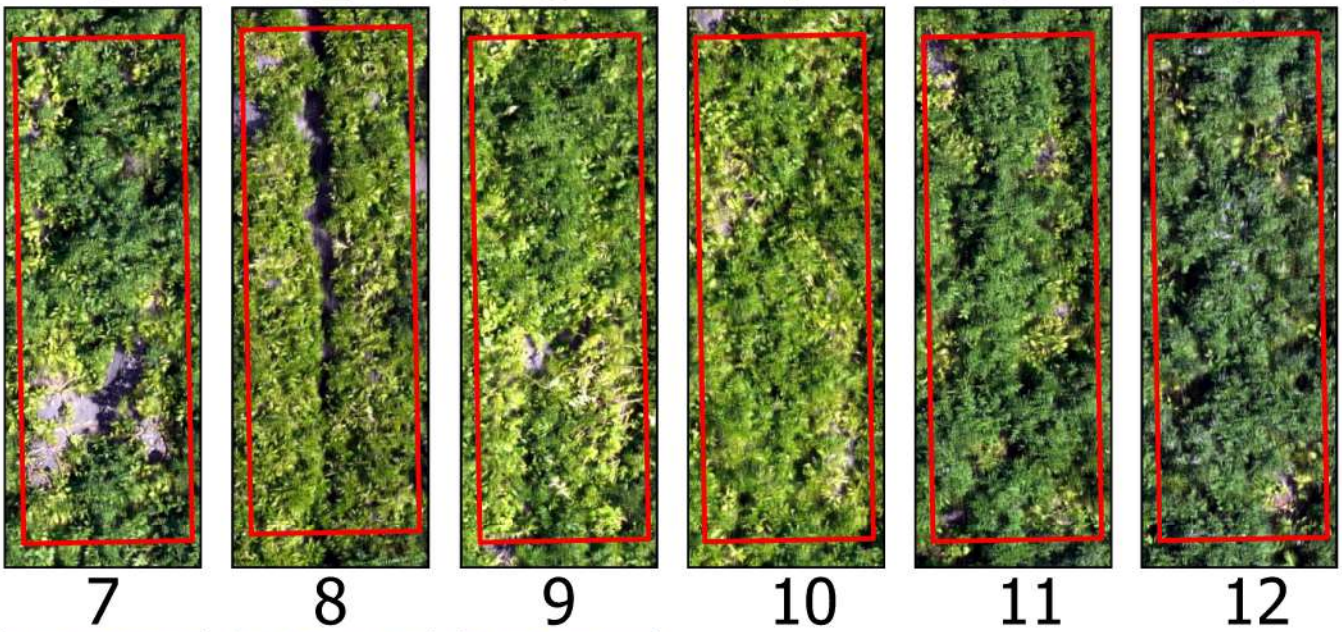

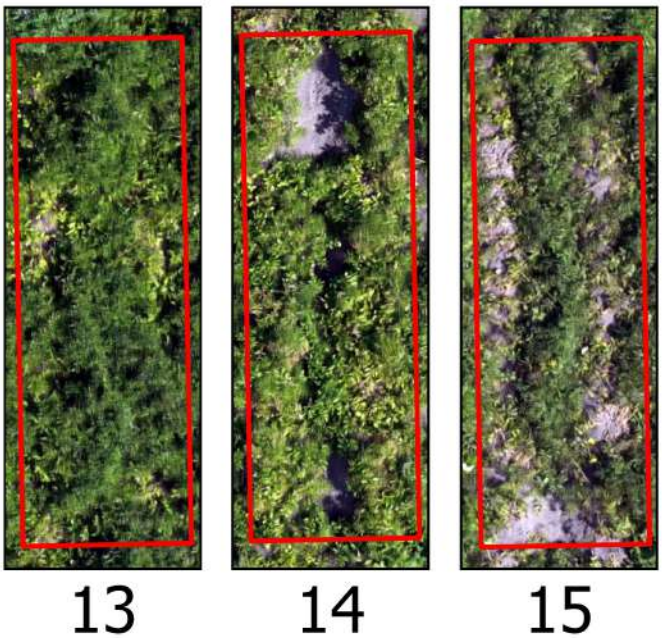

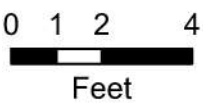

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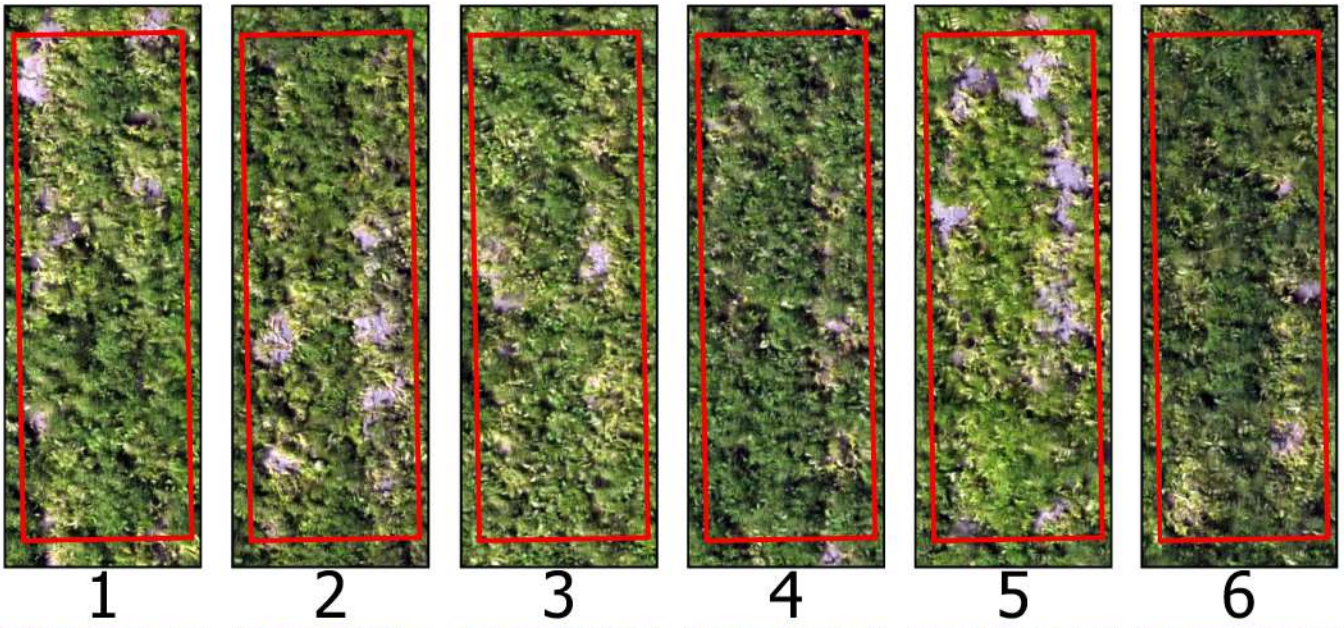

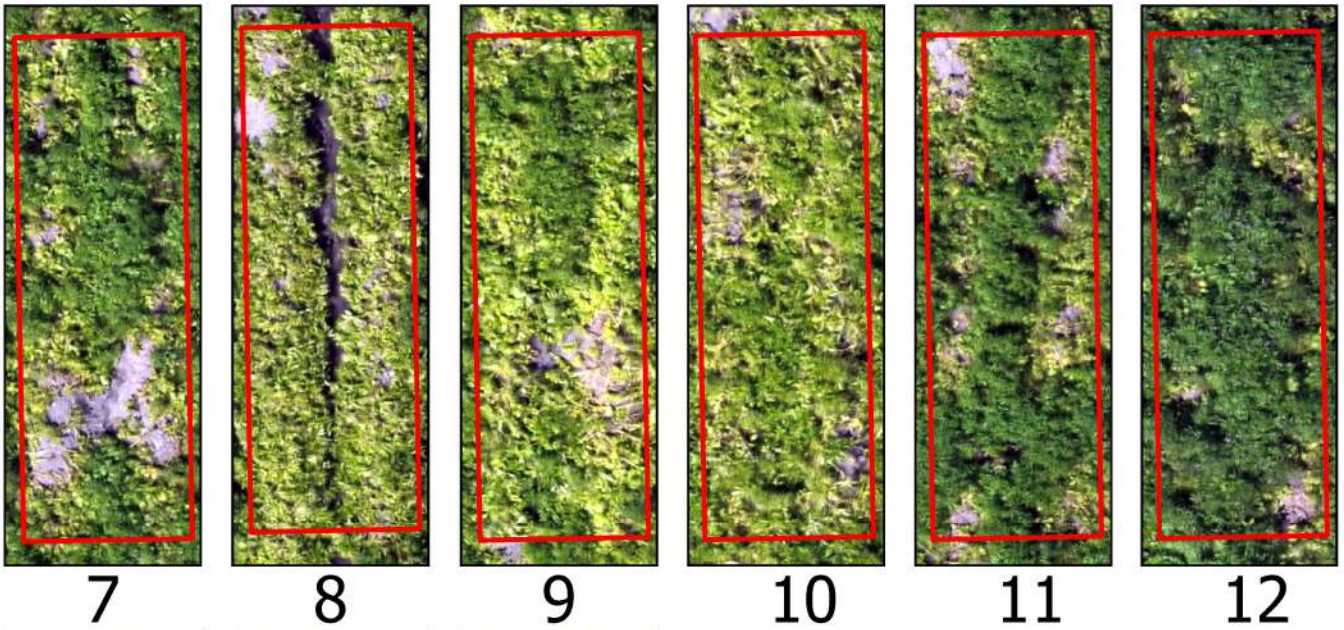

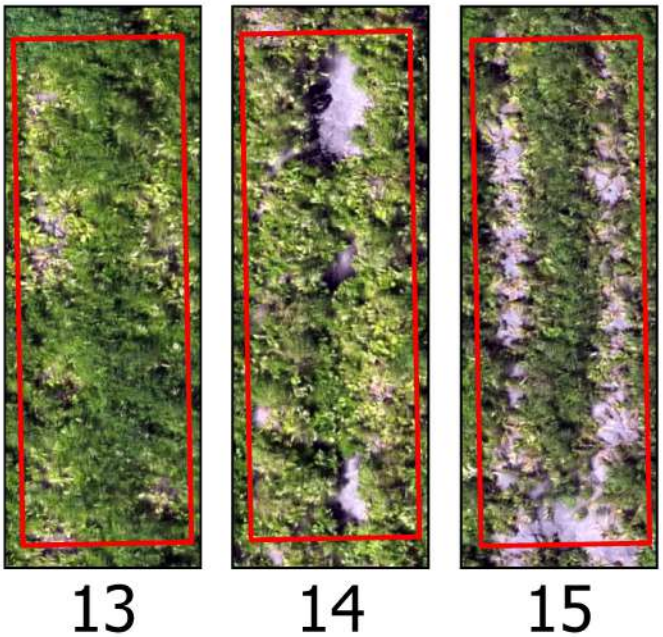

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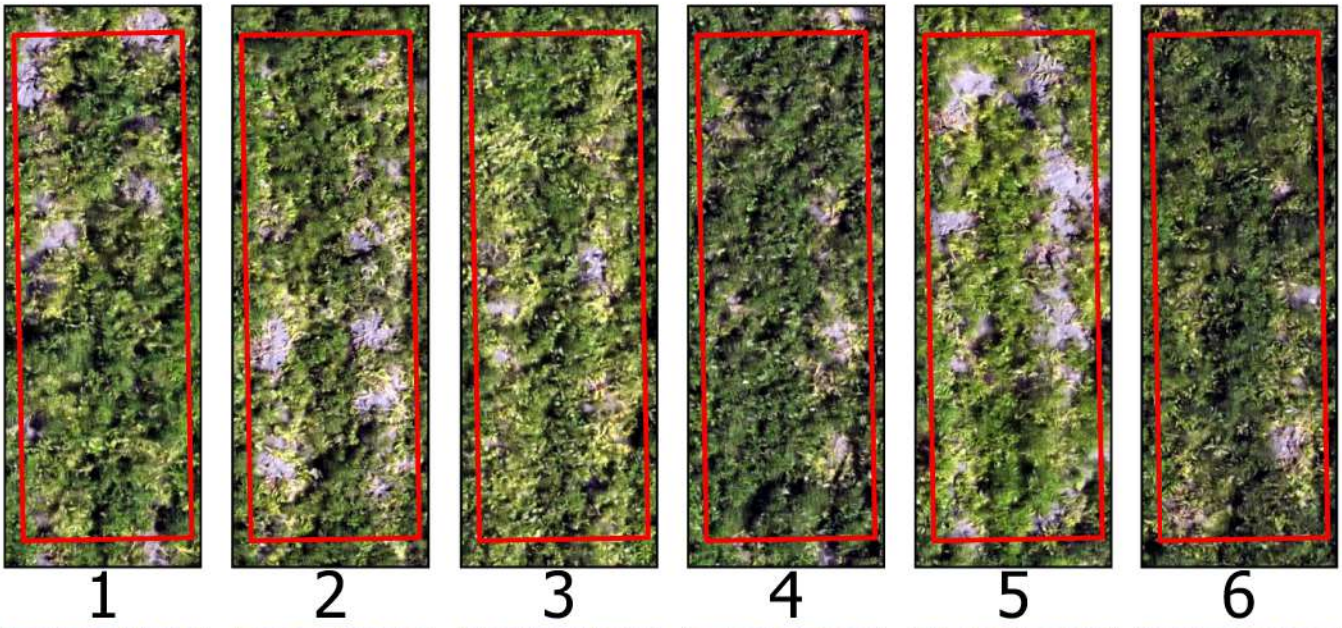

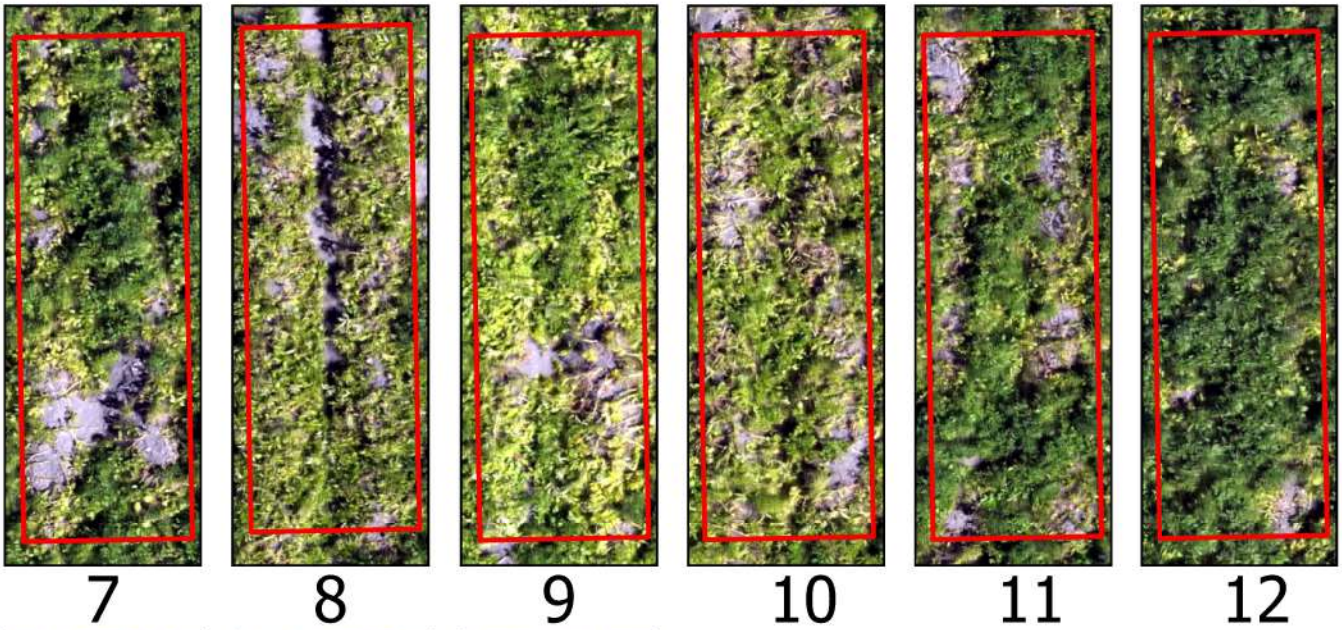

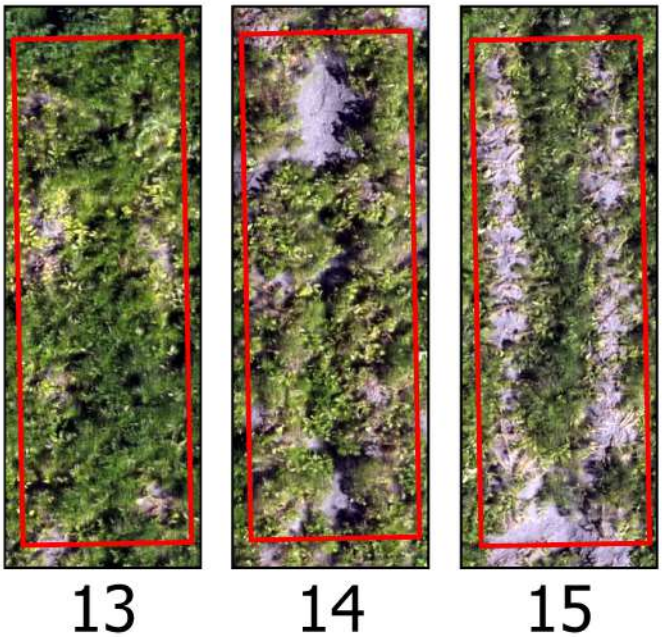

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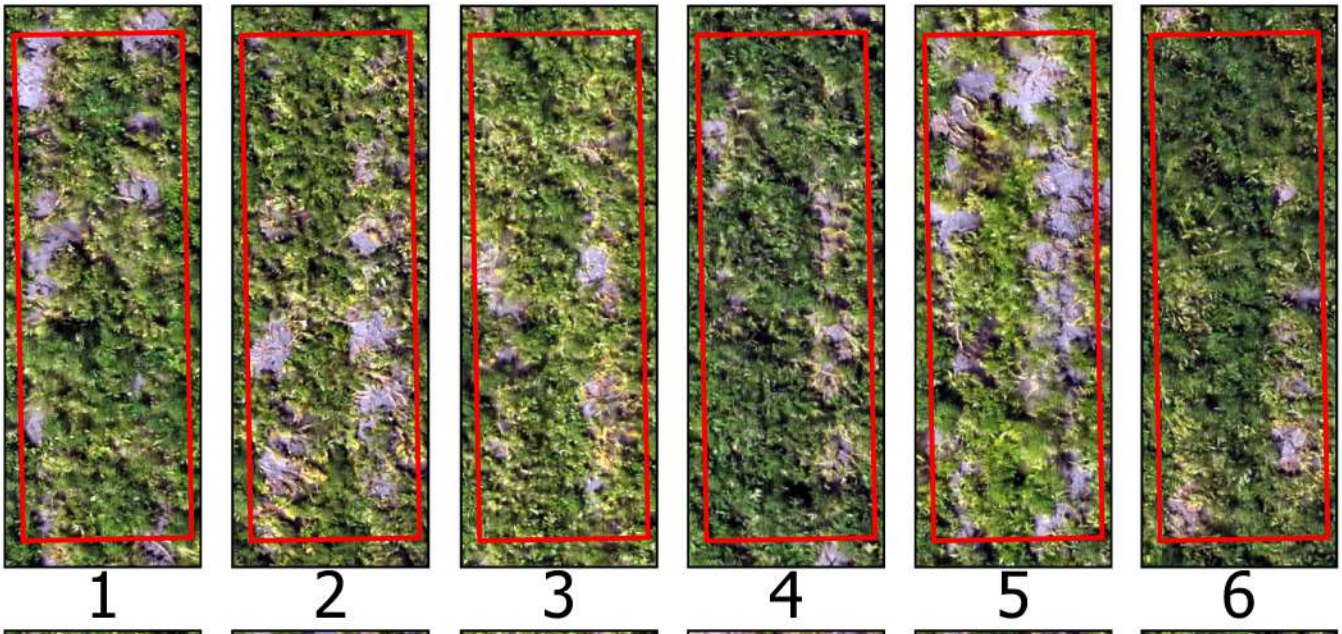

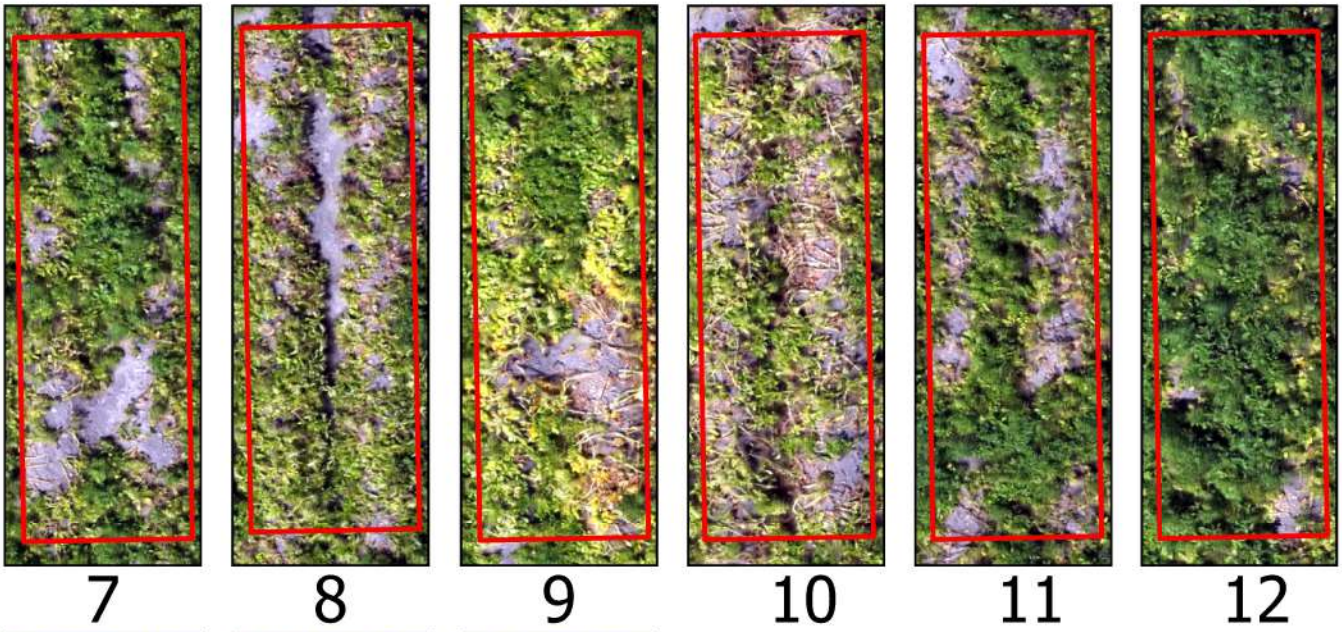

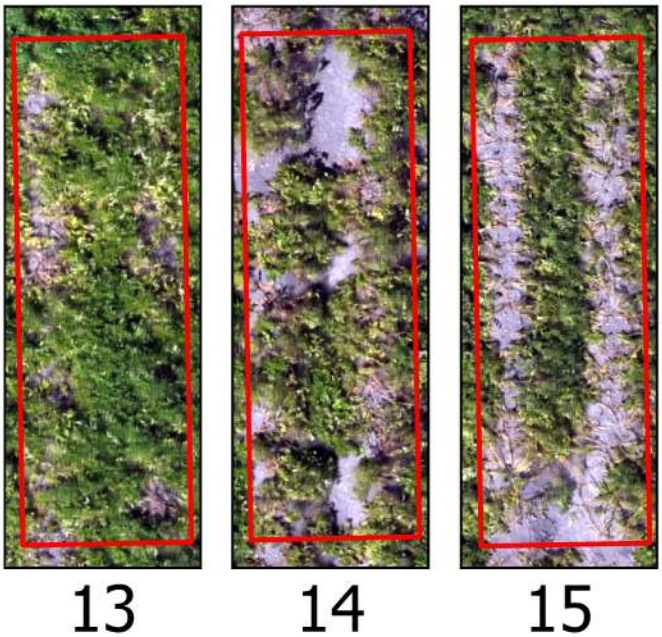

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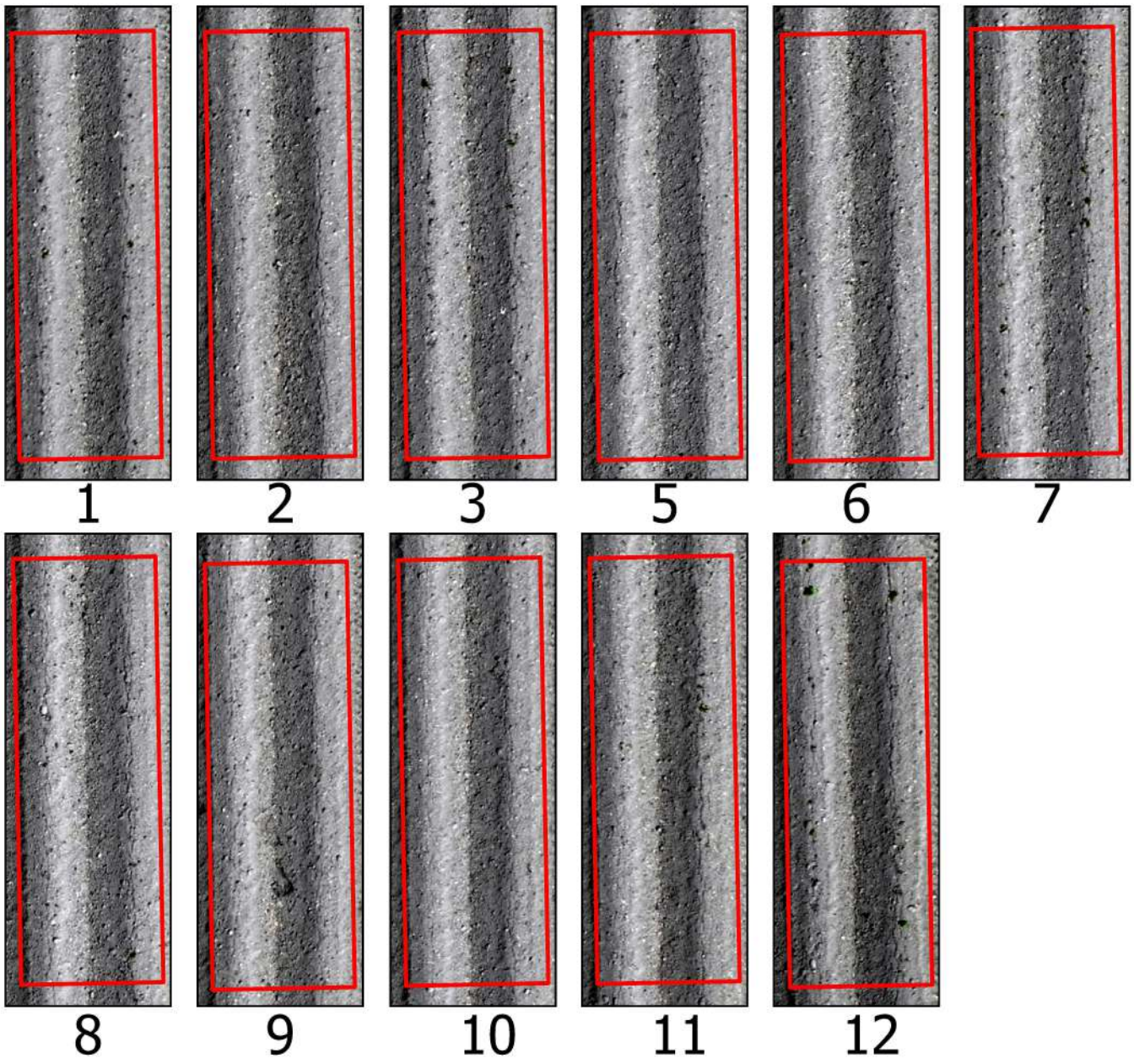

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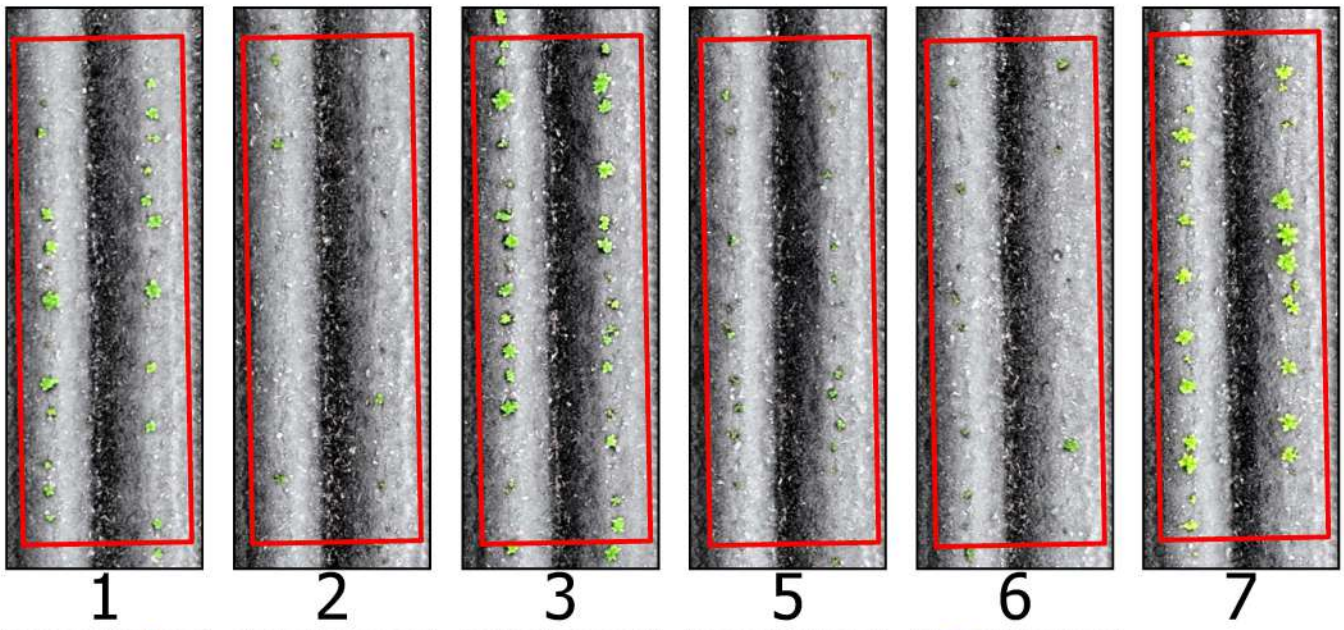

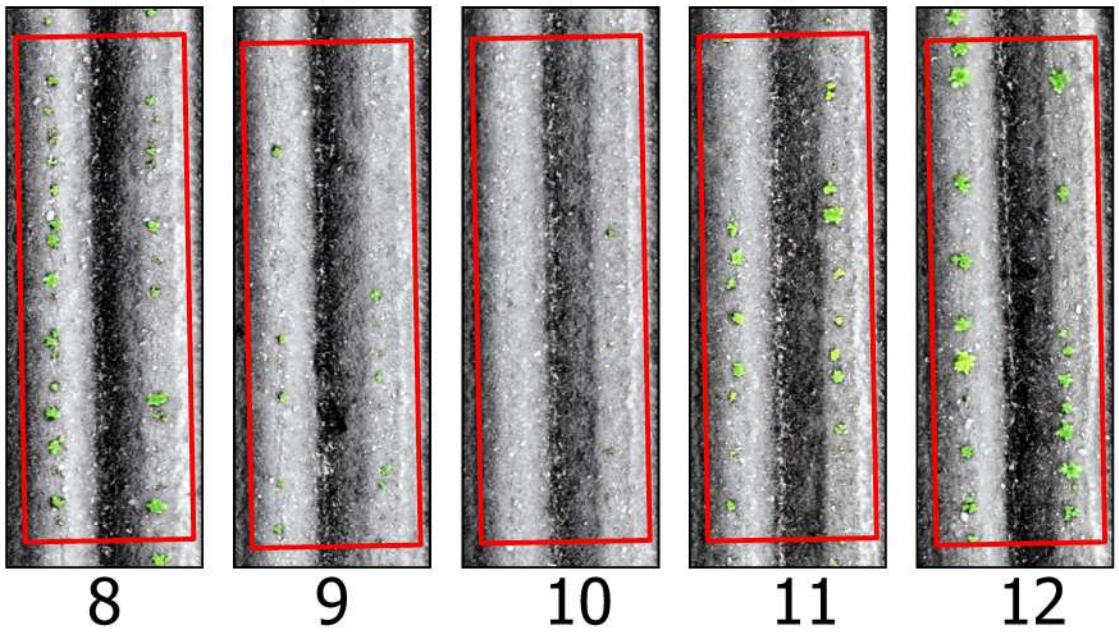

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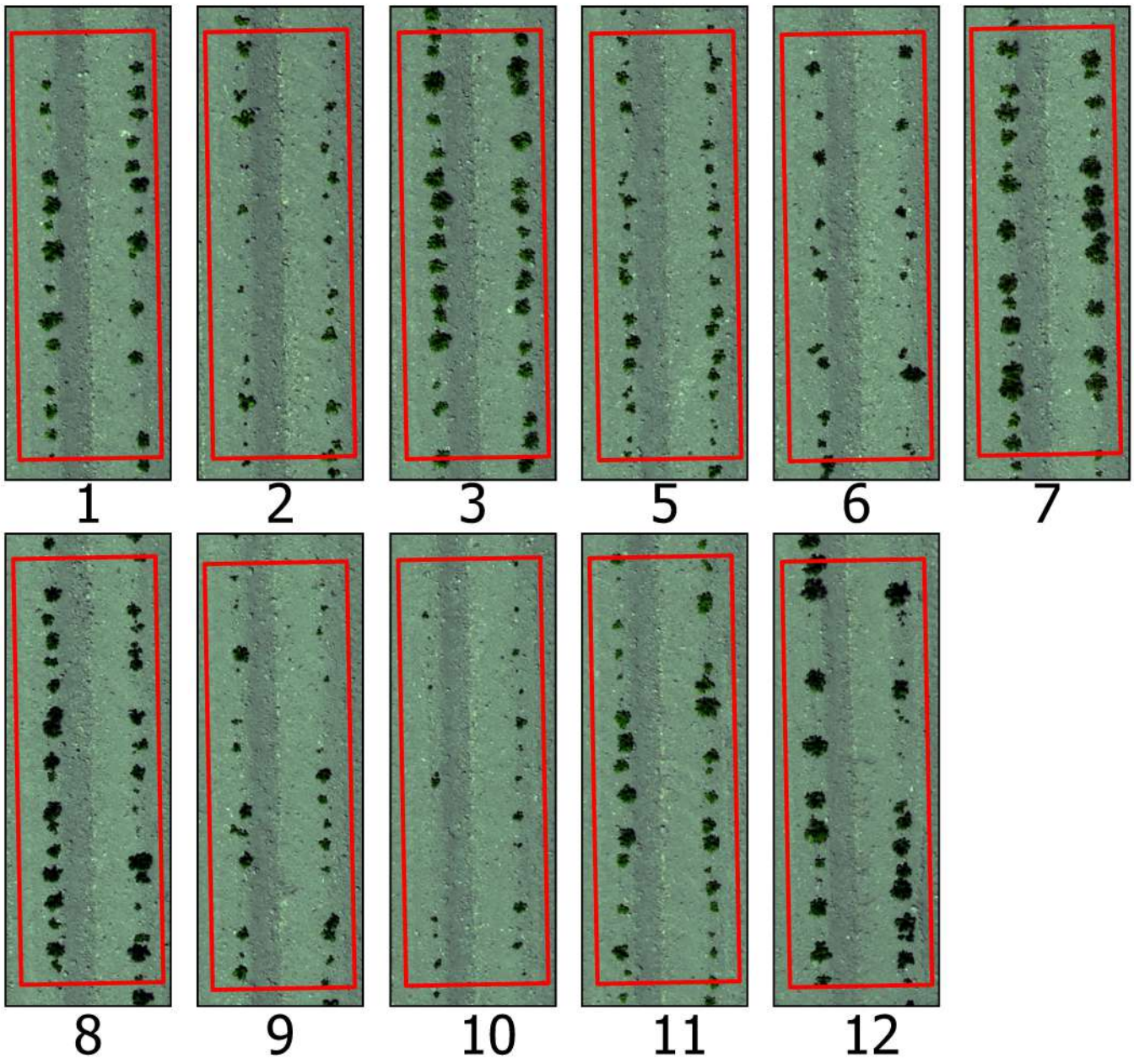

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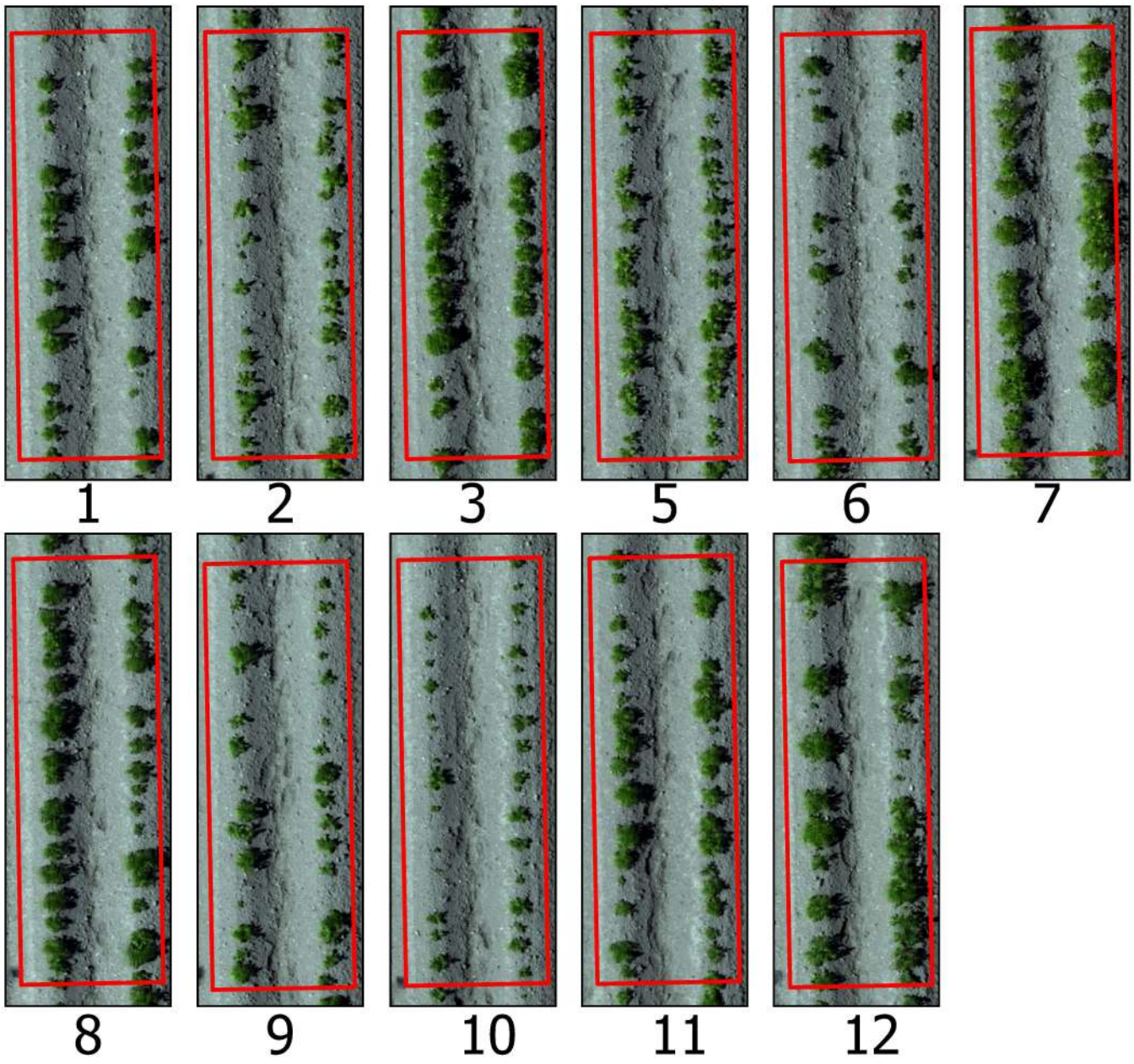

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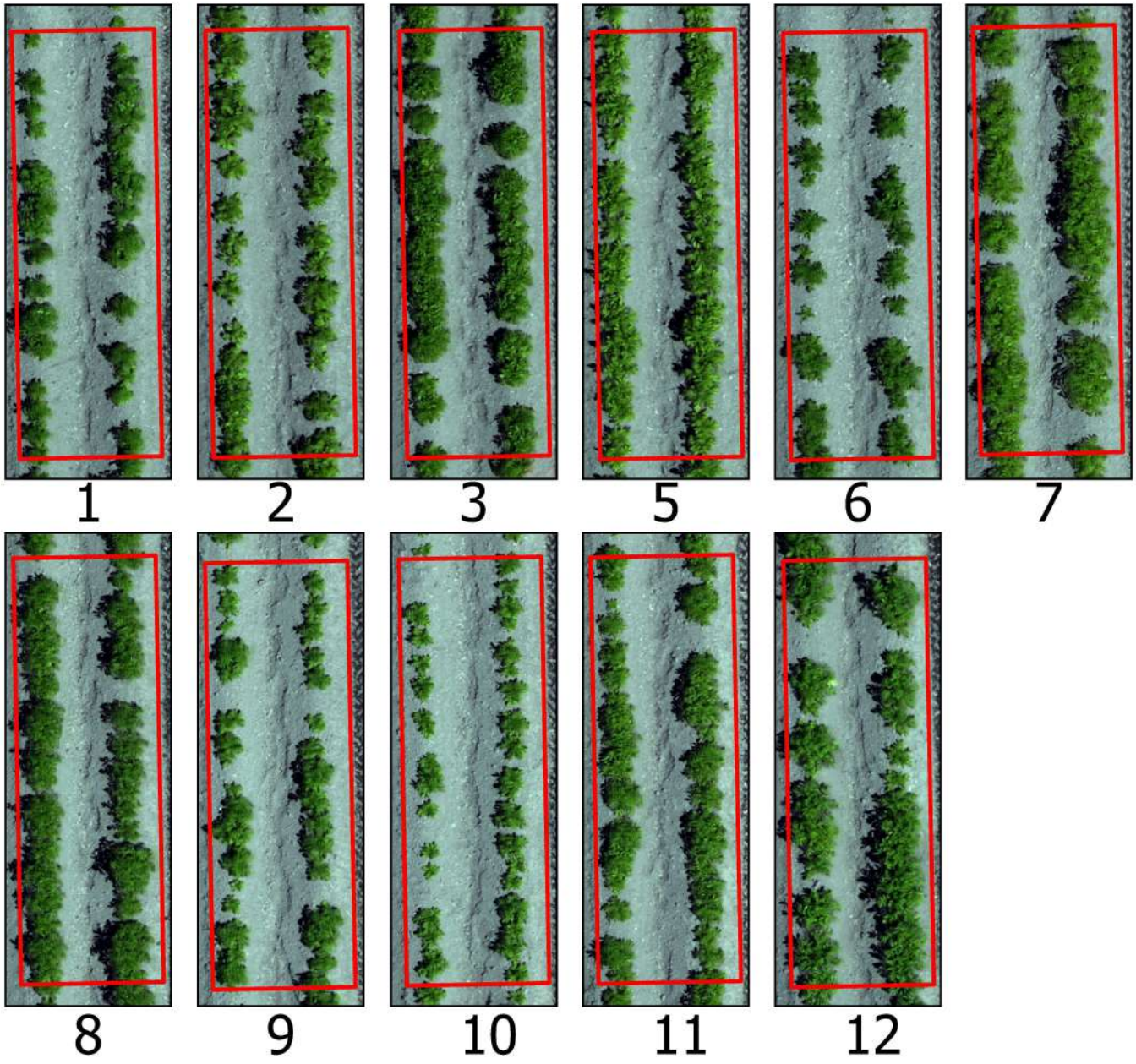

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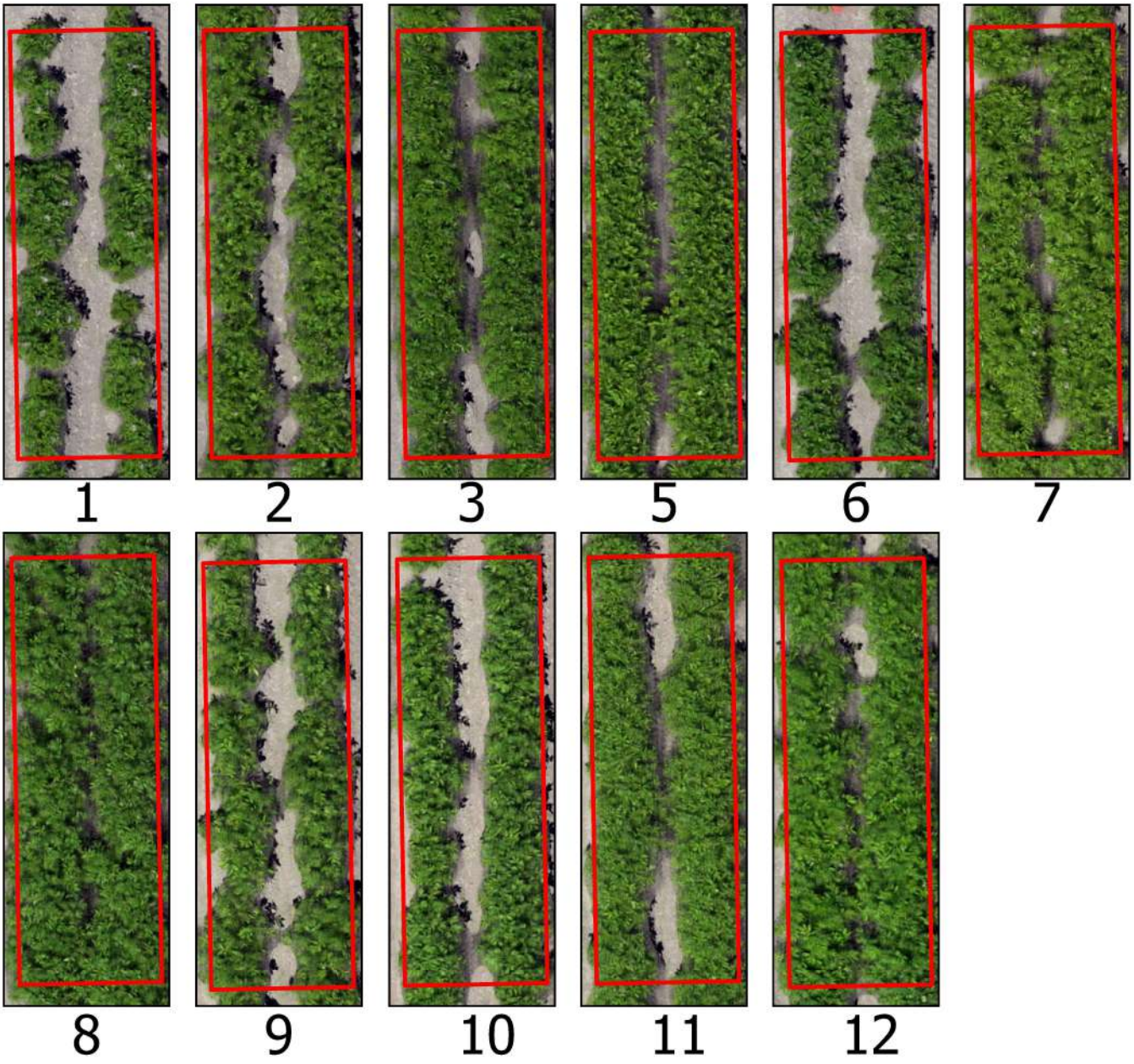

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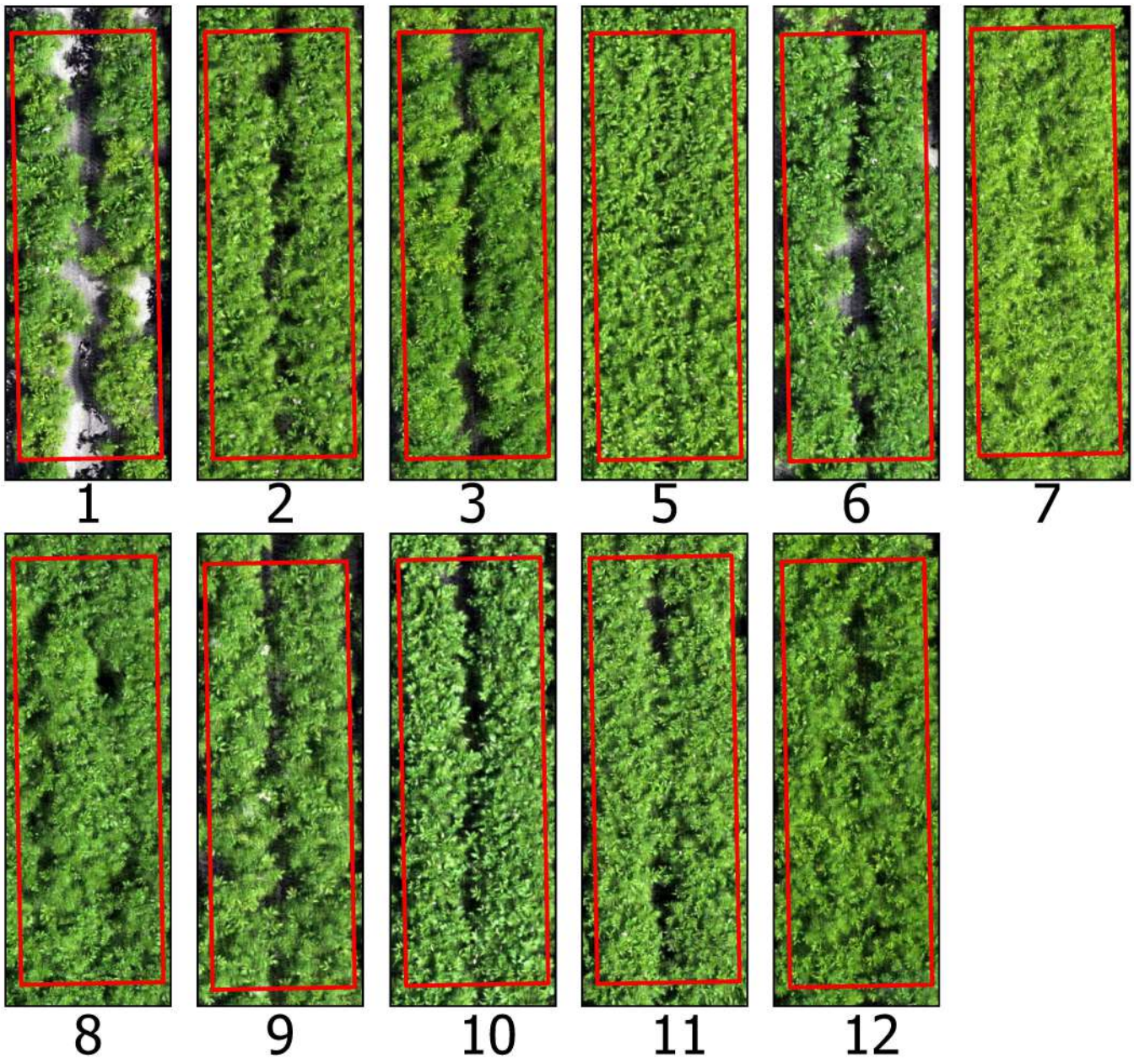

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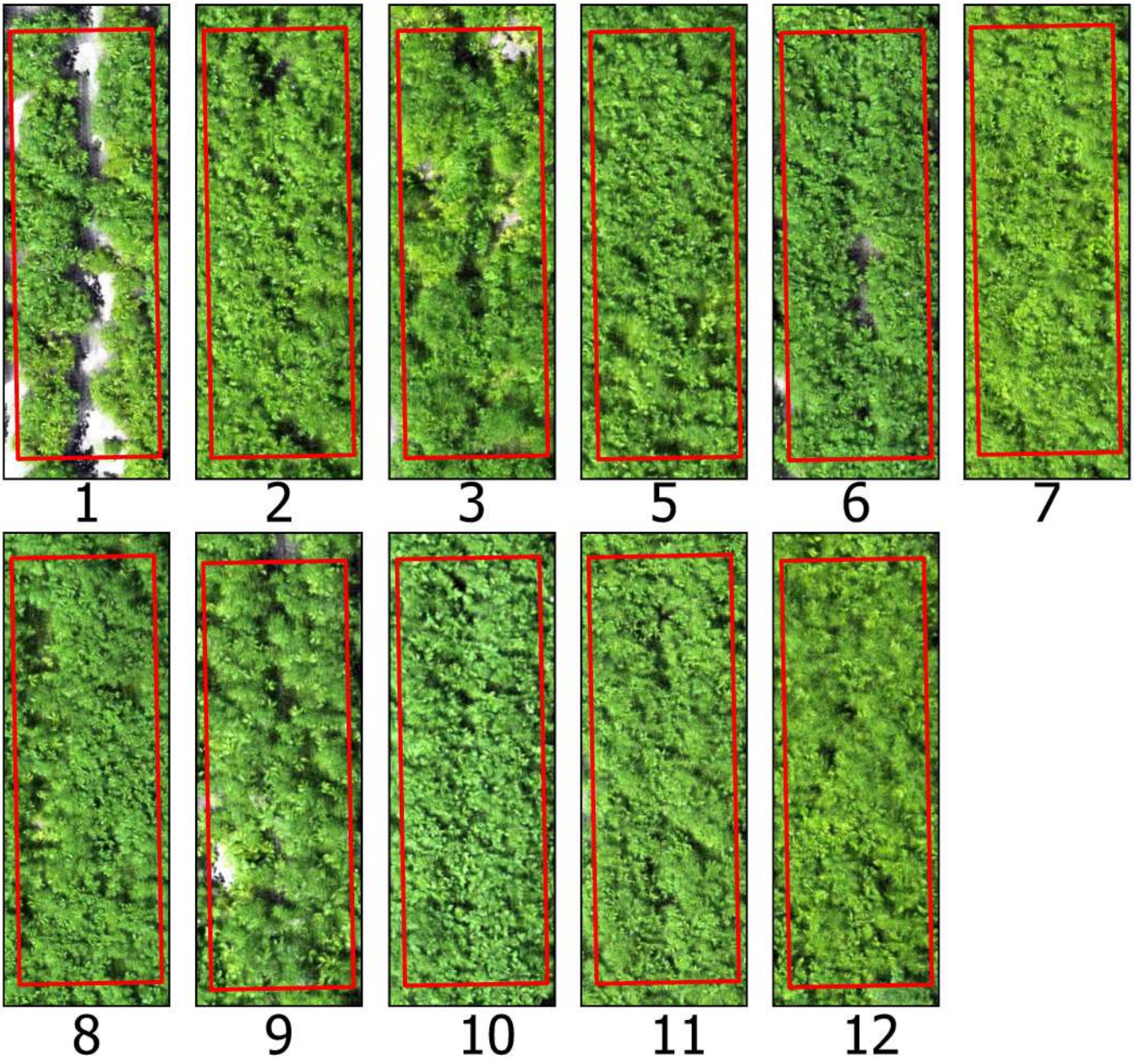

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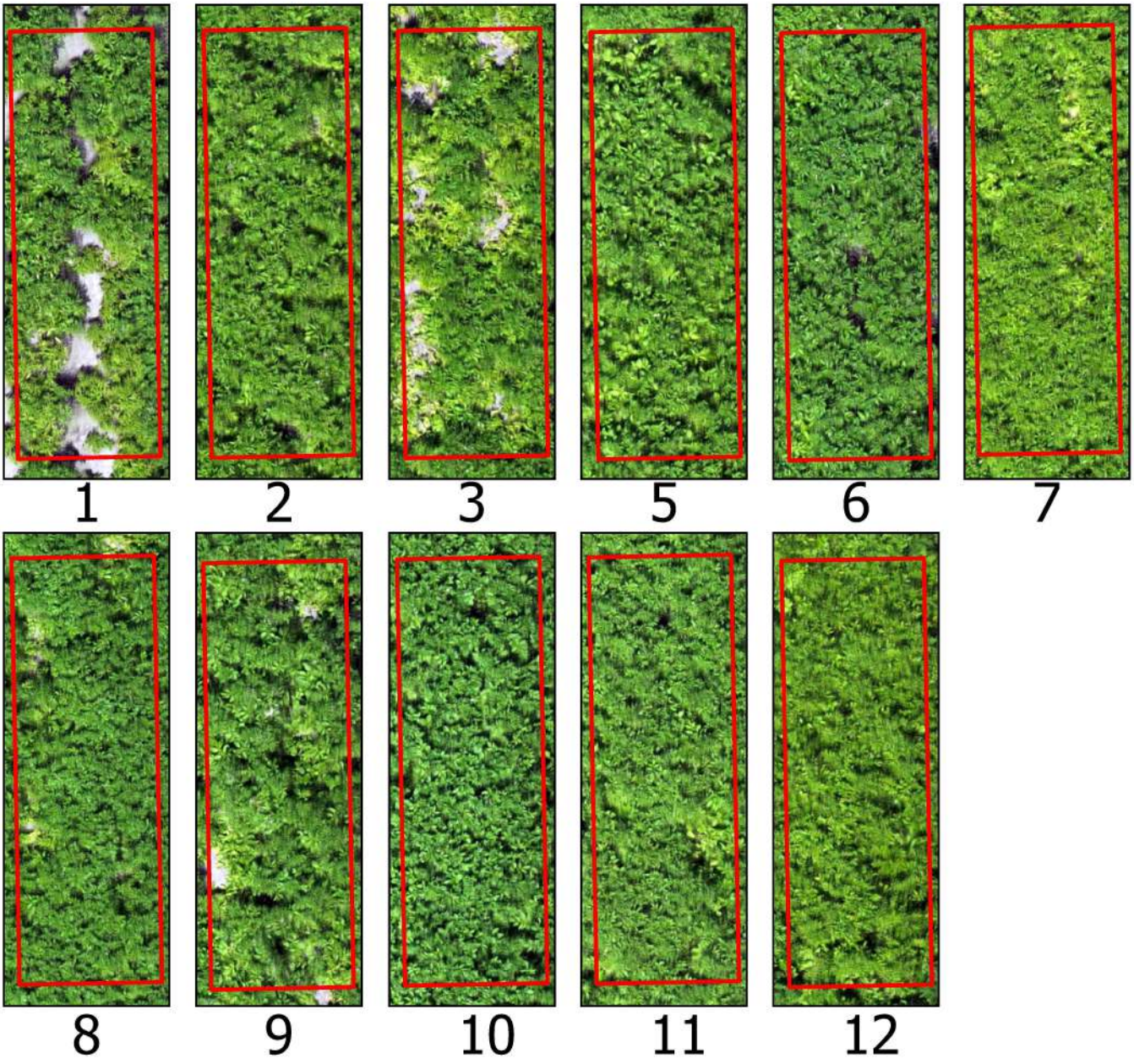

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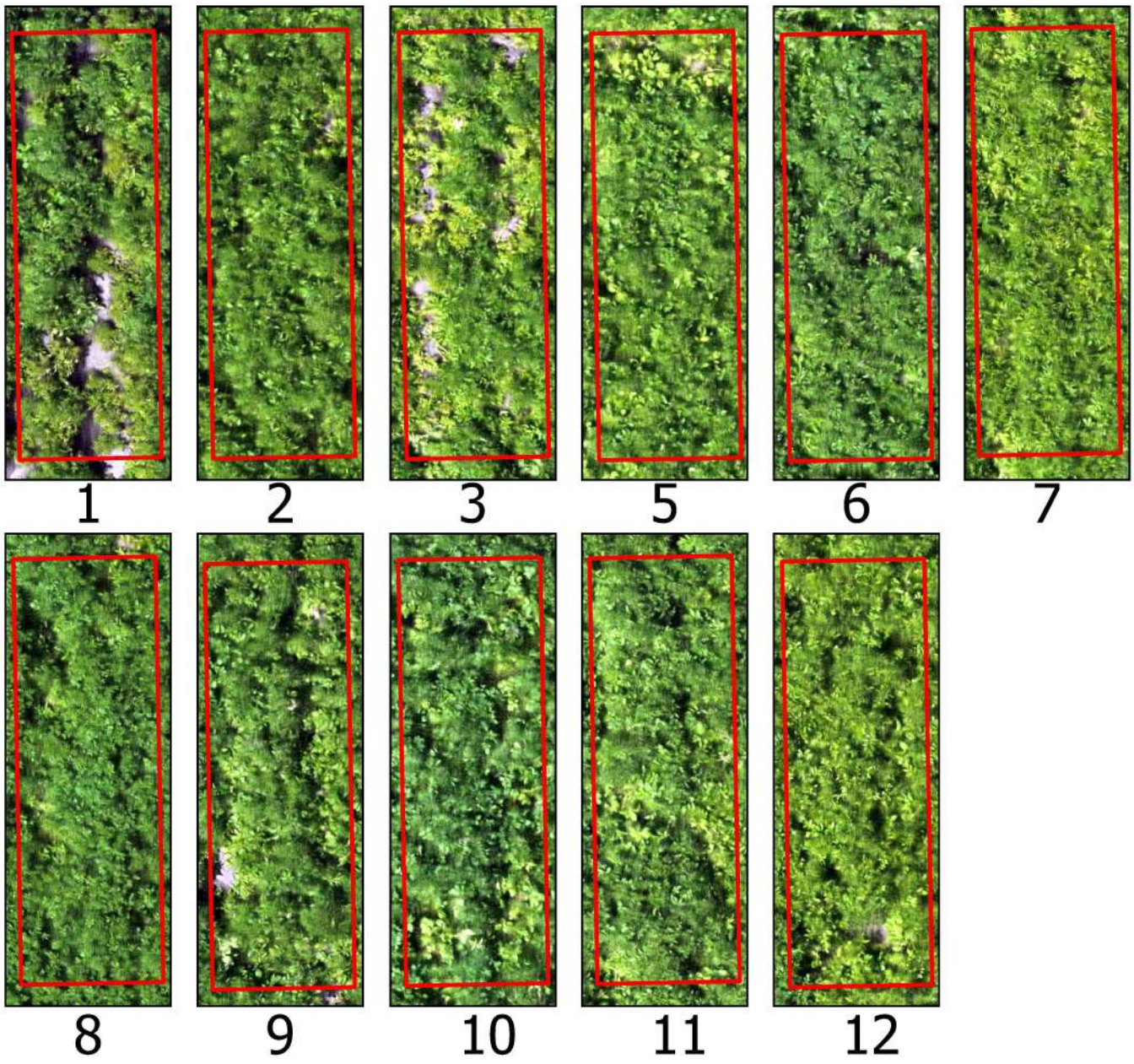

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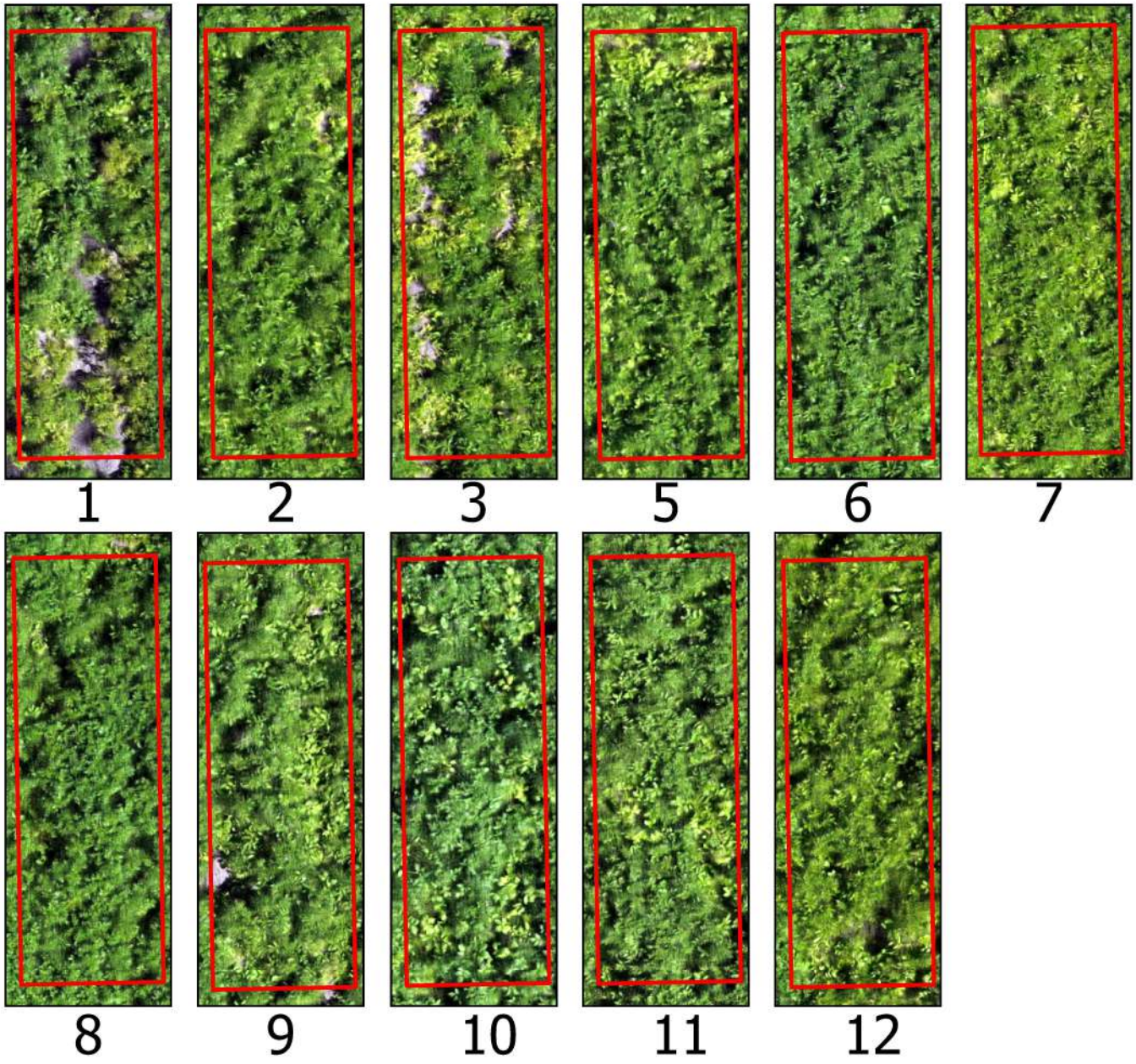

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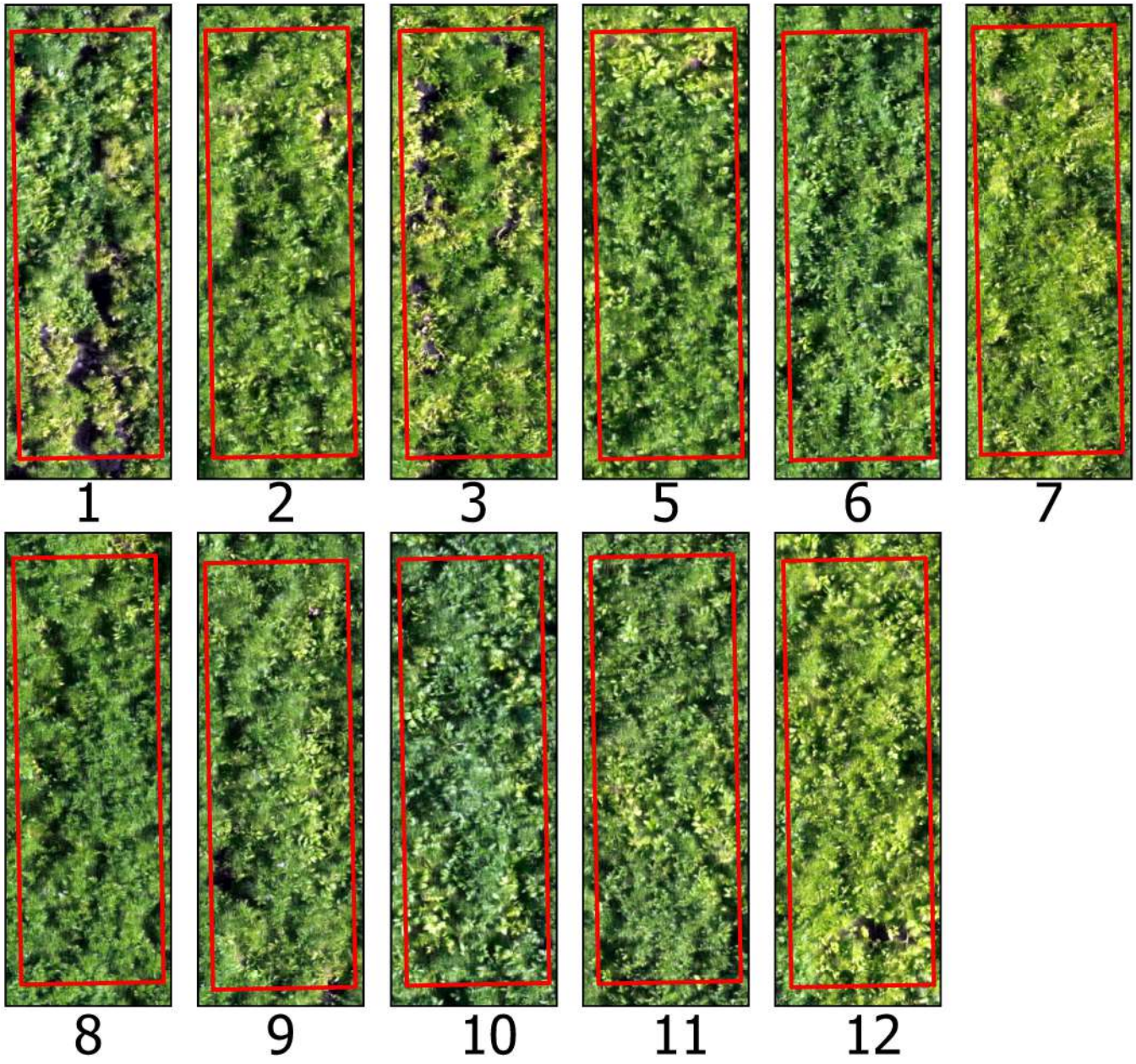

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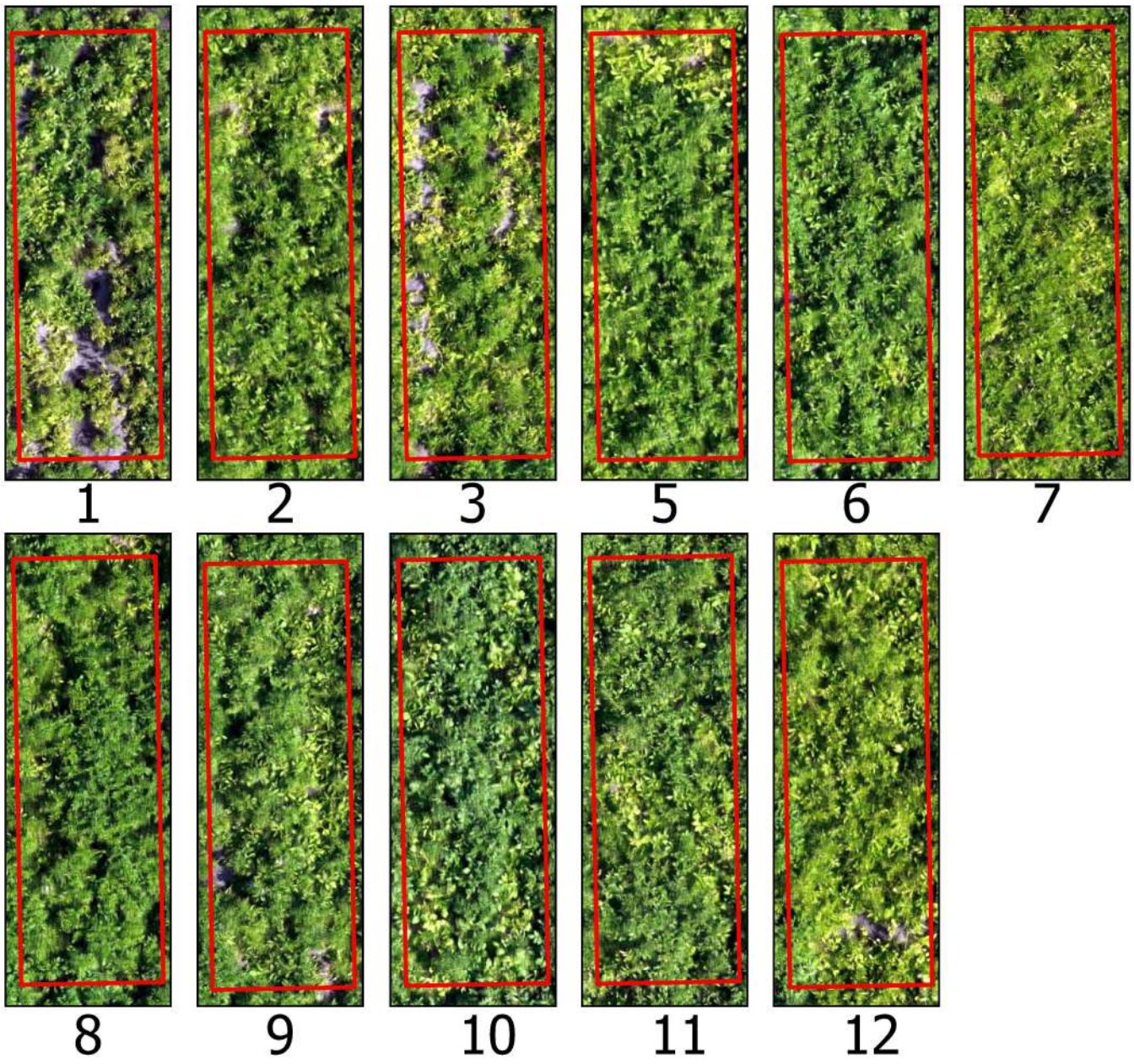

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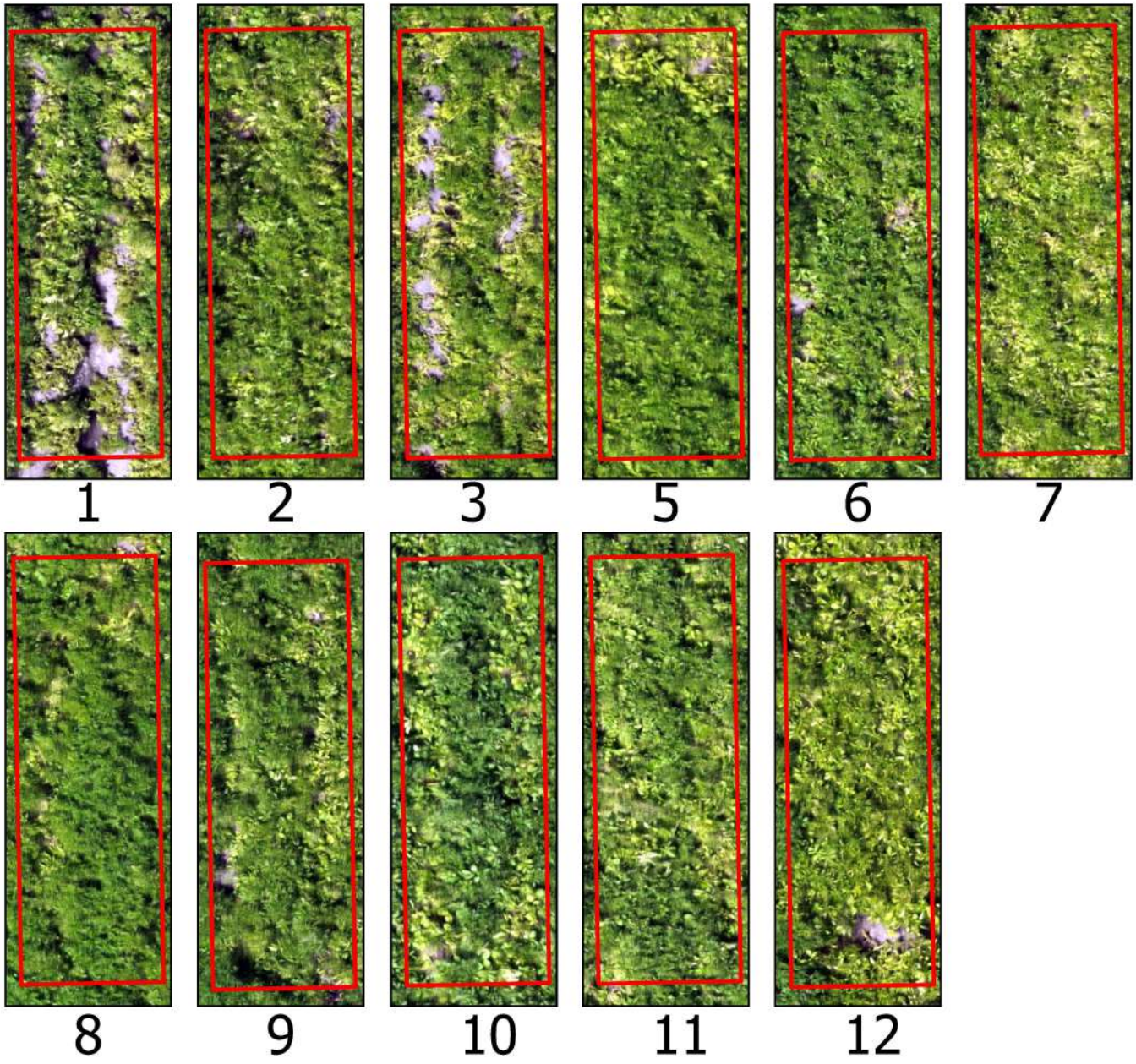

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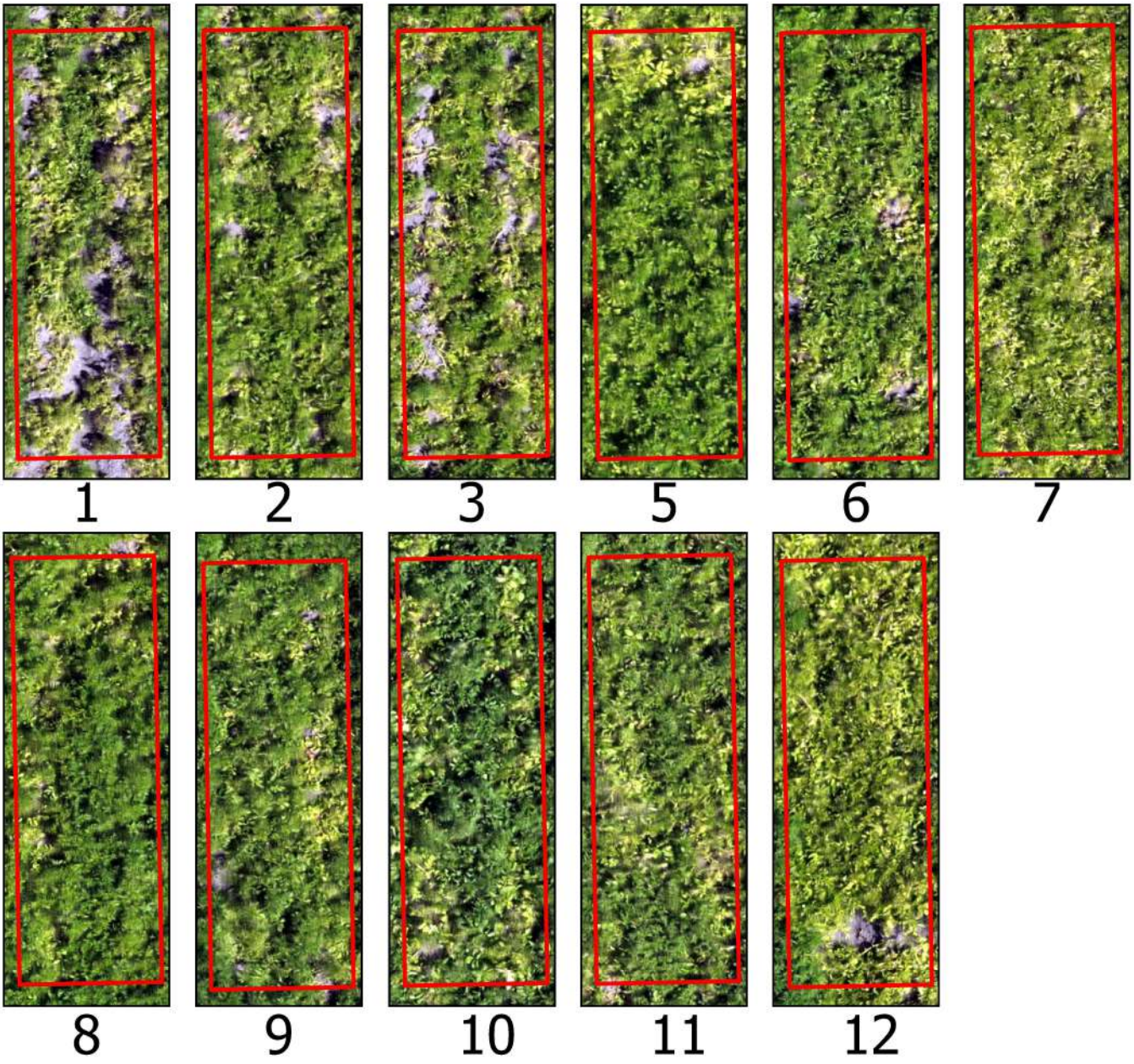

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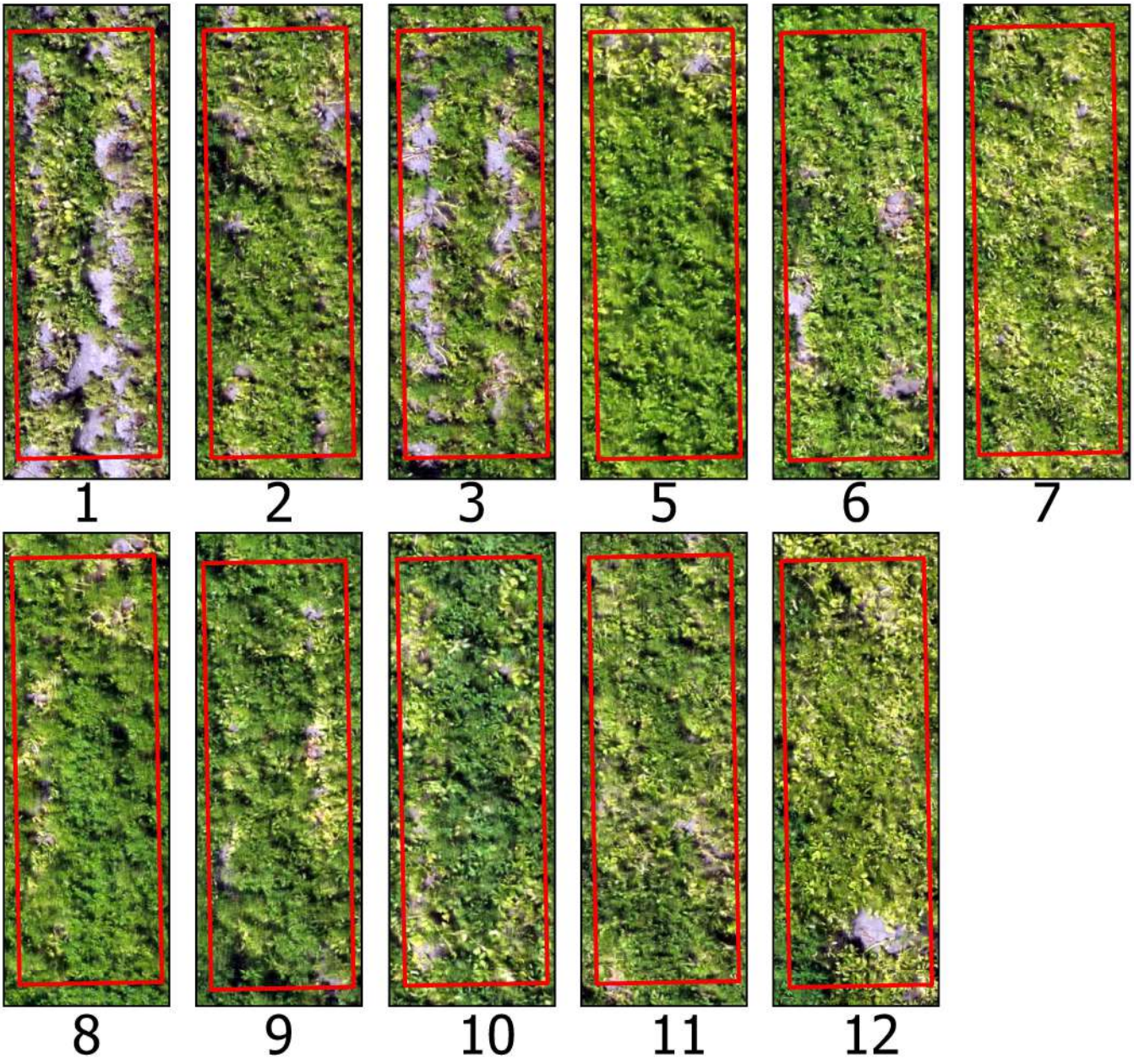

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