On possibility to identify the Saiga Antelope (*Saiga tatarica*) on very high resolution satellite images (model territory - *Stepnoi sanctuary, Astrachan region, Russia)*

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The goal of investigation:

Find out whether it is possible to monitor the saiga antelope groups from space by using satellite images

To describe the set of interpretive parameters

Tasks:

✓ To describe parameters that have to be used for distinguishing saigas from livestock (cows, horses and sheep)

✓ To describe parameters of distinguishing aggregations of saigas from livestock herds

✓ To describe characteristics of saigas that could be used for further analysis

Methods:

[1] **We** analysed the high resolution Satellite Images of:

- **What?** Plaedies, Geo Eye & EROS-B Satellites; resolution 0.5 & 0.7 m / pixel

- **Where?** the Caspian Terrain (SW) region in Russia; territory of "Yashkulski" saiga breeding center (SBC), Kalmykia and Sanctuary «Stepnoi», Astrachan region

- **Why?** antelope in the picture takes 2 - 3 pixels.

- **When?** in late November and December because animals are white in this period and background is dark

[2] **We** used for the :

- analysis of the images - the program ScanEX IMAGE Processor;

- analysis of numerical data - Statistics 8.0;

- analysis of distances between groups and between animals in groups, and for counting animals - MapInfo Professional 8.0

Methods: Satellite Images characteristics

№	Satellite	Date	Time, UTC	Resolution, m	The sun position, degrees	Place, territory
1	GeoEye-1 USA, DigitalGlobe	27.10.2009	08:05:00	0.5	30.14	Enclosure of "Yashkulski" SBC
2	Eros-B Israel, ImageSat International N.V.	25.02.2013	10:56:18	0.7	30.25	Enclosure of "Yashkulski" SBC
3	Pléiades France, EADS-Astrium	15.01.2014	08:08:41	0.5	21.3	Enclosure of "Yashkulski" SBC
4	Eros-B Israel, ImageSat International N.V.	22.11.2012	10:55:05	0.7	17.2	Steppe, open landscape, territory of Sanctuary "Stepnoi"
5	Eros-B Israel, ImageSat International N.V.	12.12.2013	10:52:33	0.8	40.49	Steppe, open landscape, territory of Sanctuary "Stepnoi"
6	Pléiades France, EADS-Astrium	22.03.2014	08:00:59	0.5	43.01	Steppe, open landscape, territory of Sanctuary "Stepnoi"

Methods:

First part of investigation:

➢ Detecting animals inside the enclosure on the satellite image ("Yashkulski" SBC, Kalmykia)

➢ Describing the main characteristics of animals (that are *exact saiga*) on the image

➢ Counting saigas in the enclosure – comparing with real data received from staff of "Yashkulski" SBC

# Methods:

Second part of investigation:

➤ Detecting saigas on the territory of Stepnoi Sanctuary, Astrakhan region (well protected)

➤ Main characteristics of saigas from the first part of investigation testing

➤ Describing the set of characteristics and interpretive signs all together for the images with different resolution

➤ Counting saigas on the territory of the steppe (well protected sanctuary) – comparing with the data received from rangers of Stepnoi sanctuary (from the place)

Results:

First part of investigation:
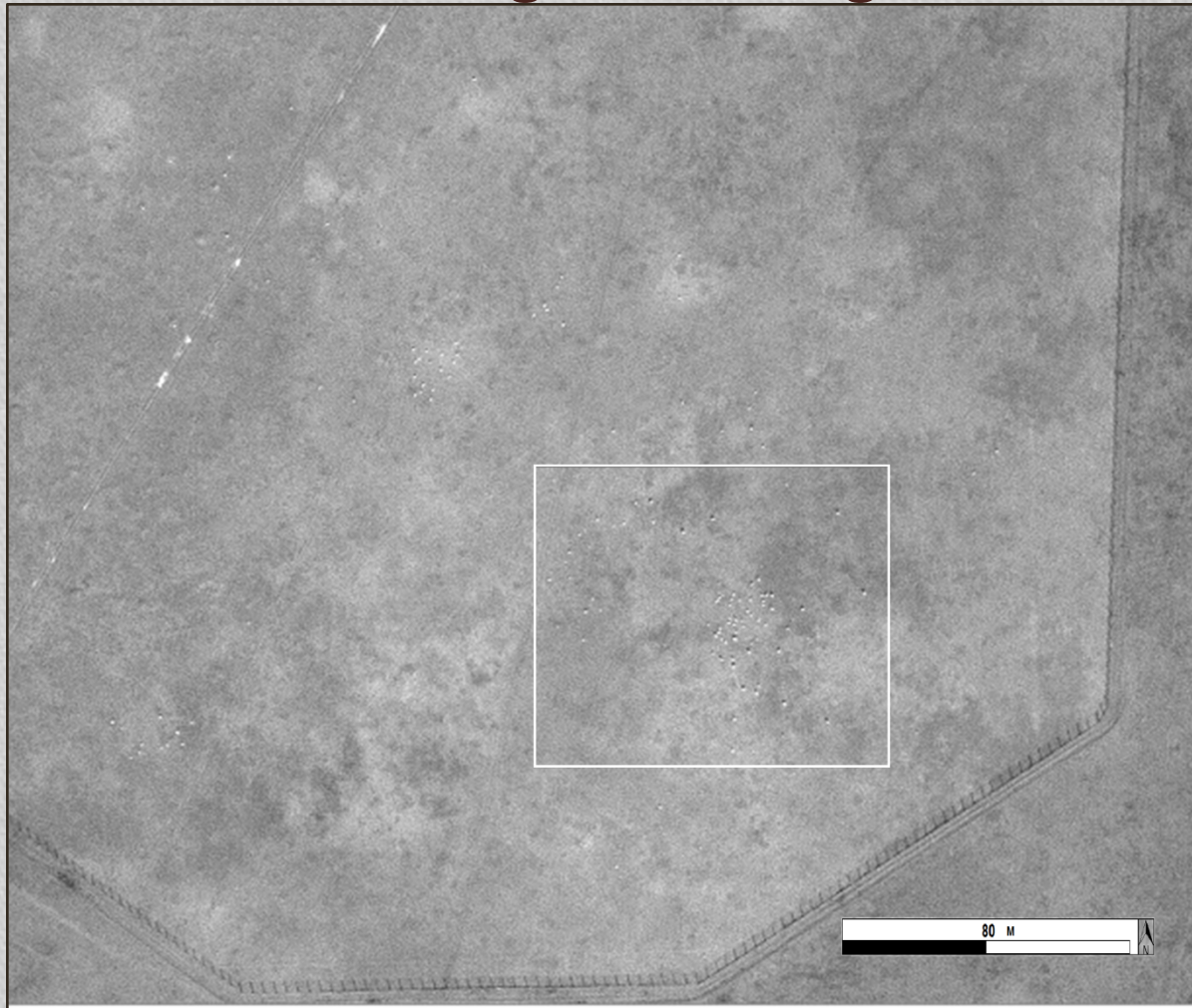
➢ Detecting animals inside the enclosure on the satellite image ("Yashkulski" saiga breeding center, Kalmykia)

Results:

First part of investigation:

➢ Detecting animals inside the enclosure on the satellite image ("Yashkulski" saiga breeding center, Kalmykia)

This image cannot currently be displayed.

Results:

First part of investigation:

➤ Describing the main characteristics of animals (that are *exact saiga*) on the image

[1] The color of animals
Saigas could be only white during this period of year;

[2] Size of animals (antelopes are shorter and narrower than the cows and horses, take up less pixels); Mean & Standard deviation, $M \pm SD$: length – 0.91 ± 0.18 м, width – 0.54 ± 0.13 м, (n = 154)

[3] The proportional size characteristics
ratio of length to width of the animal 1.74 ± 0.37, (n = 154)

[4] Height of animal (defined through **tg** of angle of the sunlight and through the distance from the animal to its shadow; antelopes are lower than cows and horses).

Results:

First part of investigation:

➢ Describing the main characteristics of animals (that are *exact saiga*) on the image
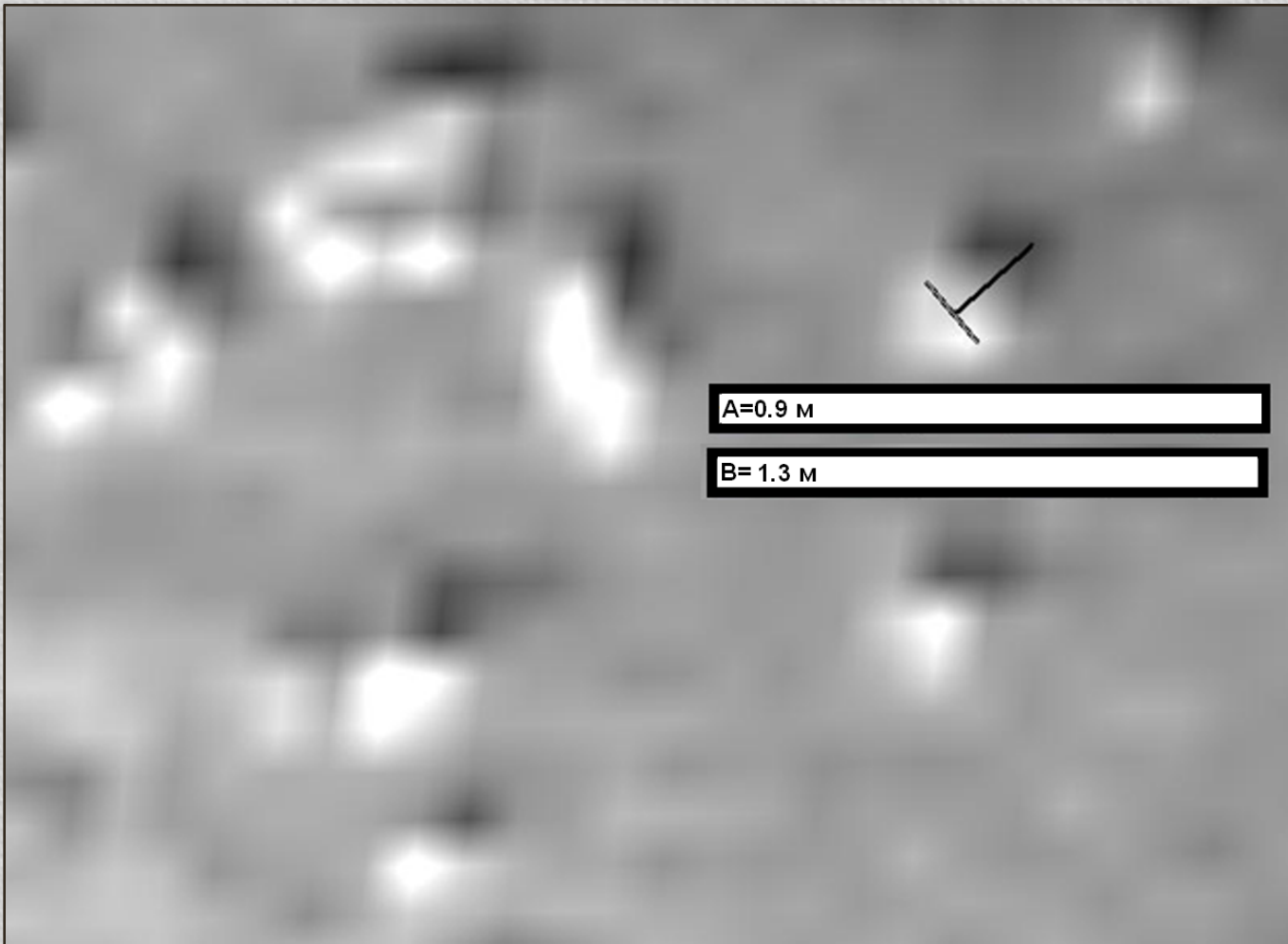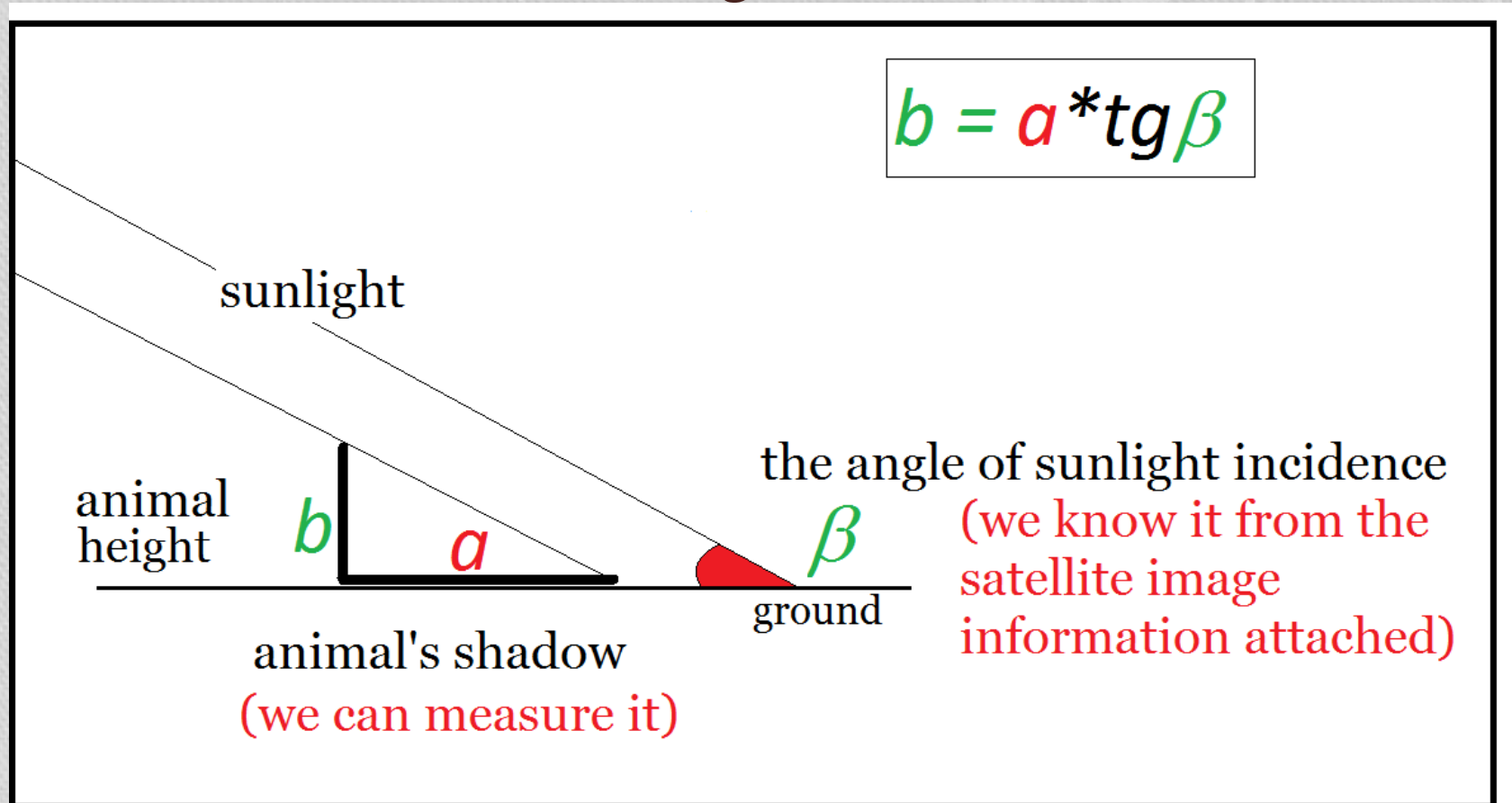
Results:

➢ Describing the main characteristics of animals (that are *exact saiga*) on the image

Animals' height calculation

$$b = a * tg\,\beta$$

sunlight

animal height

b

a

the angle of sunlight incidence (we know it from the satellite image information attached)

β

ground

animal's shadow (we can measure it)

Results:

First part of investigation:

➢ Counting saigas in the enclosure – comparing with real data received from staff of "Yashkulski" SBC

Results:

<u>First part of investigation</u>:

➤ Counting saigas in the enclosure – comparing with real data received from staff of "Yashkulski" SBC

Table 2.
The number of animals detected in the pictures, and the real number of Saigas are "Yashkul"

№	Satellite Image	Date	Number of saigas detected on the Satellite Image	The actual number received from staff of (SBC)
1	GeoEye-1	27.10.2009	52	56–58
2	Eros-B	25.02.2013	143	116
3	Pléiades	15.01.2014	154	153

Results:

Second part of investigation :

➢ Detecting saigas on the territory of "Stepnoi" Sanctuary, Astrakhan region (well protected)

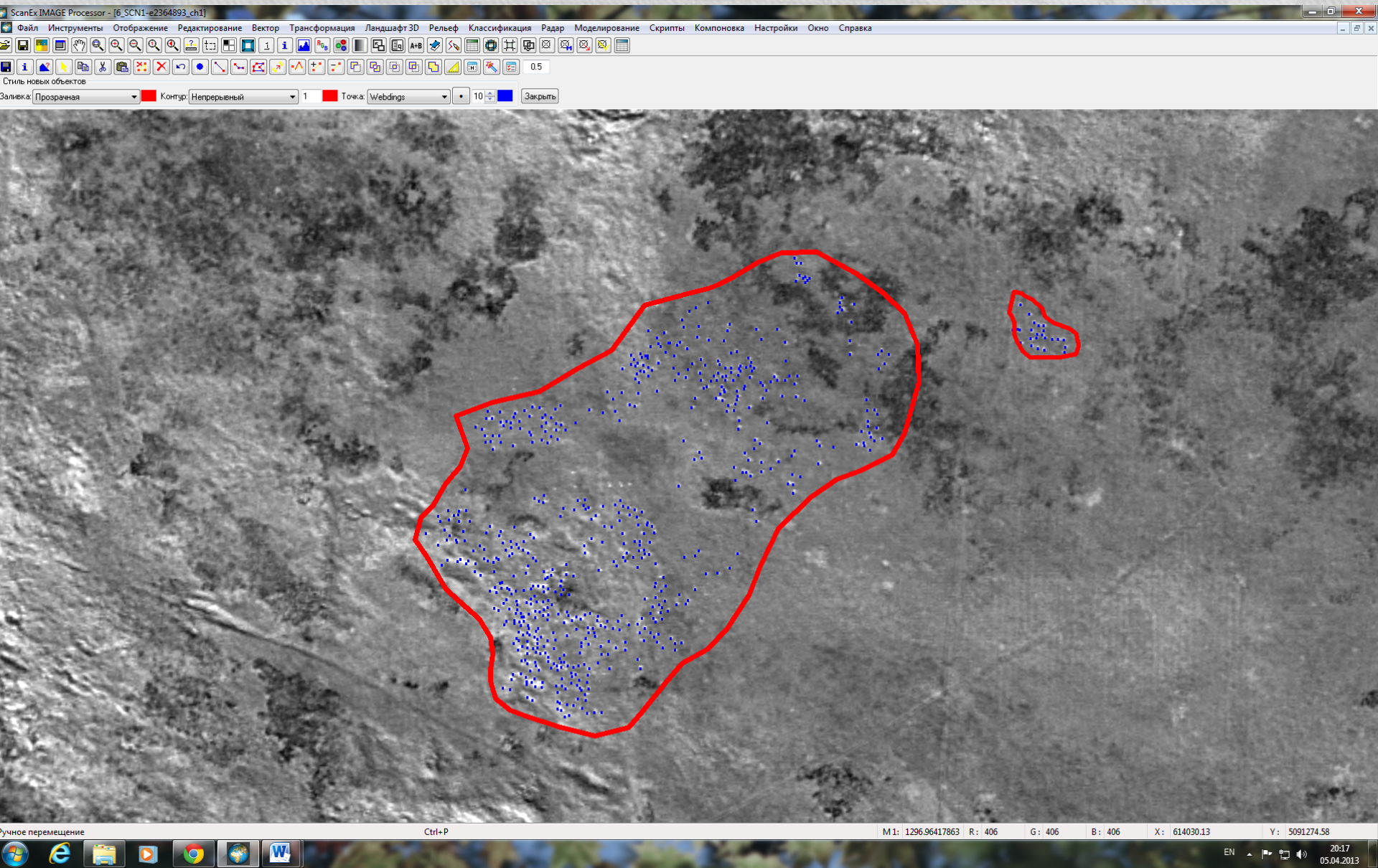# Results:

Second part of investigation :
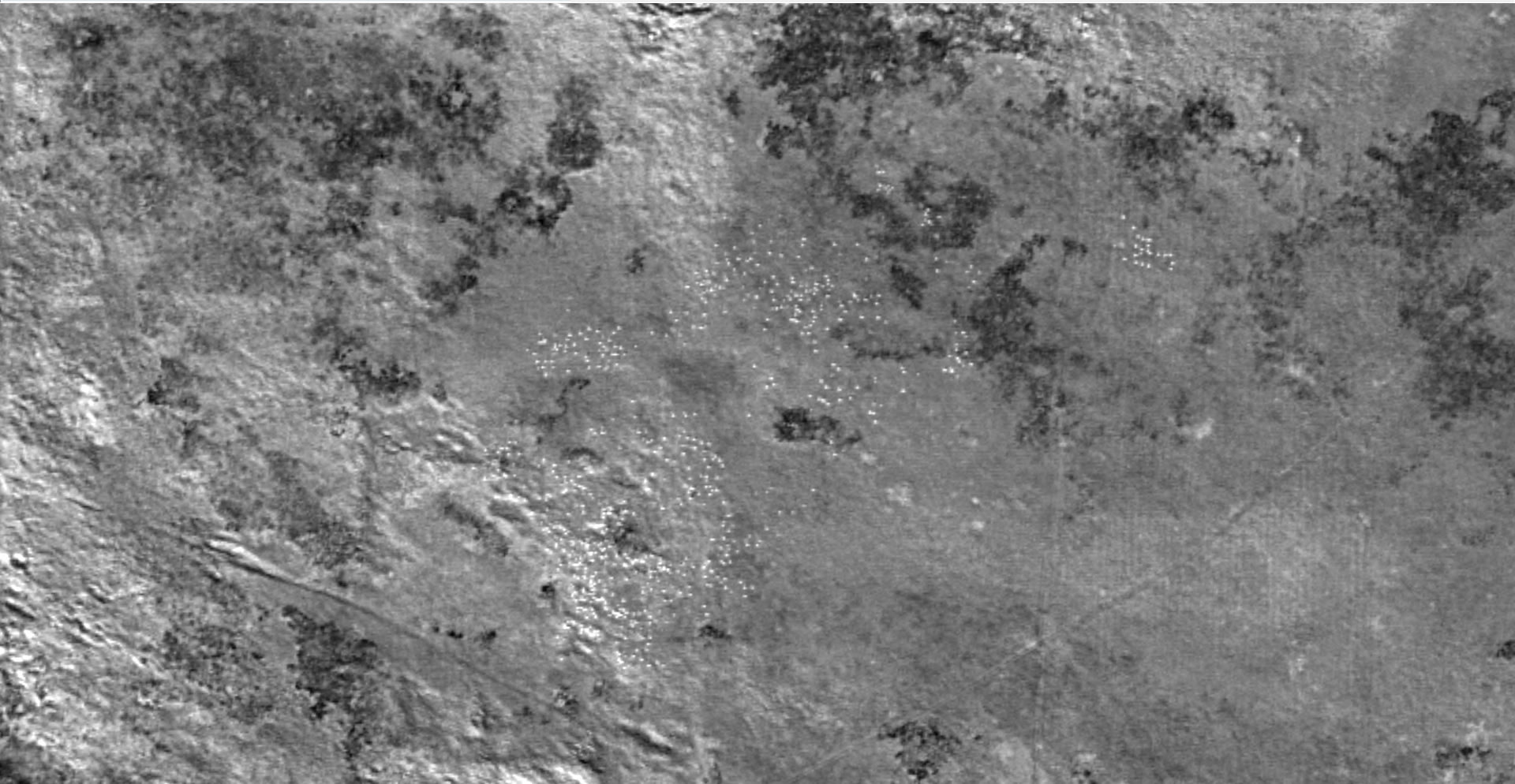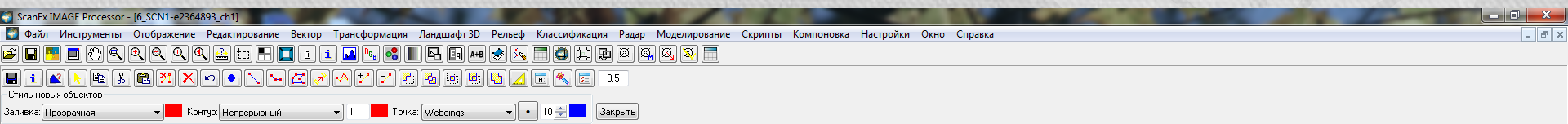
Results:

Second part of investigation :
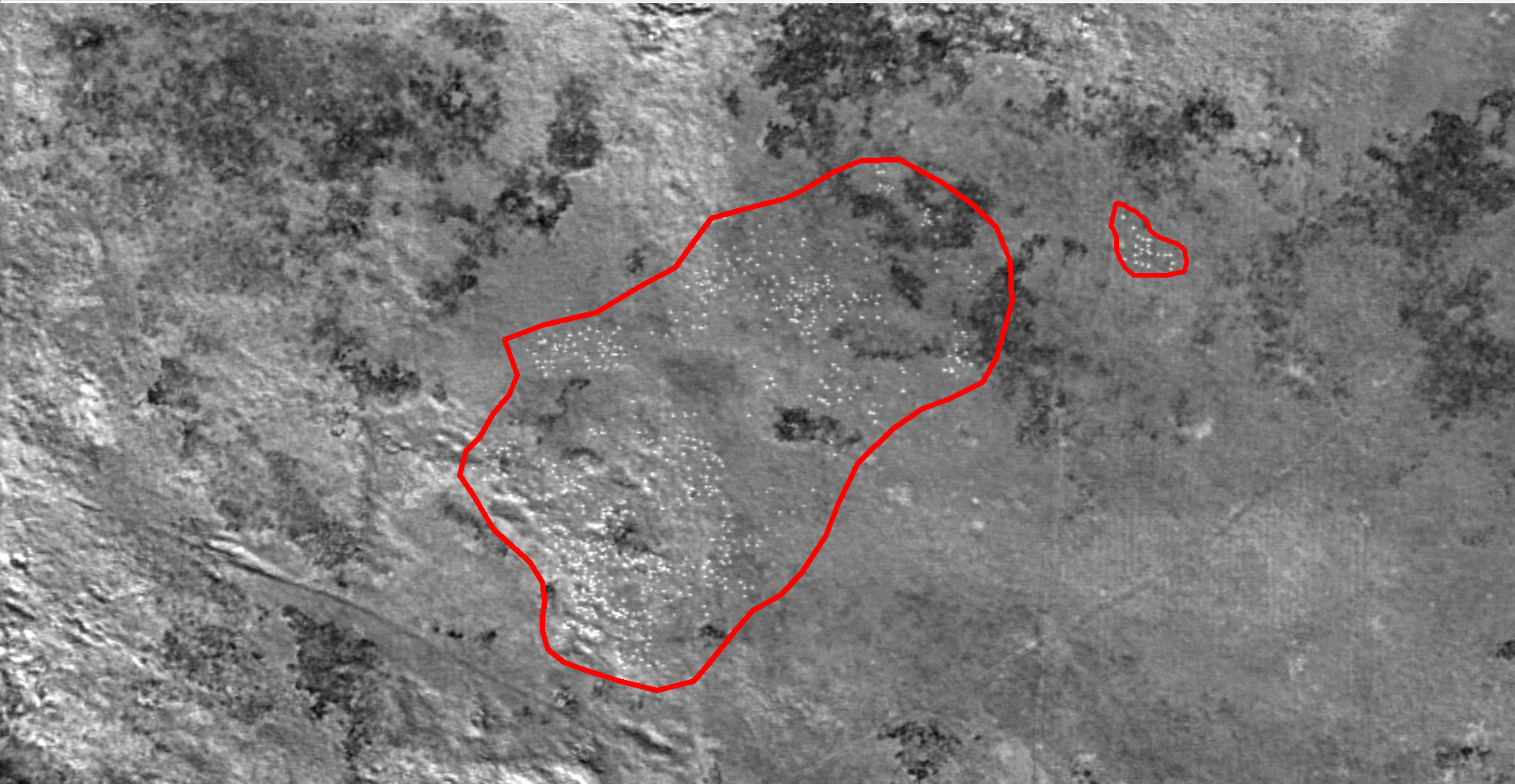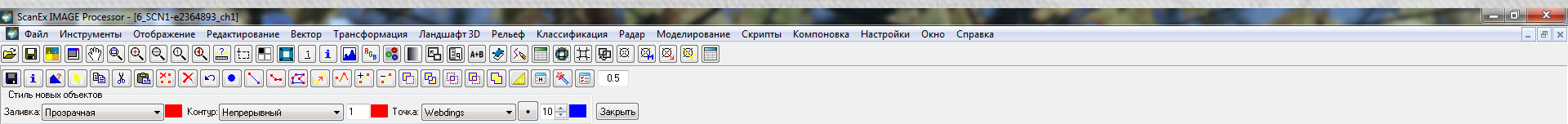
Results: Marking each animal as a point and develop a vector layer on the base of raster layer

Why do we think that the animals that we see on the Images are the saiga in the wild?

(a set of interpretive characteristics)

Results:

Second part of investigation:

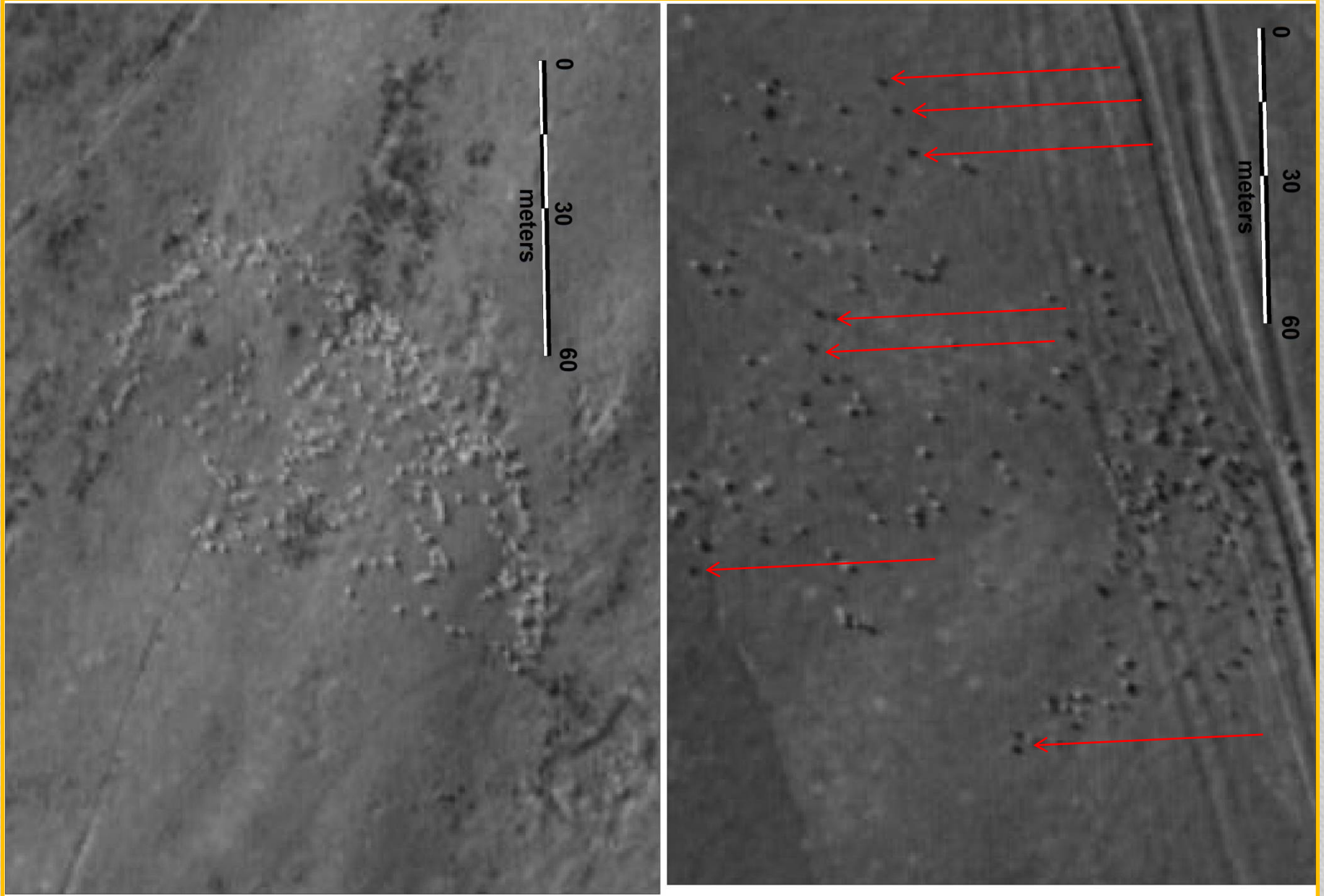➢ Main characteristics of saigas from the first part of investigation testing

[1] The color of animals in the herd (ex.: saigas are only white in winter – other animals can be colored);

[2] Size of animals (antelopes are shorter and narrower than the cows and horses, take up less pixels);

[3] The ratio of length to width of the animal (for sheeps ≤ 1; for saigas > 2);

[4] Height of animal (defined through **_tg_** of angle of the sunlight and through the distance from the animal to its shadow; antelopes are lower than cows and horses).

[1] The color of animals in the herd (ex.: saigas are only white in winter – other animals can be colored);

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Table 3. Measurements (m) of saigas and cattle/livestock animals				
Animal		**Height**	**Body length**	**Width in the breast**
Saigas		0.6-0.8	1.04-1.46	0.4-0.6
Sheep	Kalmyk kurdjuk *	0.75-0.84	0.74-0.83	0.9
	Soviet Merino *	0.65	0.75	0.95
	Karakul *	0.7-0.75	0.7-0.82	0.97-1.6
Cows**		1.28-1.52	1.5-2.4	1.7-1.9
Horses**		1.5-1.8	1.59-2.56	1.75-1.95
*Erokhin, 2004; ** Shaidullin et al., 2005.				

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[3] The ratio of length to width of the animal (for sheep ≤ 1; for saigas > 2);

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	Soviet Merino *	0.65	0,79
	Karakul *	0.7-0.75	0,72 - 0,51
Cows**		1.28-1.52	0.88 - 1,26
Horses**		1.5-1.8	0, 9 - 1,3
*Erokhin, 2004; ** Shaidullin et al., 2005.			

Results:

Second part of investigation:

➢ Main characteristics of saigas from the first part of investigation testing

If the Image does not allow to reveal saiga with a previous parameters?
(a set of "bonus" interpretive signs; Information from wildlife)
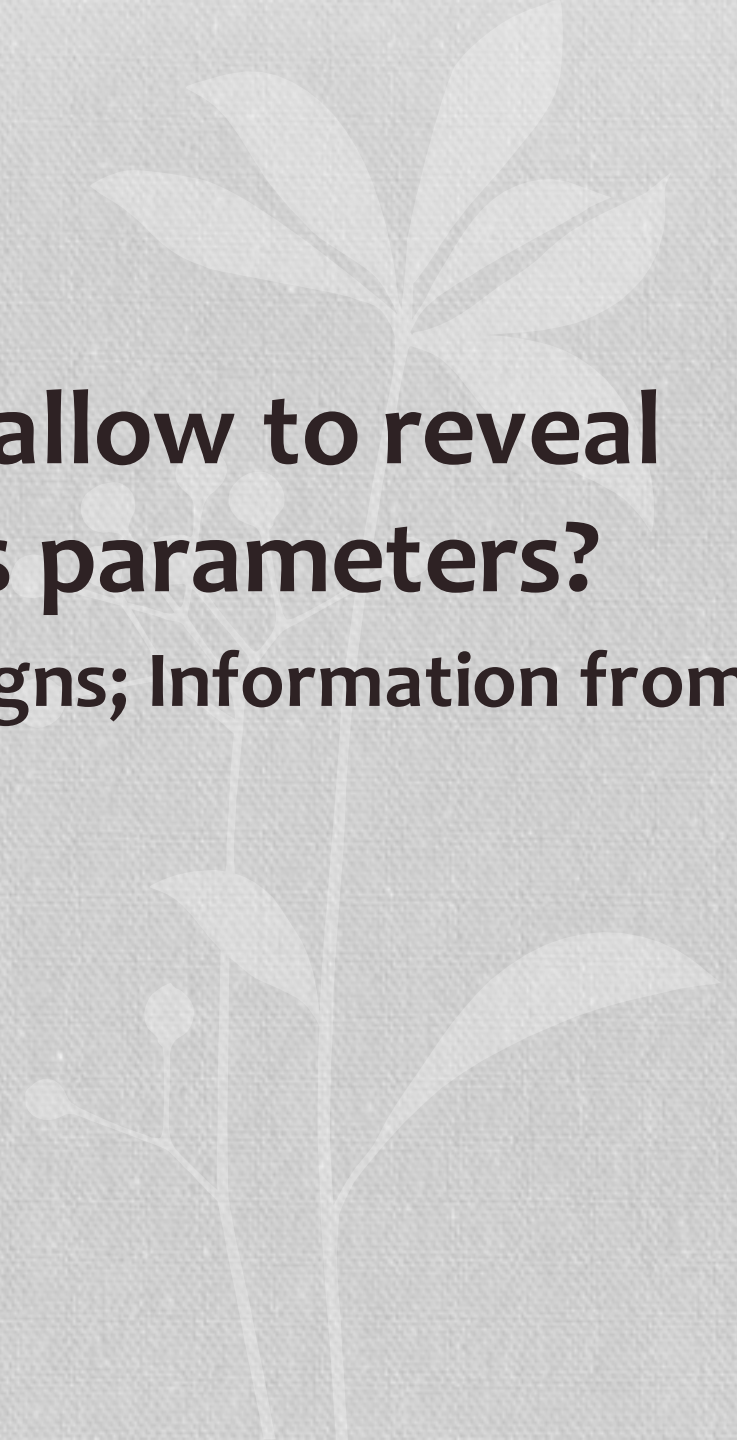
Results:

Second part of investigation:

➢ Defining a set of interpretive characteristics, that are totally together could be used to determine saigas on pictures that differs by quality/conditions during taking images

In addition if the characteristics of objects are not enough then the characteristics of groups of objects (agglomerations) should to be used

[1] objects are organized in structures and characterized by their form (clusters of saigas and herds of cattle grazing) are different;

[2] antelopes differ from cattle by behavior

structure - a system of interrelations between the points (units of composite object - herd);
*** form - "perimeter" that connect distant points (animals) of the aggregation*

Results:

<u>Second part of investigation</u>:

- structure and clusters of objects (comparing clusters of saigas and aggregations of livestock during grazing)
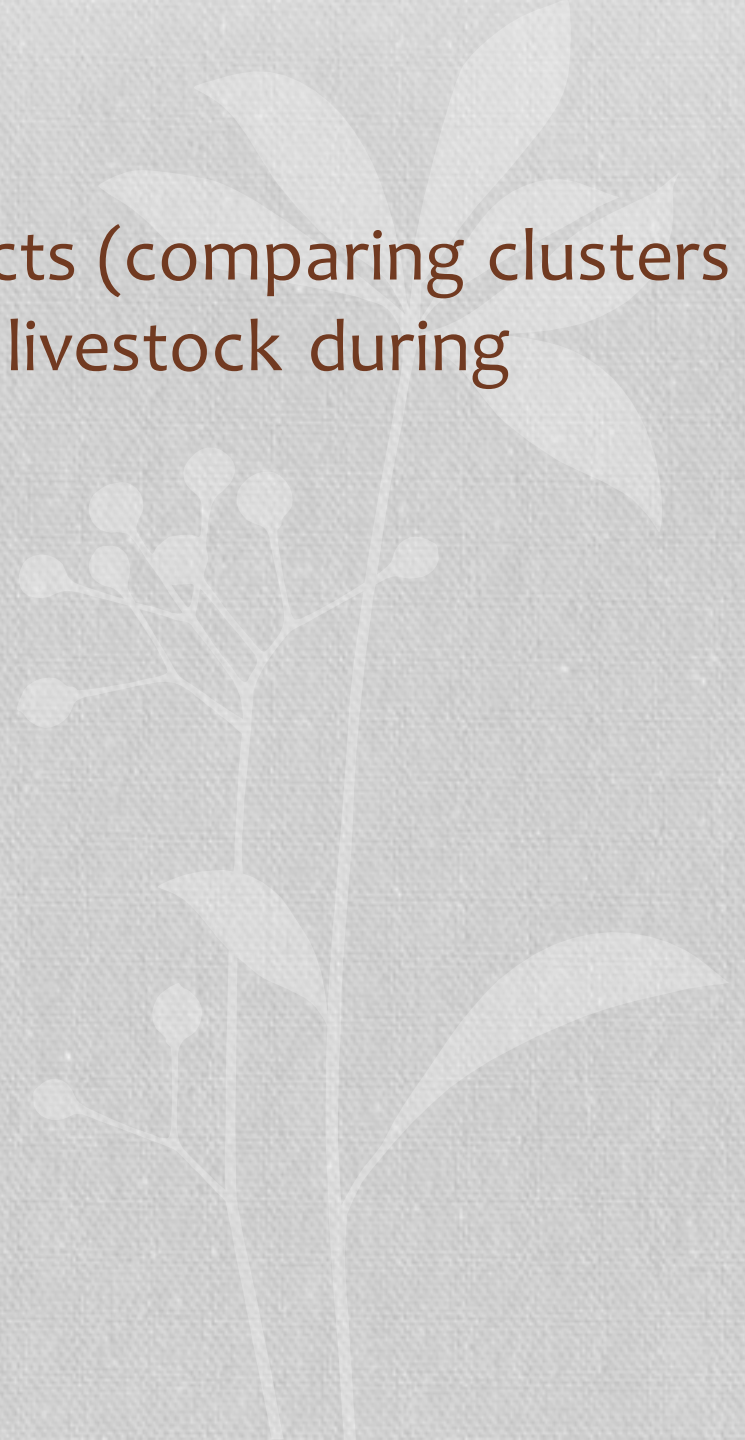
Results:

Second part of investigation:

This image cannot currently be displayed.
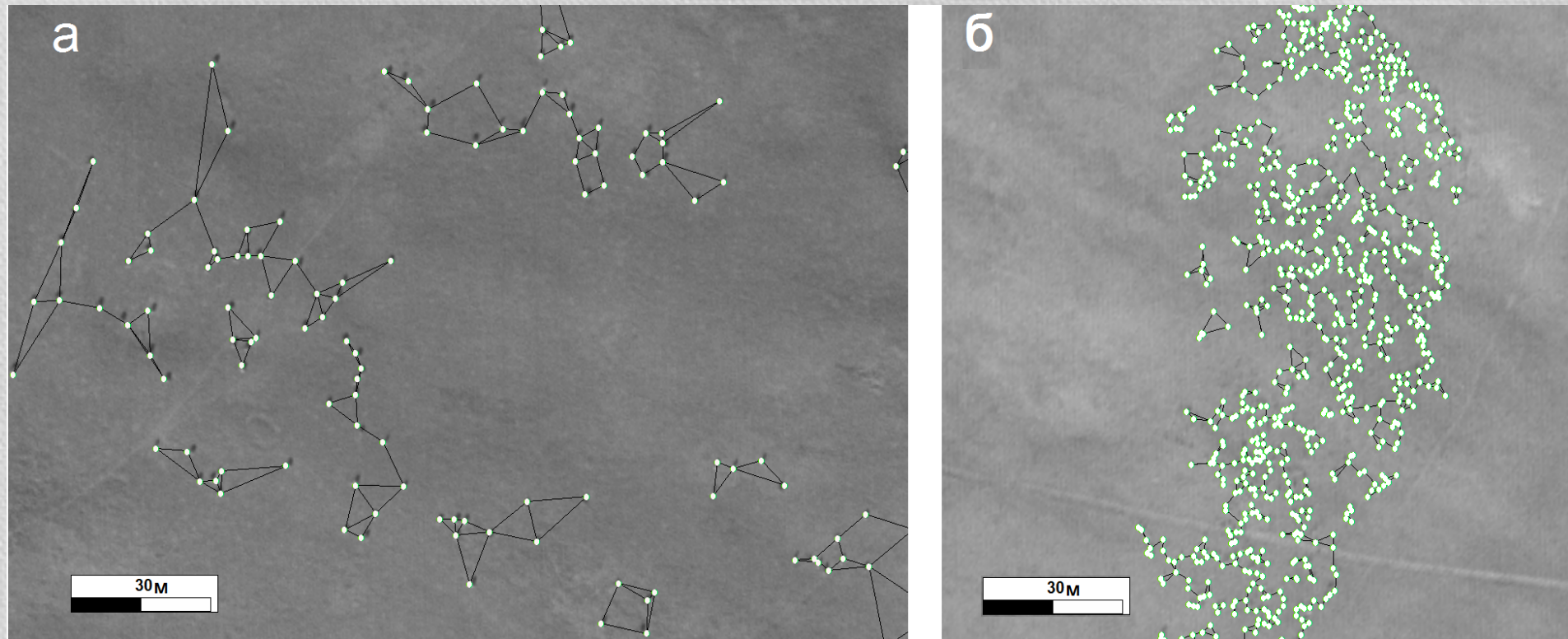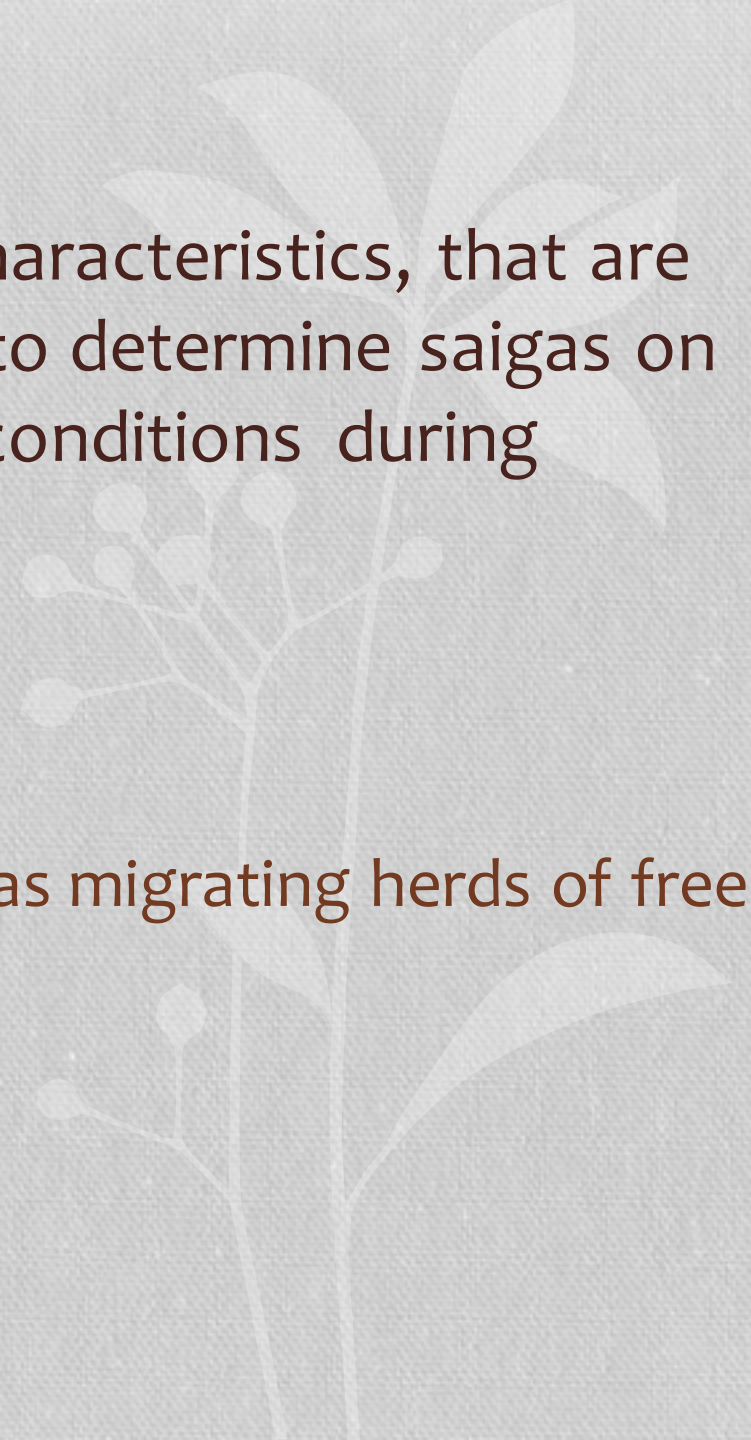
Results:

Second part of investigation:

Results:

structure and clusters of objects (comparing clusters of saigas and aggregations of livestock during grazing)

The average distance between the animals was significantly different in clusters of saiga (2.84 ± 1.3 m), and herds of sheep (2.18 ± 1.51 m), the criteria value **t** = 6.58, p <0.005.
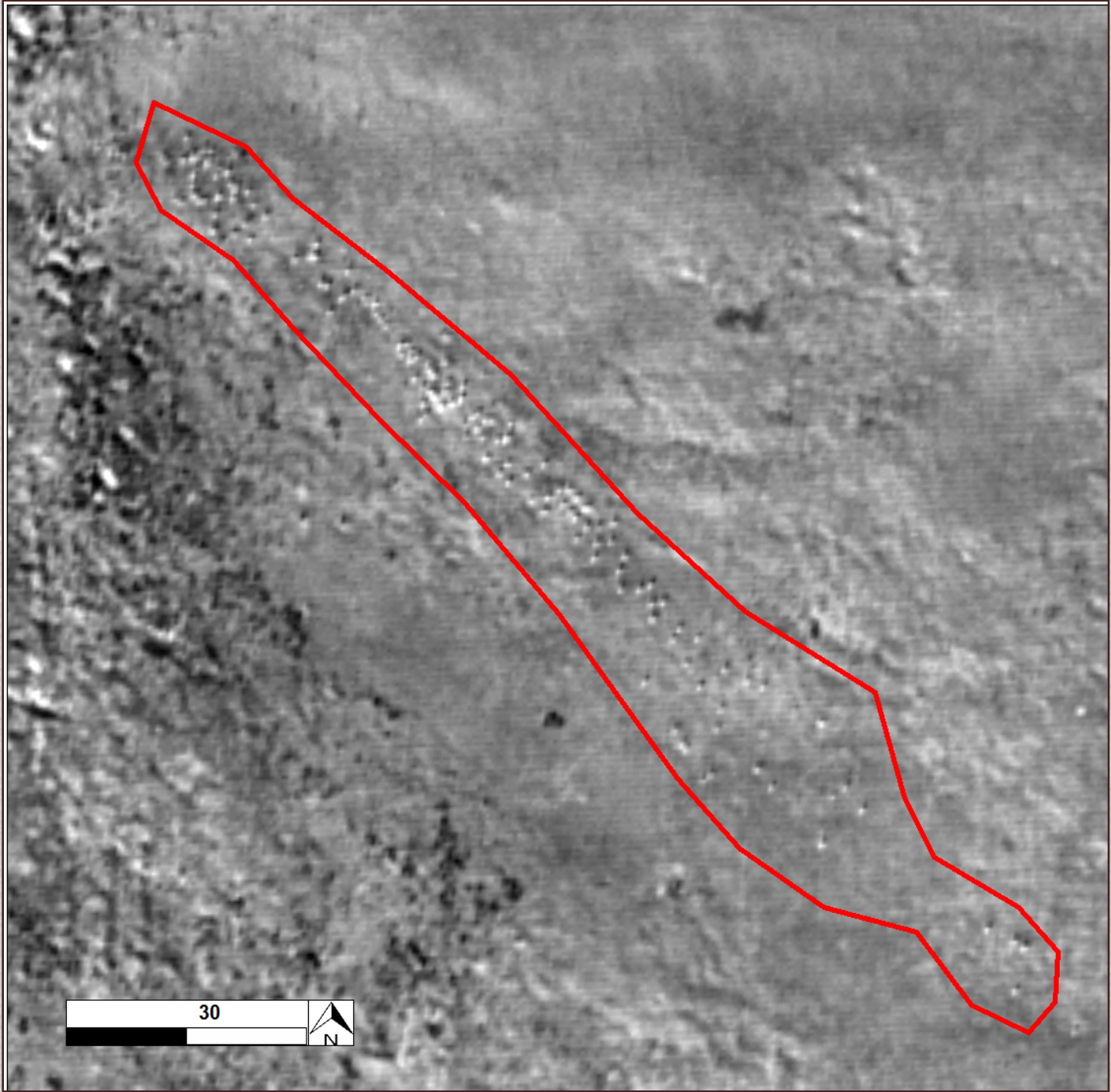
Results:

Second part of investigation:

➢ Defining a set of interpretive characteristics, that are totally together could be used to determine saigas on pictures that differs by quality/conditions during taking images

- Behavioral Features

A herd of cattle cannot has a form as migrating herds of free ungulates have:

General results on the example image #3:

Second part of investigation:

➢ Counting saigas on the territory of the steppe (well protected sanctuary) – comparing with the data from rangers (from the place)
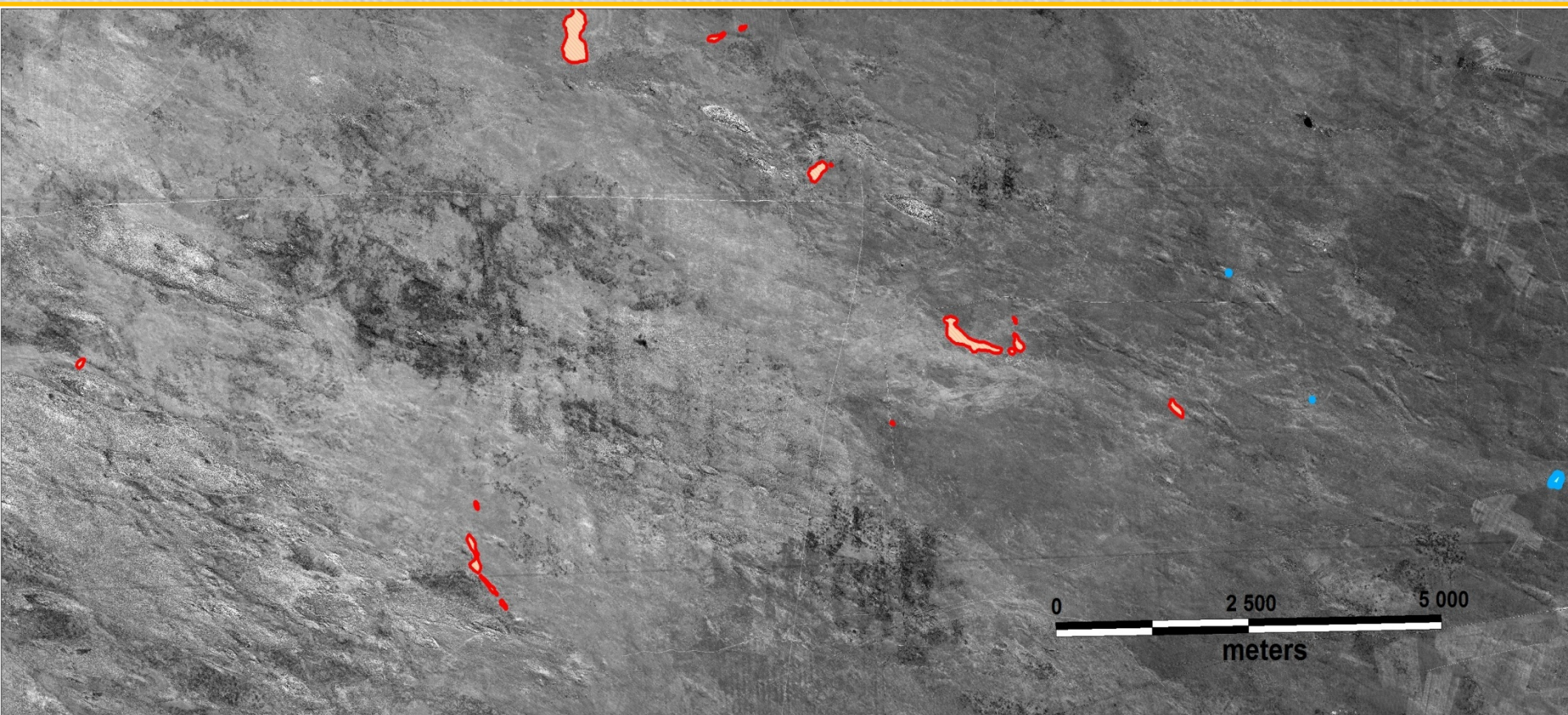
General results on the example image #3:

- Number of saiga aggregations on the area of 265.6 km²

N = 14 aggregations
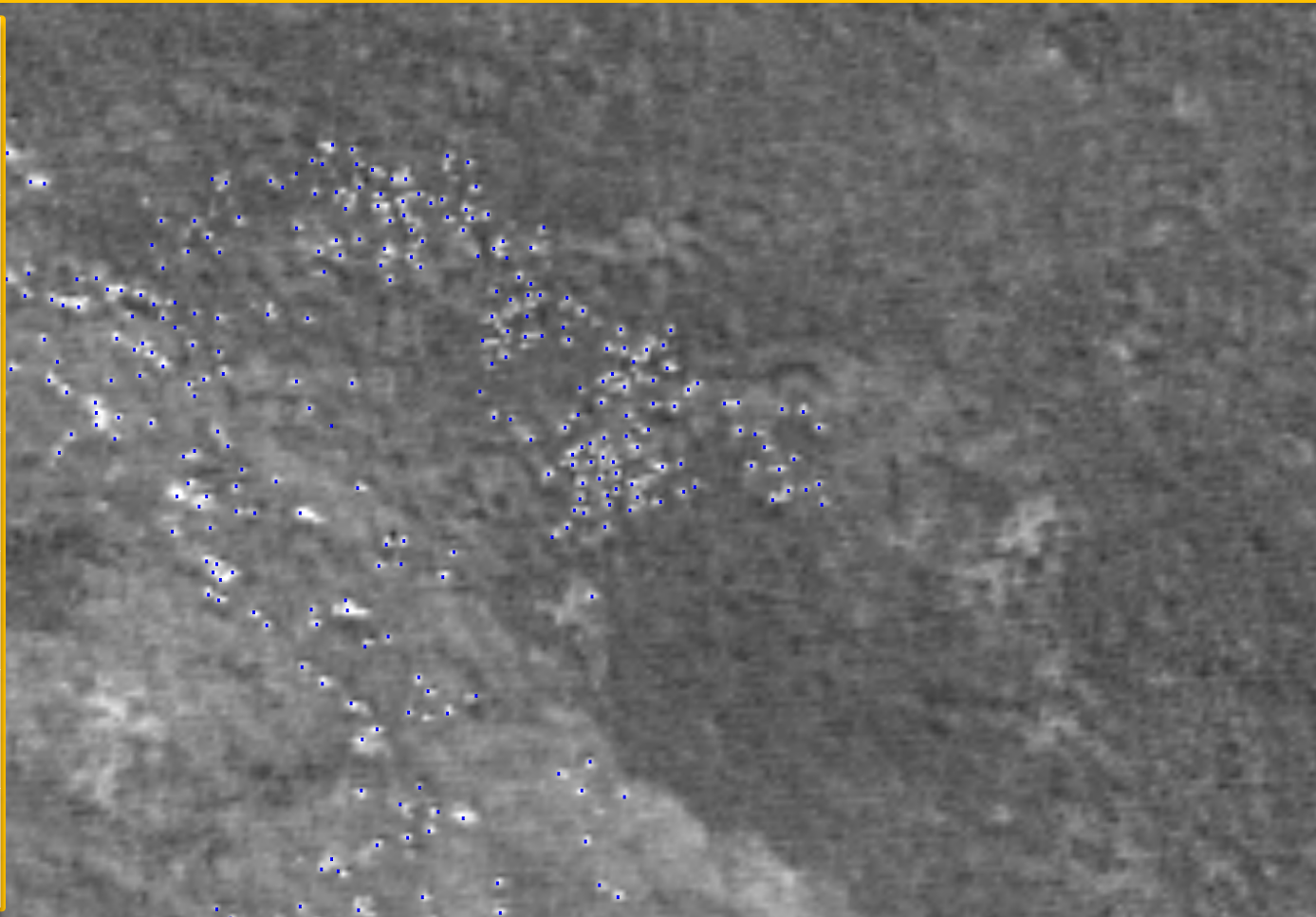n = 3 aggregations of other ungulates

General results on the example image #3:

- Number of saiga aggregations on the area of 265.6 km²

Number of animals in the herd (Average):
Mean (±SD) 366.3±460.7 km MIN: 16; MAX: 1657

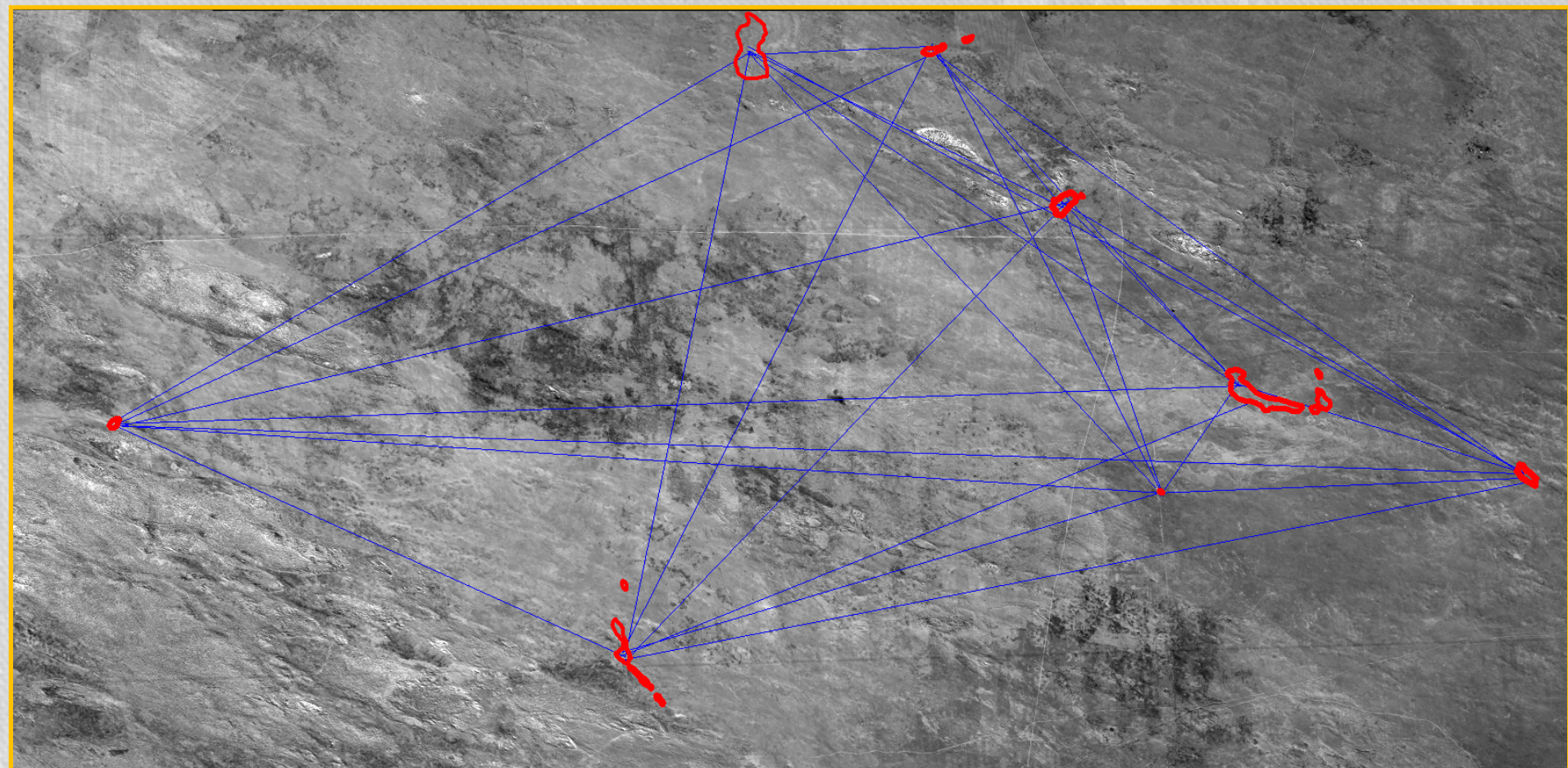| Herds ID	N animals
1	338
2	607
3	62
4	46
5	338
6	26
7	167
8	224
9	646
10	348
11	88
12	1657
13	16
14	92

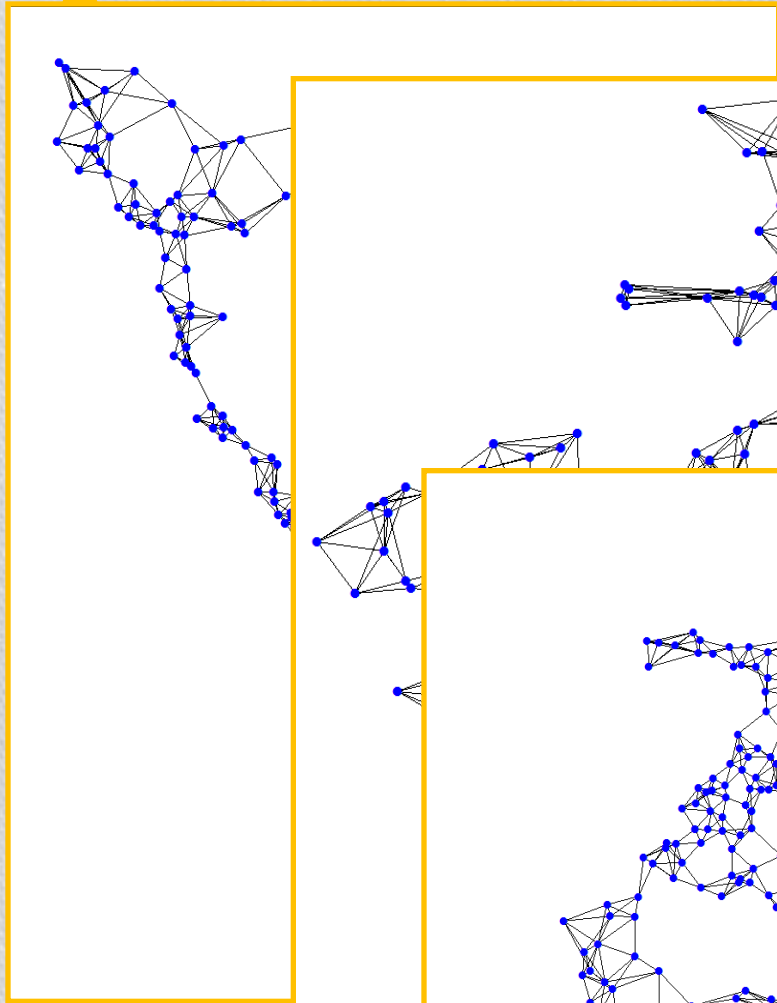# General results on the example image #3:

- The distance between aggregations

The average distance between all of the aggregations of saiga:
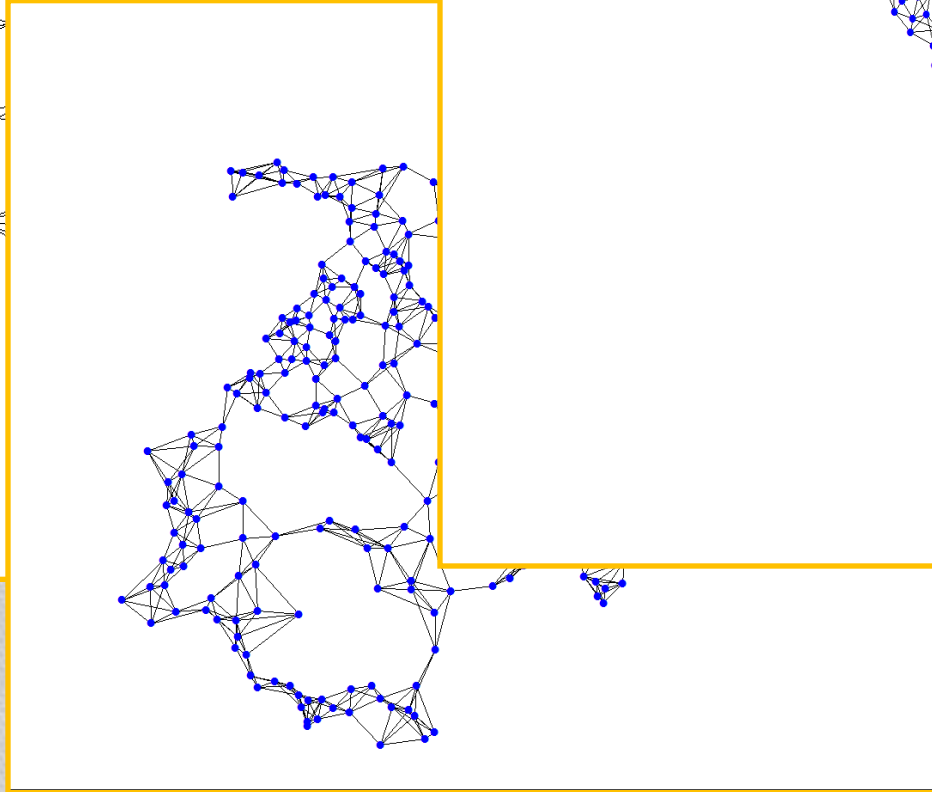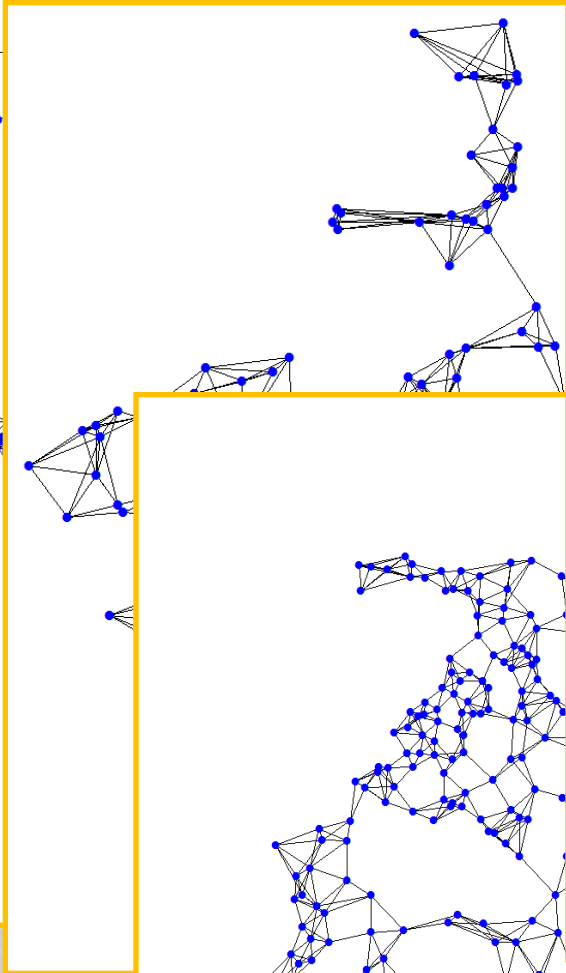Mean (± SD) 15.763 ± 8.85 km;
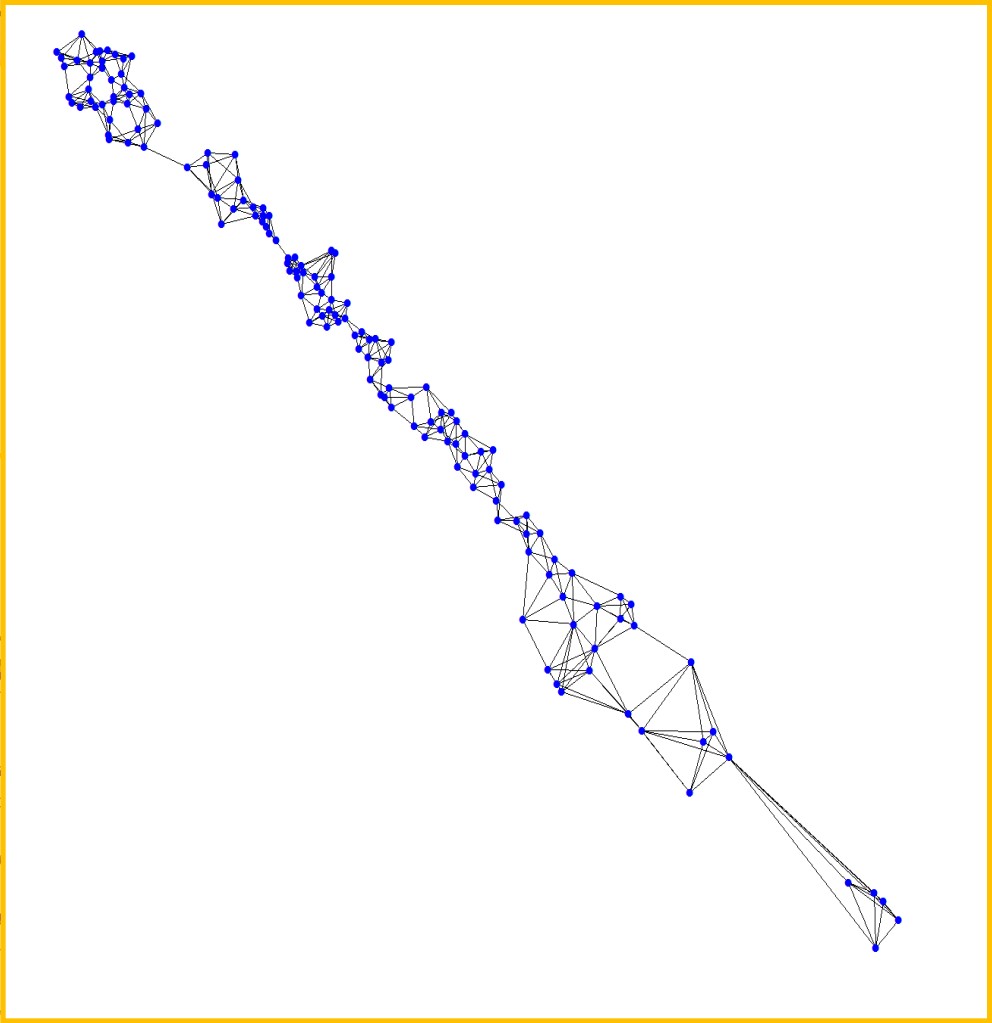The average distance between two nearest aggregations: 3.681 ± 2.0 km

3,48±1,6 m
Mean (±SD)

6,04±3,95 m
Mean (±SD)

Conclusions:

Analysis of high resolution satellite images are made during winter period allows:

o to identify aggregations of saiga and their distribution over a large area at the same time.

o it is necessary to use the entire set of interpretive parameters, selecting from them those parameters that are sharper and more bright on the image (depends on the shooting conditions), as well as their combination.

o The obtained results have to be used for further development of the method of accounting of saiga by using high resolution satellite image.

o This method has the minimum error, because there is no error due to animal movements.

o This method does not cause any harm to animals or disturb them.

Conclusion:

o   *Minus*: it is unable to select the exact date of the survey, which determines the result of shooting (due to weather).

o   Using high resolution satellite images ⟶ new possibilities for the study of [1]distribution of natural groups of saiga and [2]the dynamics of the structure of this distribution, [3]the type of animals activity

o   If individual animals are tagged with with satellite collrs/radio transmitters, then it is possible to monitor some focal groups and aggregations of saigas.

o   Via satellite images it can be identified also limiting factors for saigas: [1]the amount and distribution of livestock in the steppe, [2] steppe condition and the degree of degradation in different areas, [3] changes in plants distribution and phenology .

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