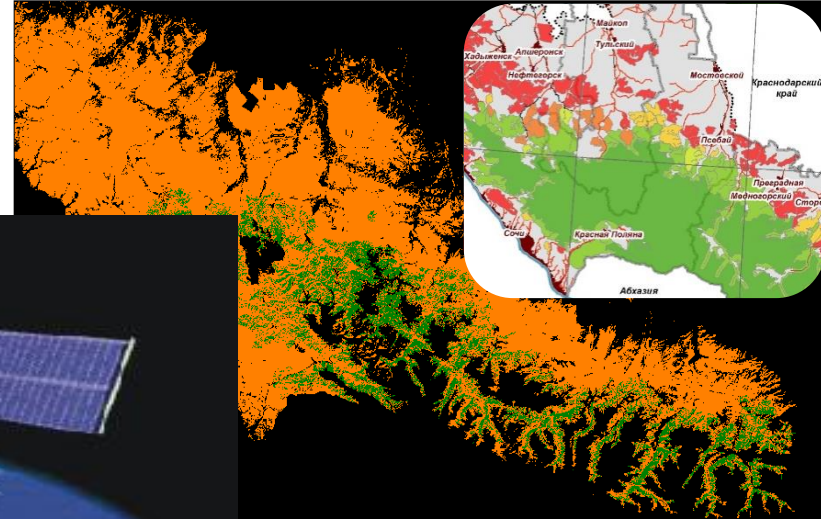# North-West Caucasian fir forest:
ideas, results, IFL approach implementation

Anna Komarova[1,3],
Natalia Alatortseva[2],
Alexander Zudkin[1,4], Eugeny Altshuler[3]
[1]GIS Lab of Greenpeace Russia; [2]Transparent World;
[3]Lomonosov Moscow State University, Biology Department;
[4]University of Maryland, College Park, USA

Caucasus:

-> **high conservation value** region (Global 200; Center of Plant Diversity, CPD;
   Biodiversity Hotspots)

-> no spatial regional data

-> **Intact Forest Landscapes** and **Intact Forest Tracts** approaches

Caucasian fir forests:

-> **rare plant communities**: _Vaccinio-Fagion
orientalis_ и _Rhododendrono pontici - Fagion
orientalis_ (subal. _Abieti-Fagenion orientali_)
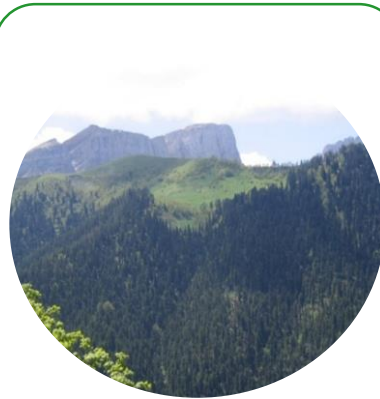
-> Red Data Book species – 73% of releves

Methodological aspect:

If we can use open source
RS data for vegetation
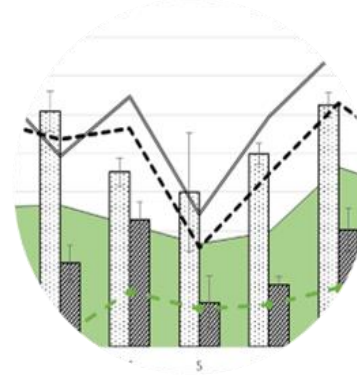researches and predictions
on very detailed level?

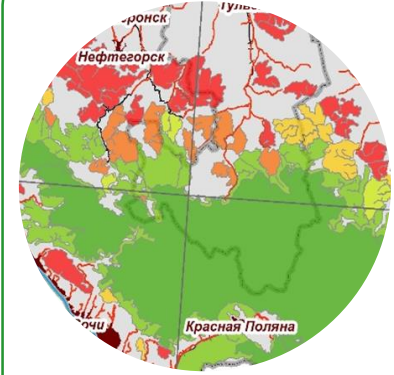**Goal:** specify diversity and spatial rules of fir forests in Russian North-West Caucasus
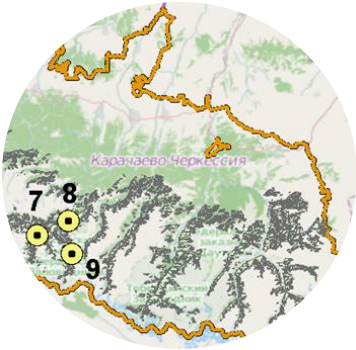
Fir forests' localization (and canopy share of fir)

Spatial rules of their distribution

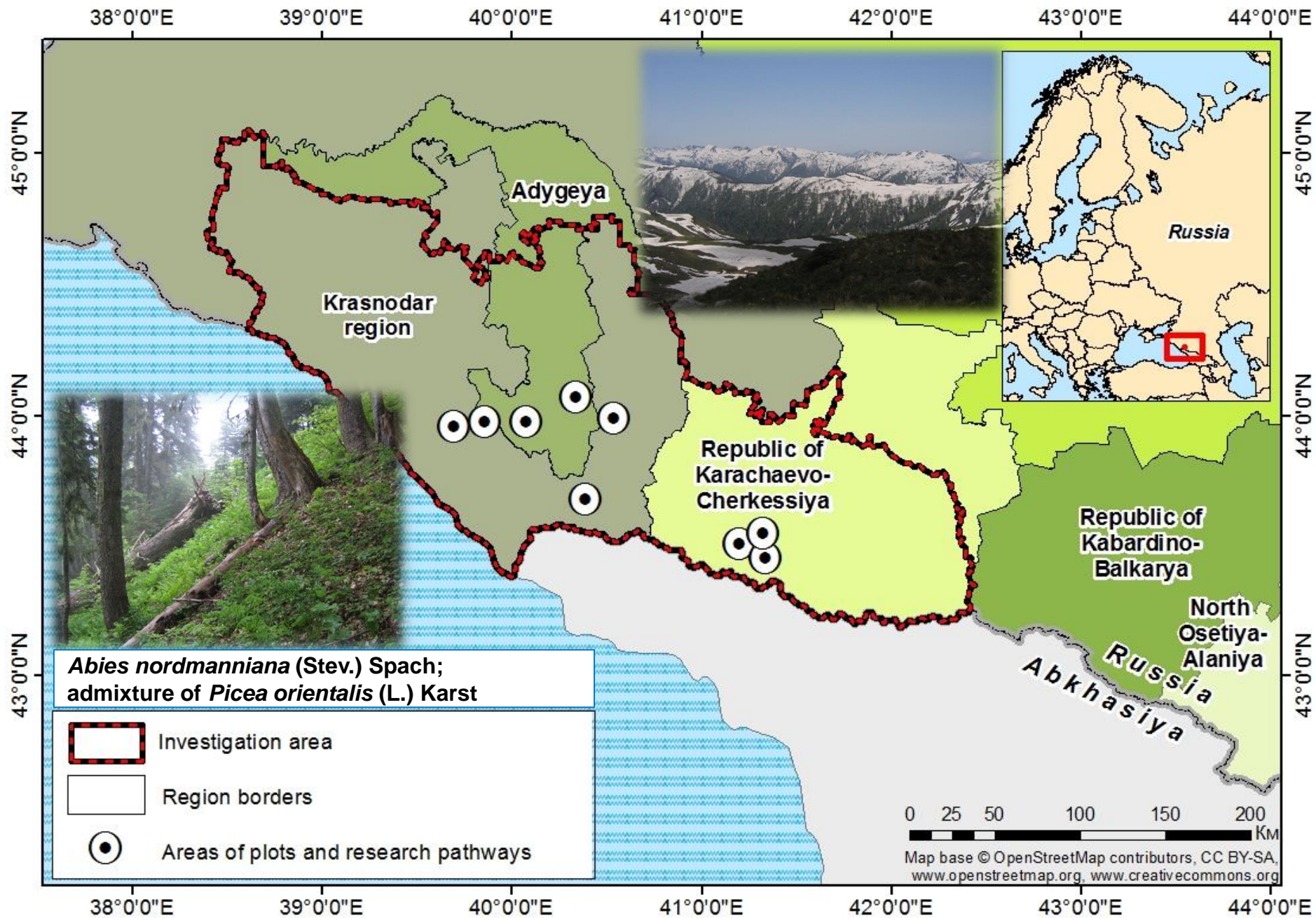Syntaxons' features

IFL & Intact Forest Tracts

RS + Field Data

The area and object of the research

Abies nordmanniana (Stev.) Spach; admixture of Picea orientalis (L.) Karst

Investigation area

Region borders

Areas of plots and research pathways

1. Fir forest mapping

Open Source RS data

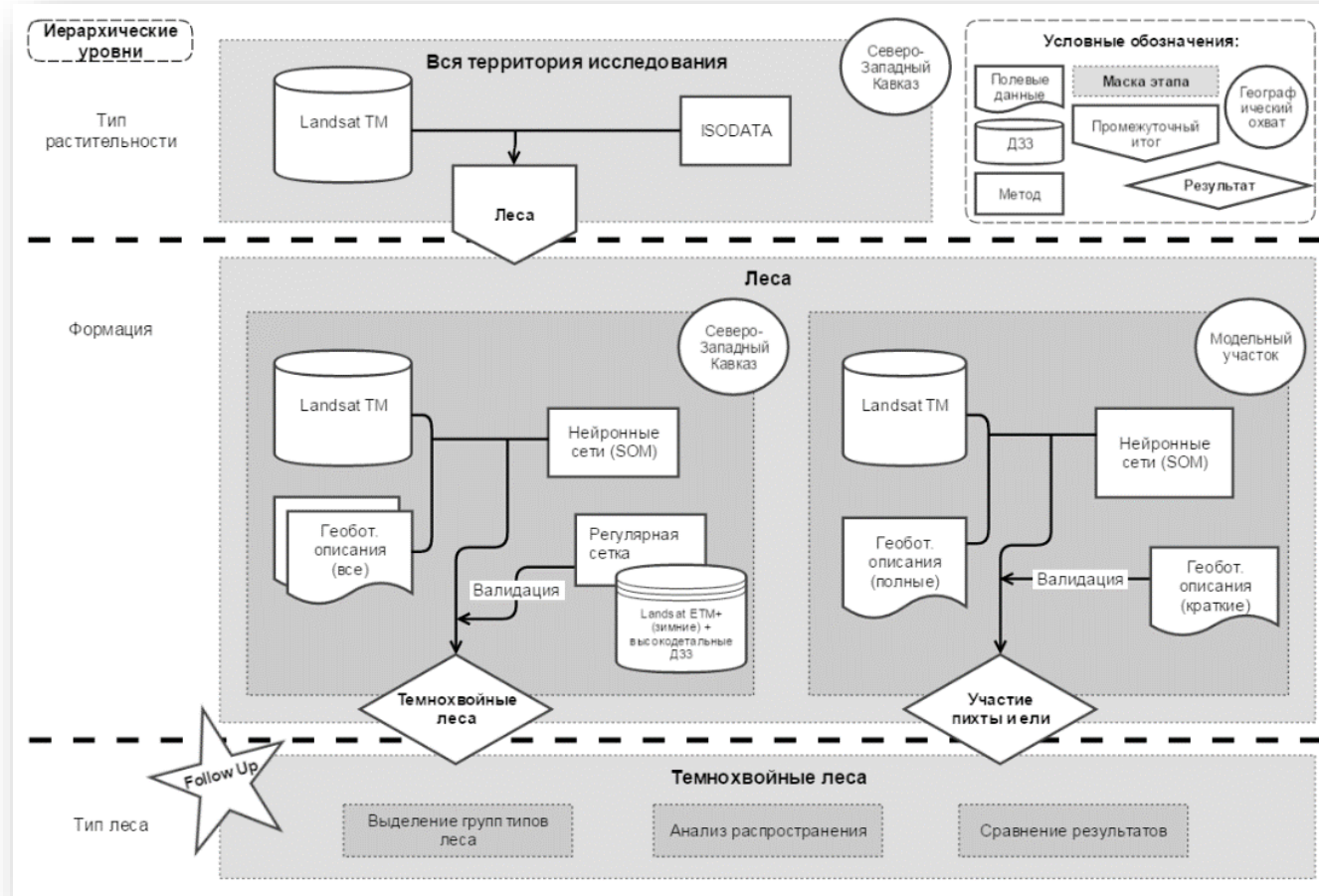-NIR, SWIR

-20-30 m

-Continual borders

Available methods

- **for NGOs**

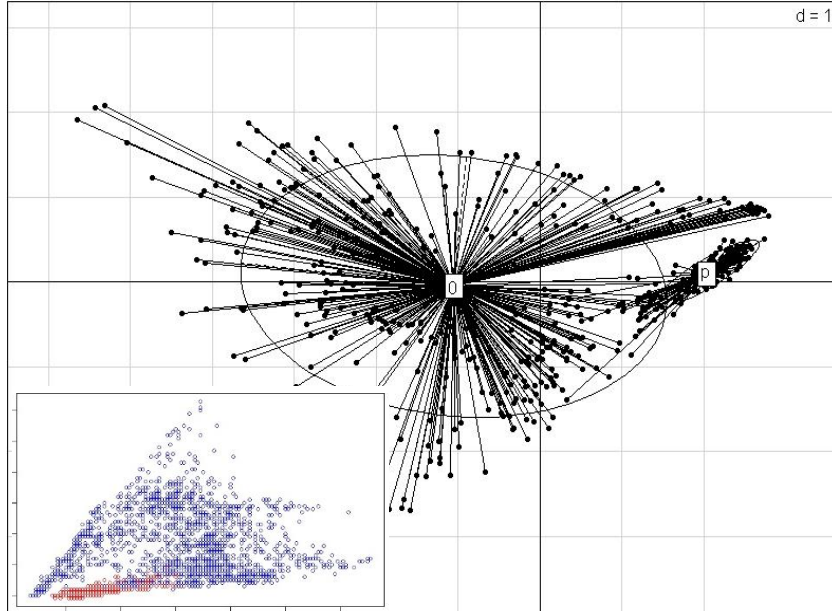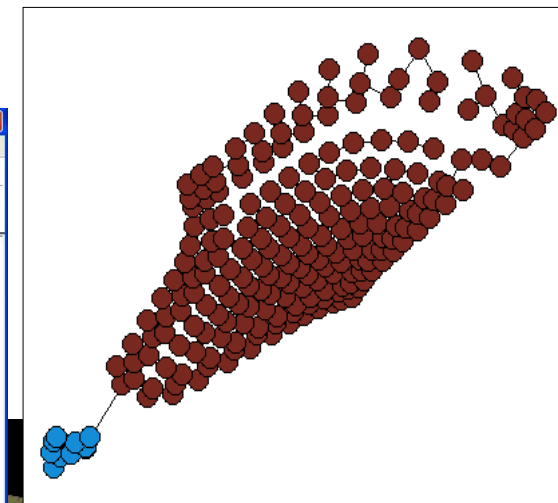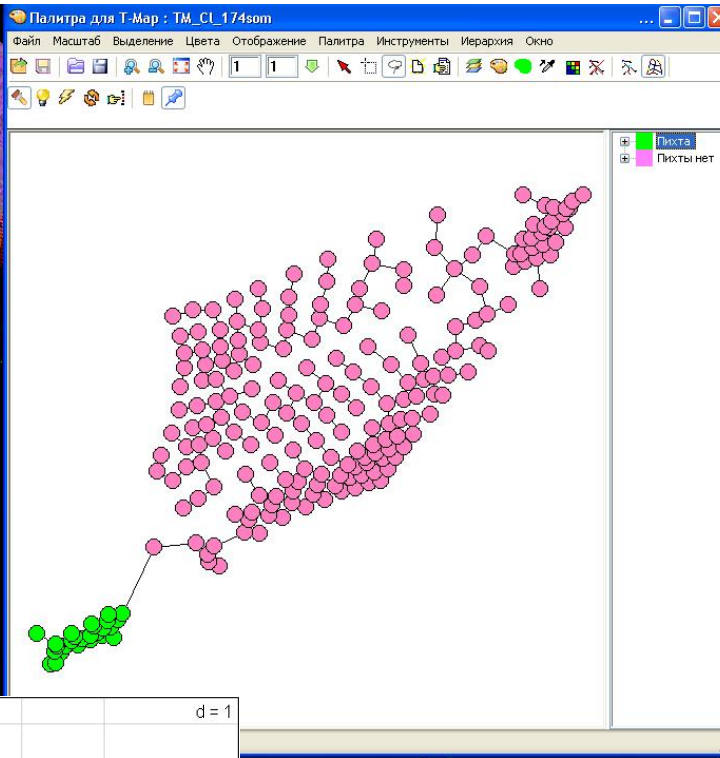- Simple steps

- Analysis "from scratch"

Landsat TM x 4

- Coregistration to
N 37-40 mosaic

- Radiometric calibration

Hierarchical approach (forest mask – ISODATA, fir forest - NeRIS)

Fir forest area: classification (NeRIS, SOM)
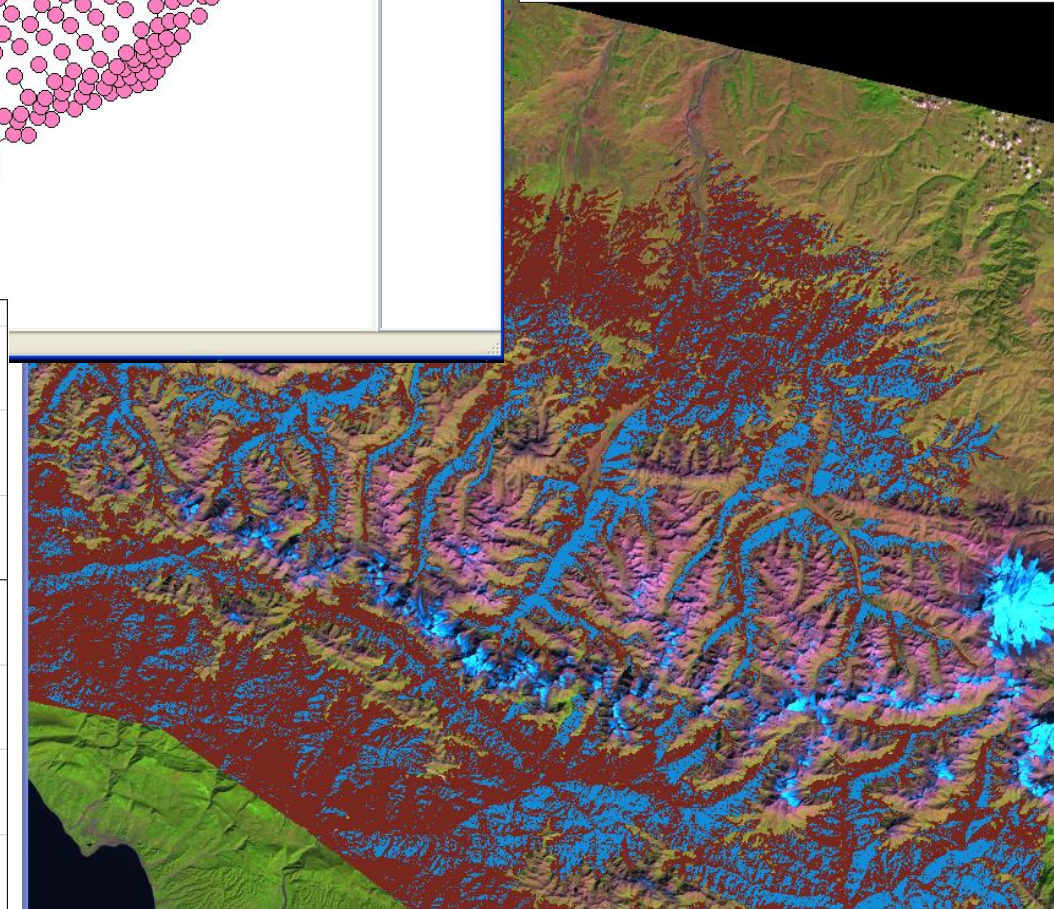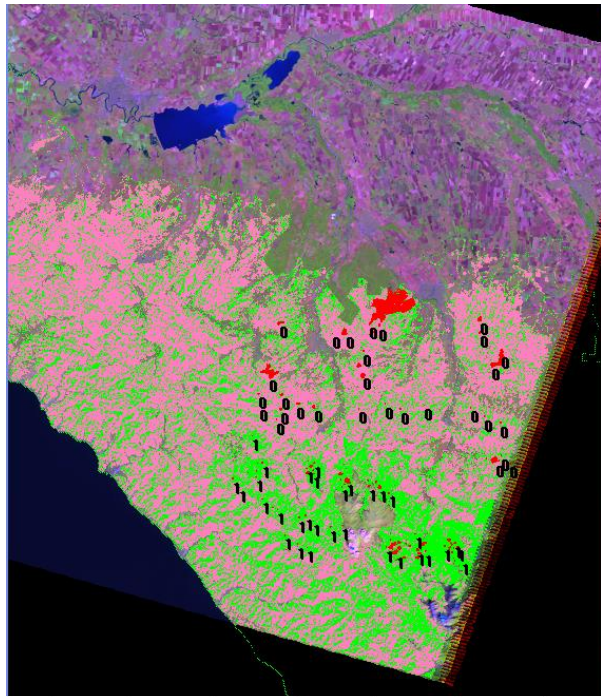
Fir forest area: result & validation

- Fishnet 2x2 km

- Winter Landsat ETM+, TerraLook Aster, GoogleEarth, SasPlanet, photos

Цвет	%	Комментарий
(green)	12.16...	Пихтарники
(orange)	87.83...	Другие леса

Caucasian Fir Forests - 237 Kha, 12,2%
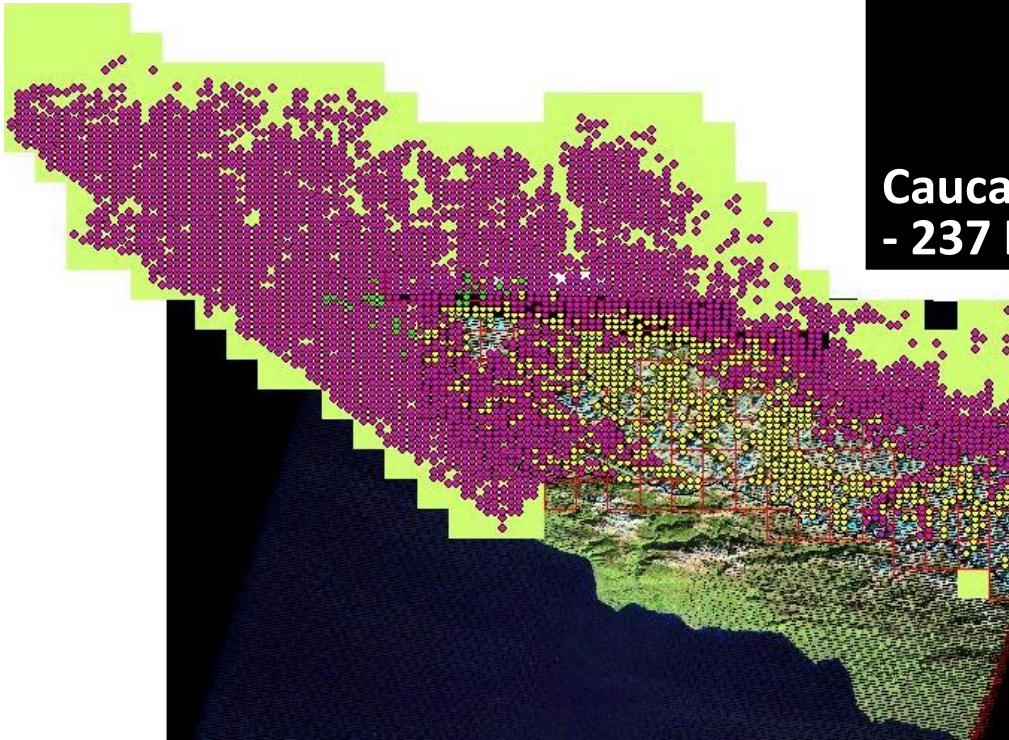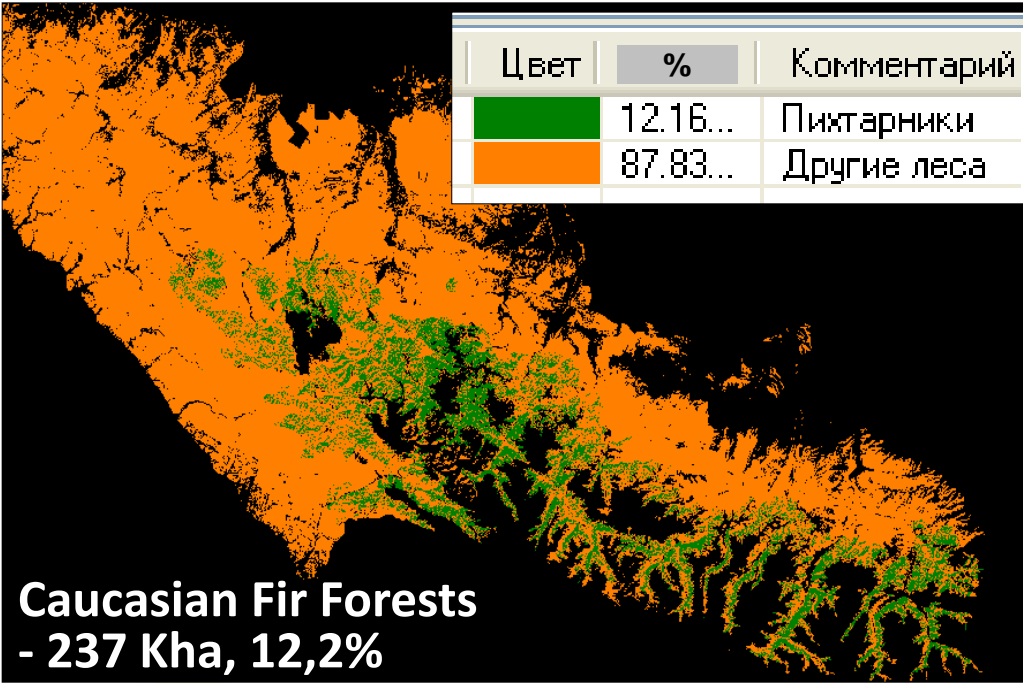
Raster data	Validation data		
	1 (fir)	2(no-fir)	*UA*
1 (fir)	496	97	0,84
50 (other)	102	4161	
PA	0,83	*OA*	*0,96*

Cohen's kappa = 81,5%

VS

DT
*NextGIS
QGIS*
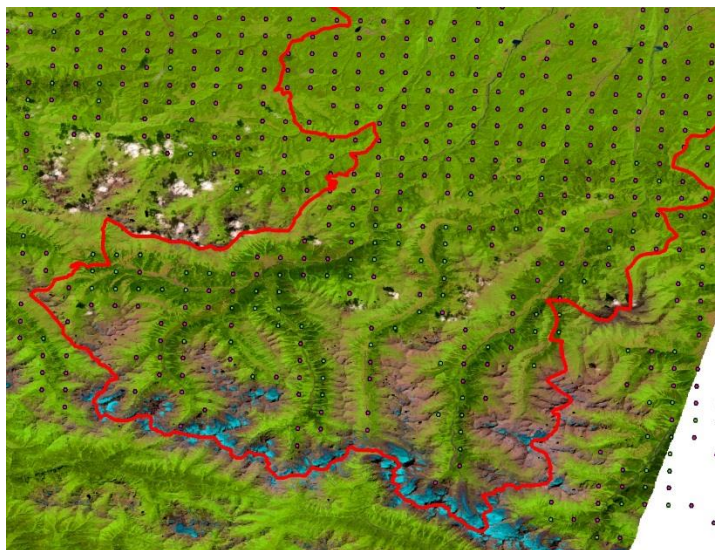
NeRIS
*ScanEx Image
Processor*

DT	проверочные				
	1	2		UA	
1	35	8	43	81,40%	
50	23	287	310	92,58%	
	58	295	353		
PA	60,34%	97,29%	OA		91,22%
			k		0,643

NeRIS	проверочные				
	1	2		UA	
1	52	13	65	80,00%	
50	8	285	293	97,27%	
	60	298	358		
PA	86,67%	95,64%	OA		94,13%
			k		0,797

NeRIS – more accurate, but difference isn't very crucial
DT gives underestimated fir forests area, while NeRIS gives overestimated one
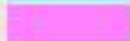
Canopy fir percent: classification (NeRIS, SOM)

Model area
Calibration based on field data
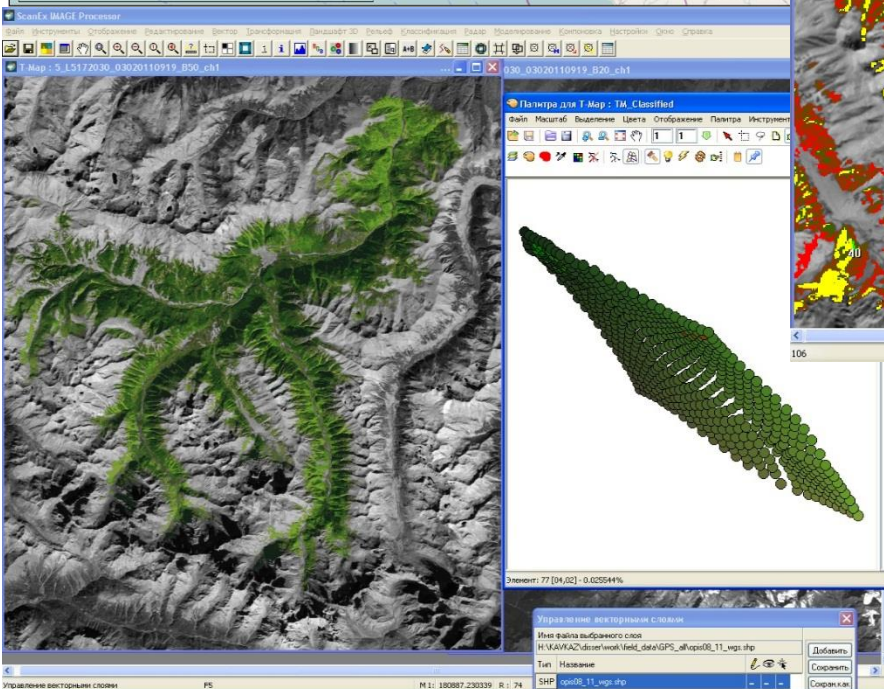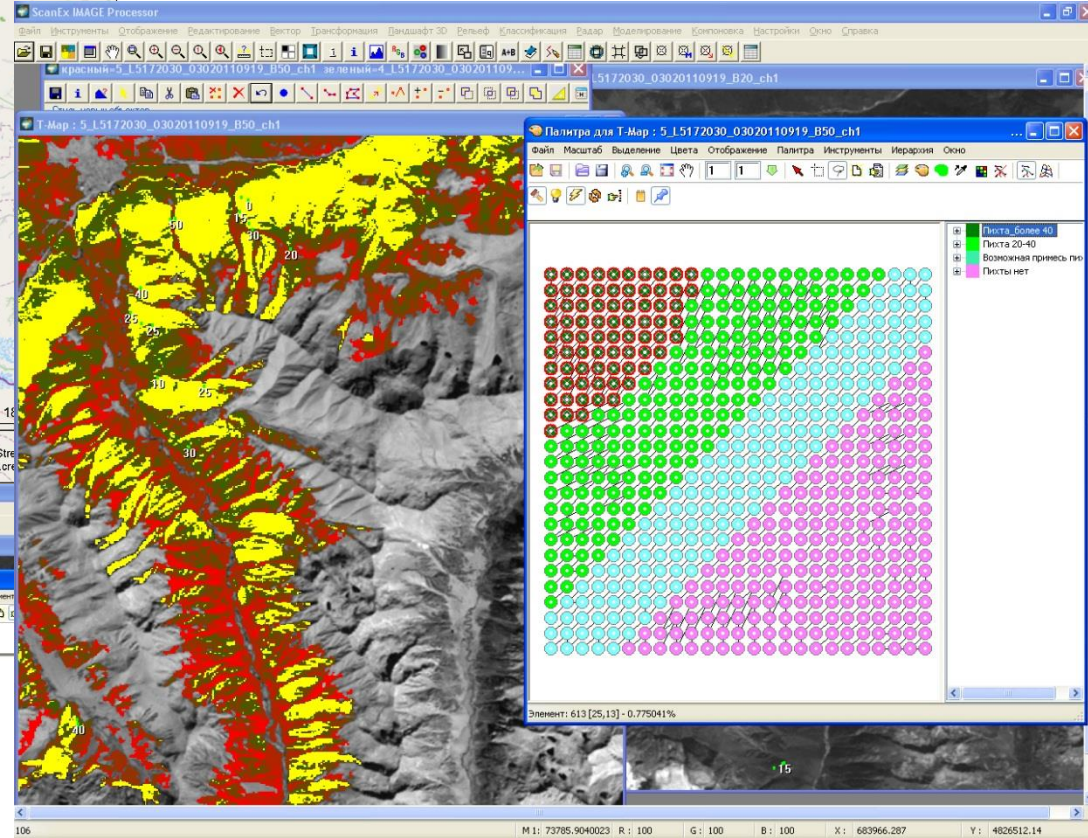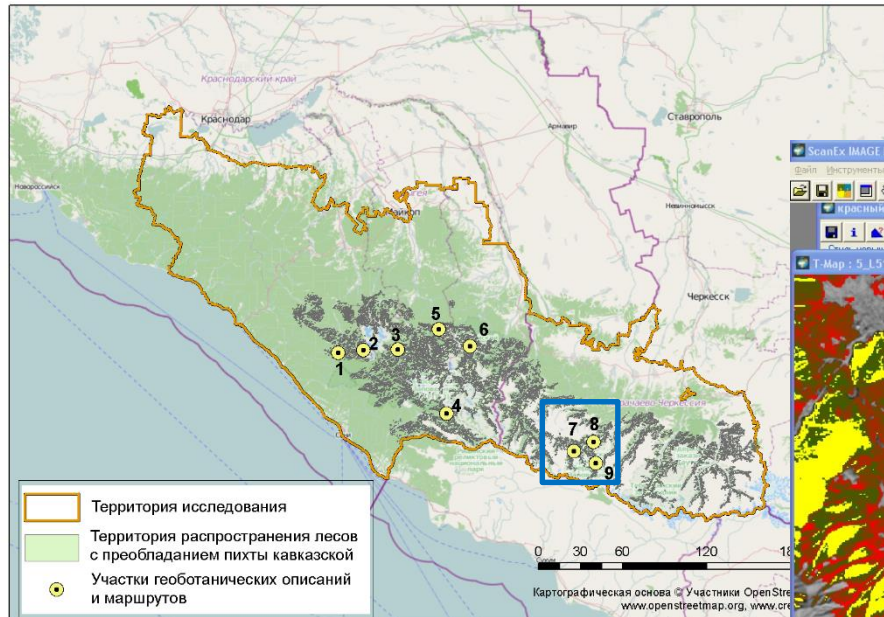
	18.26...	пихта более 40%
	25.65...	пихта 20-40%
	29.85...	возможное участие пихты
	26.21...	пихты нет

Canopy fir percent: result & validation

Цвет	Про...	Комментарий
	18.26...	пихта более 40%
	25.65...	пихта 20-40%
	29.85...	возможное участие пихты
	26.21...	пихты нет
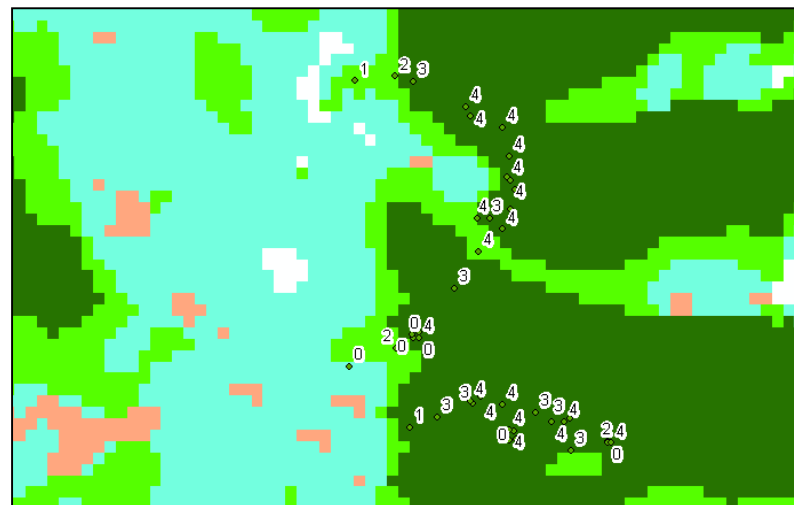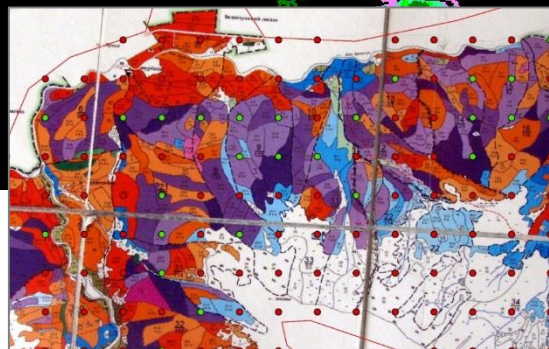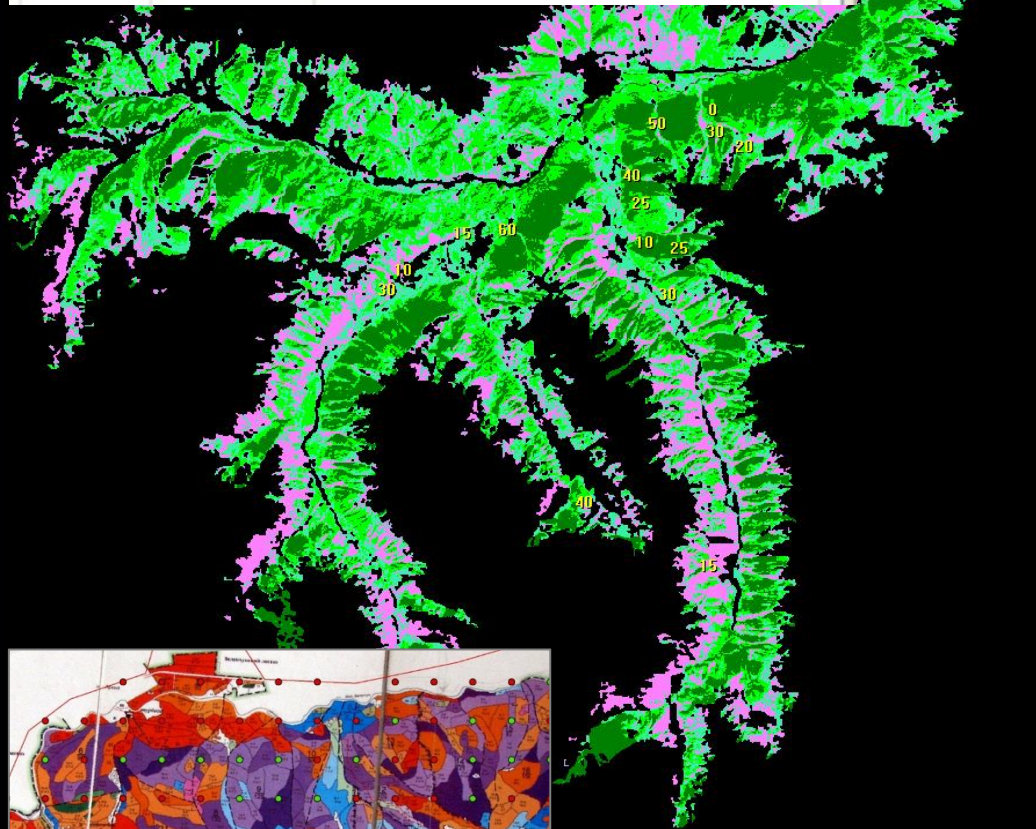
	GPS					
Растр	1	2	3	4		UA
10	14	3	1		18	0.86
20	8	19	3		30	0.82
30		17	27	4	48	0.78
40	1	4	6	60	71	0.89
	23	43	37	64	167	
PA	0.78	0.67	0.85	0.97		**0.72**

Accuracy = 72%, kappa 0,6; Fuzzy Boundaries Accuracy *(Fassnacht et al 2006)* = 84%. 66,4% to forest inventory data

2. Fir forest spatial distribution = previous result + SRTM

The main basins and fir forest area, Kha

Legend:
- ■ Кубань Запад
- ■ Черное море
- ■ Белая
- ■ Лаба
- ■ Уруп
- ■ Зеленчук
- ■ Теберда
- ■ Верховья Кубани

Pie chart values: 30,2 | 4,6 | 25,2 | 15 | 26,3 | 4 | 62,4 | 69,3 | 236,9 (12,2%)

Map percentages: 1,7% | 19,6% | 24,4% | 9,8% | 6,3% | 44,4% | 20,2% | 16,4% | 33,1%

Share of the watershed for all fir forests
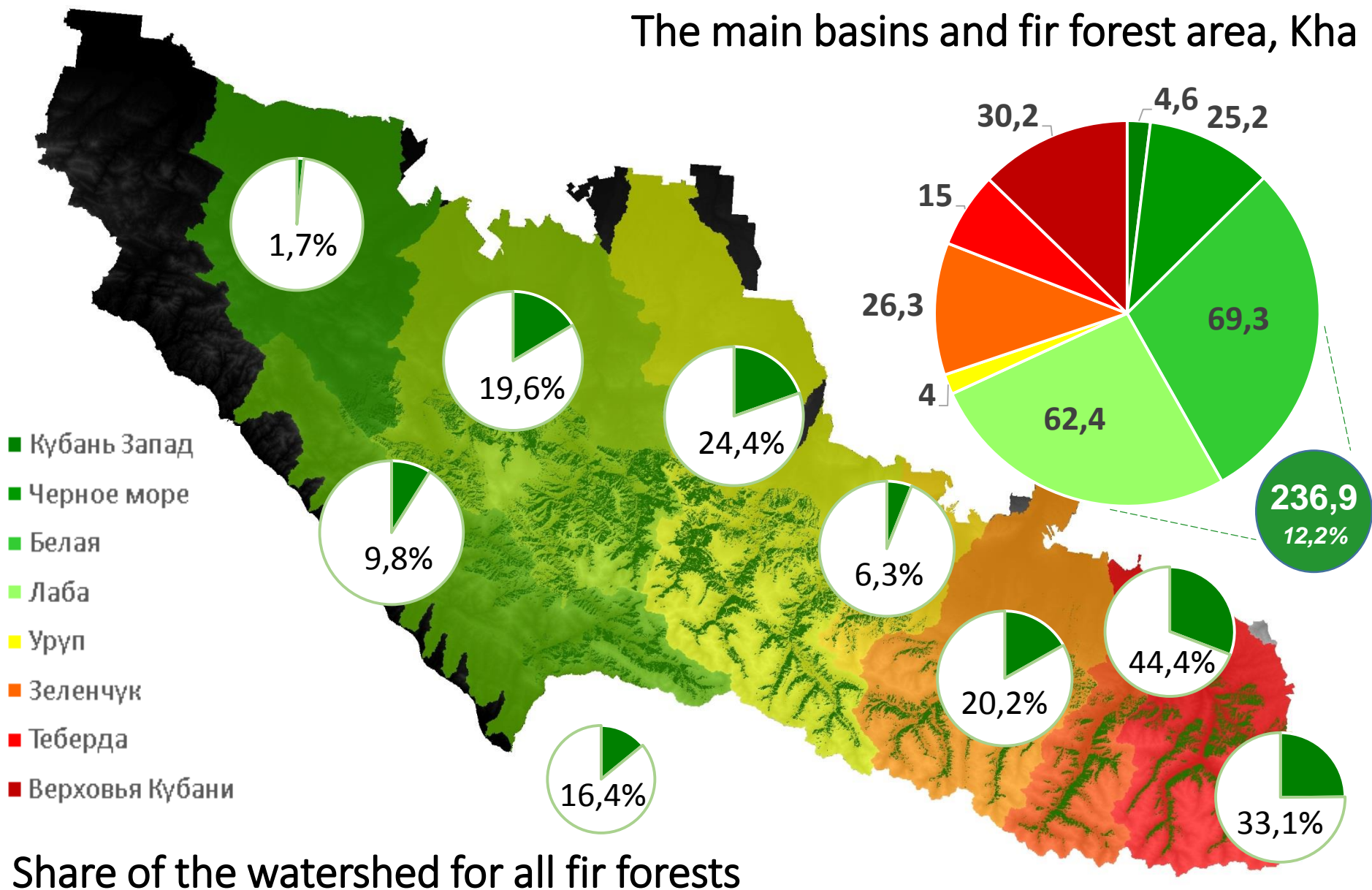
Fir forest distribution corresponds to aspect and slope

Темнохвойные леса
Прочие леса

А

Б

Западная
Кубань

Черное море

Белая

Лаба

Уруп

Зеленчук

Верховья
Кубани

Теберда

В

тыс. га

90
80
70
60
50
40
30
20
10
0

50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%

Площадь
темнохвойных
лесов, тыс. га

Доля
темнохвойных
от всех лесов, %

Крутизна склона, °: flat   1-10   11-20   21-30   31-40   41-50   >50
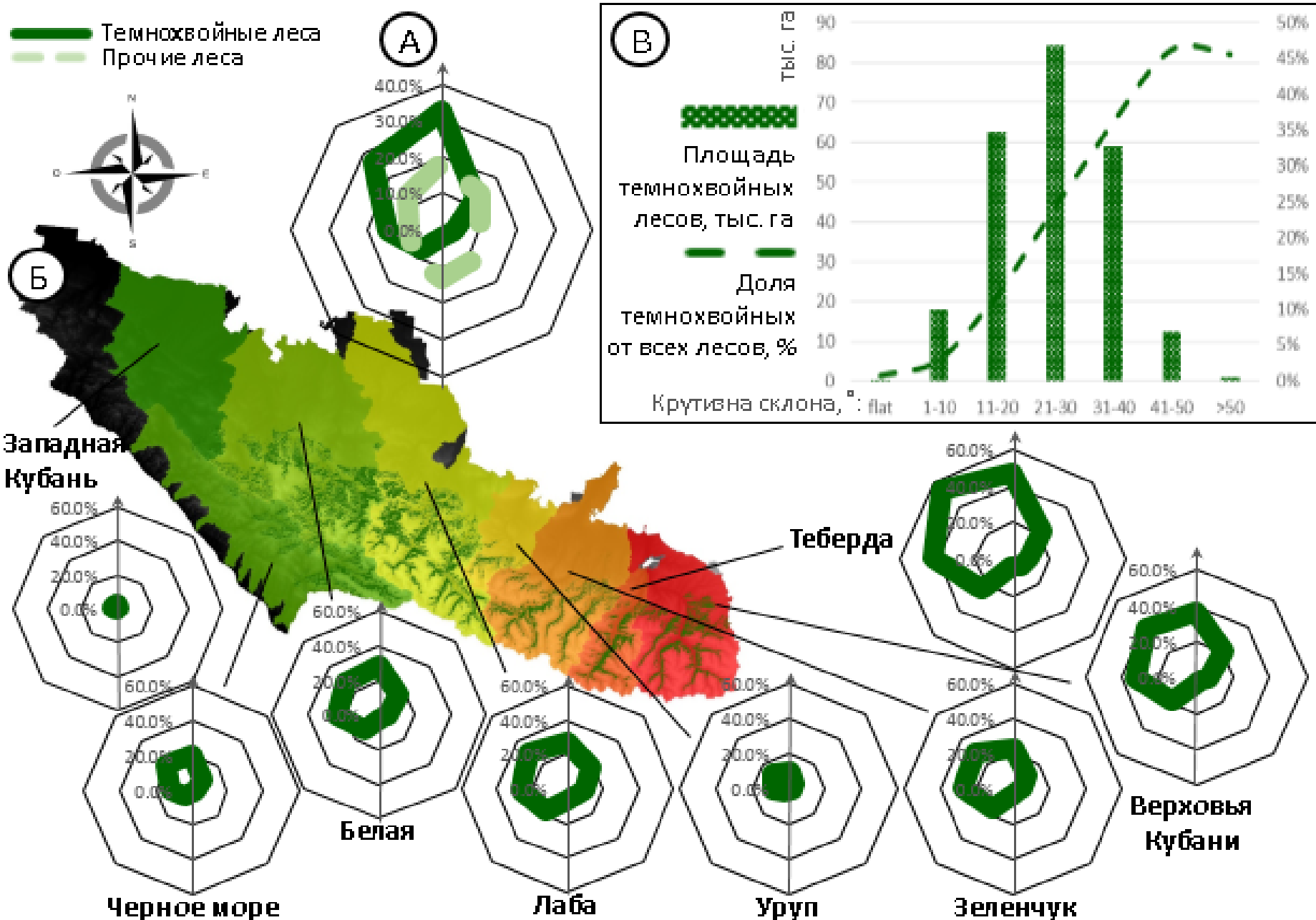
Area (Kha) and share of fir forests by positions of various slope and aspect: geomorphometry features

slope	aspect									
	flat	n	ne	e	es	s	sw	w	nw	∑
0-10		**6,2**	**2,6**	1,2	0,9	0,8	1,1	2,1	**4,8**	19,9
		4%	2%	1%	1%	1%	2%	3%	4%	3%
11-20		**20,9**	**8,5**	**2,4**	1,4	1,9	**4,8**	**8,6**	**15,8**	64,5
		17%	11%	5%	2%	2%	6%	14%	18%	10%
21-30		**26,9**	**10,0**	2,4	1,1	1,7	**7,0**	**12,7**	**22,2**	**84,1**
		39%	21%	8%	3%	3%	14%	32%	44%	22%
31-40		**19,9**	**7,0**	1,1	0,4	0,4	**3,8**	**7,9**	**16,0**	56,6
		64%	33%	9%	3%	2%	20%	48%	70%	36%
41-50		**3,6**	1,2	0,2	0,04	0,04	0,5	1,9	**3,5**	11,0
		71%	37%	9%	2%	2%	29%	60%	77%	**47%**
>50		0,2	0,06	0,006	0,002	0,003	0,02	0,1	0,3	0,8
		43%	38%	7%	3%	8%	38%	59%	59%	**44%**
∑	0,6	**77,8**	29,3	7,3	3,9	4,9	17,3	33,4	**62,4**	236,9
	11%	**20%**	11%	4%	2%	2%	8%	**18%**	**22%**	12%

Area of fir and non-fir forests by elevation levels

темнохвойные леса   прочие леса
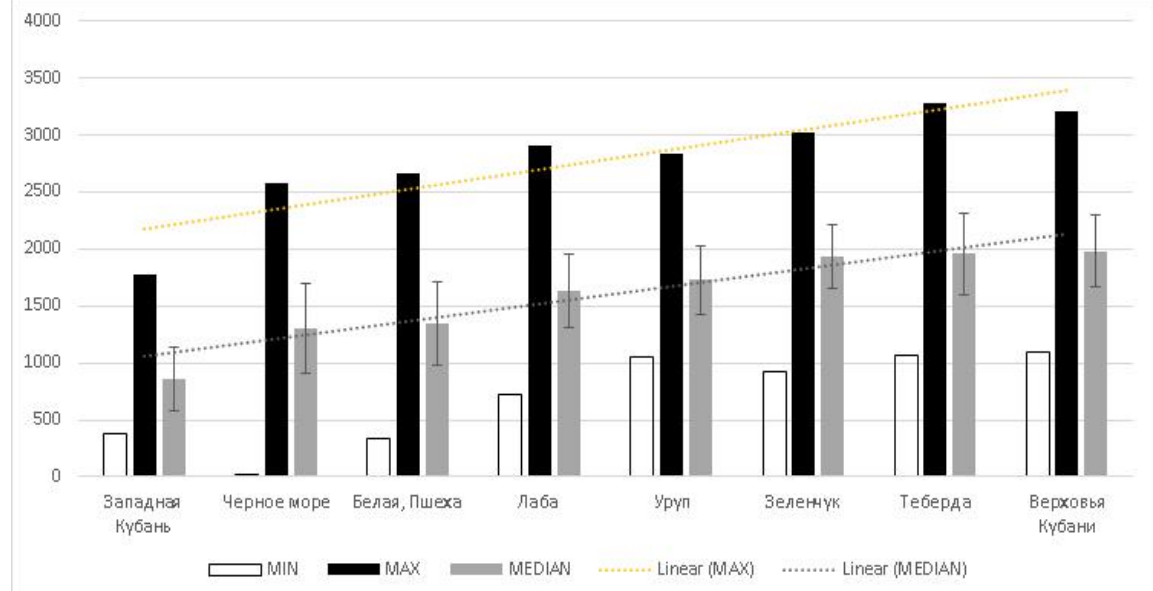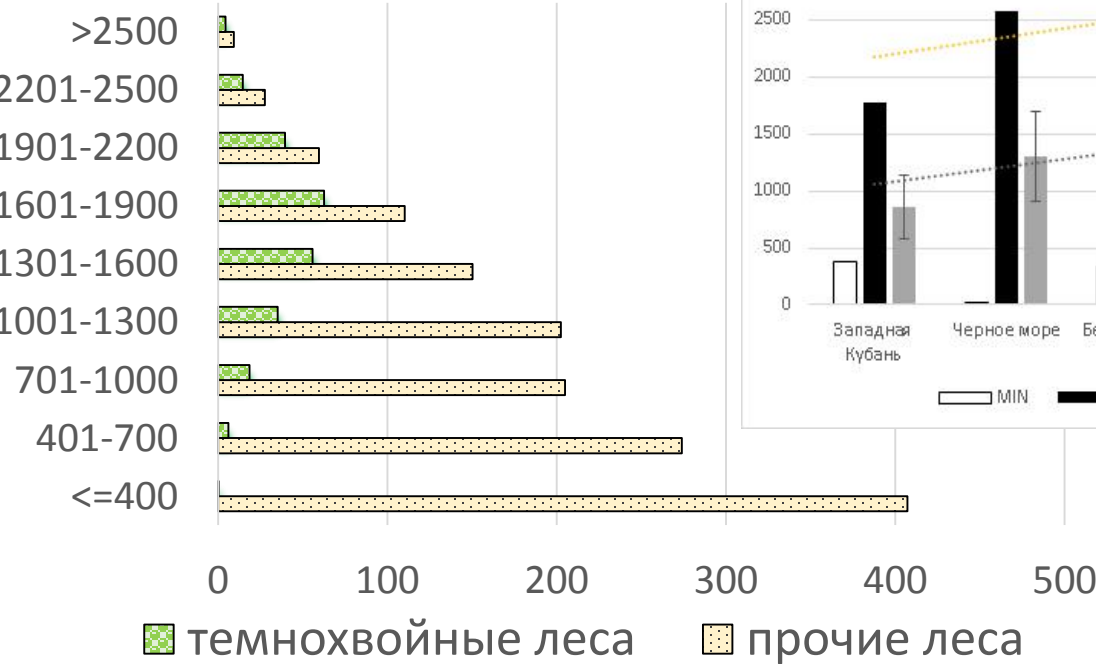
Fir forest elevation by basin (from West to East)

Fir forests area (Kha) and share of all forests to elevation (m above s.l.) by basin

Черное море

Белая

Лаба

Теберда
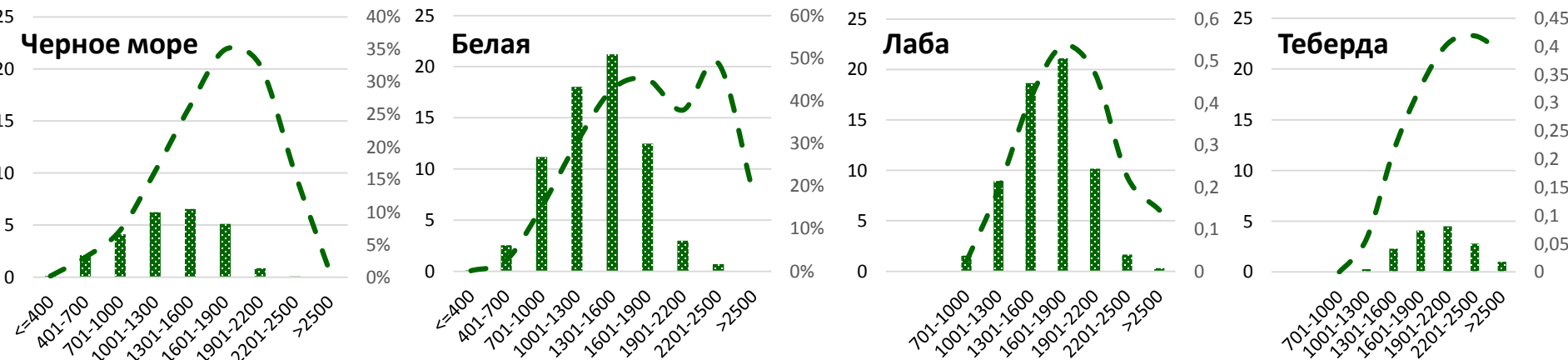
3. Syntaxonomy – based on synopsis table (Braun-Blanquet approach)
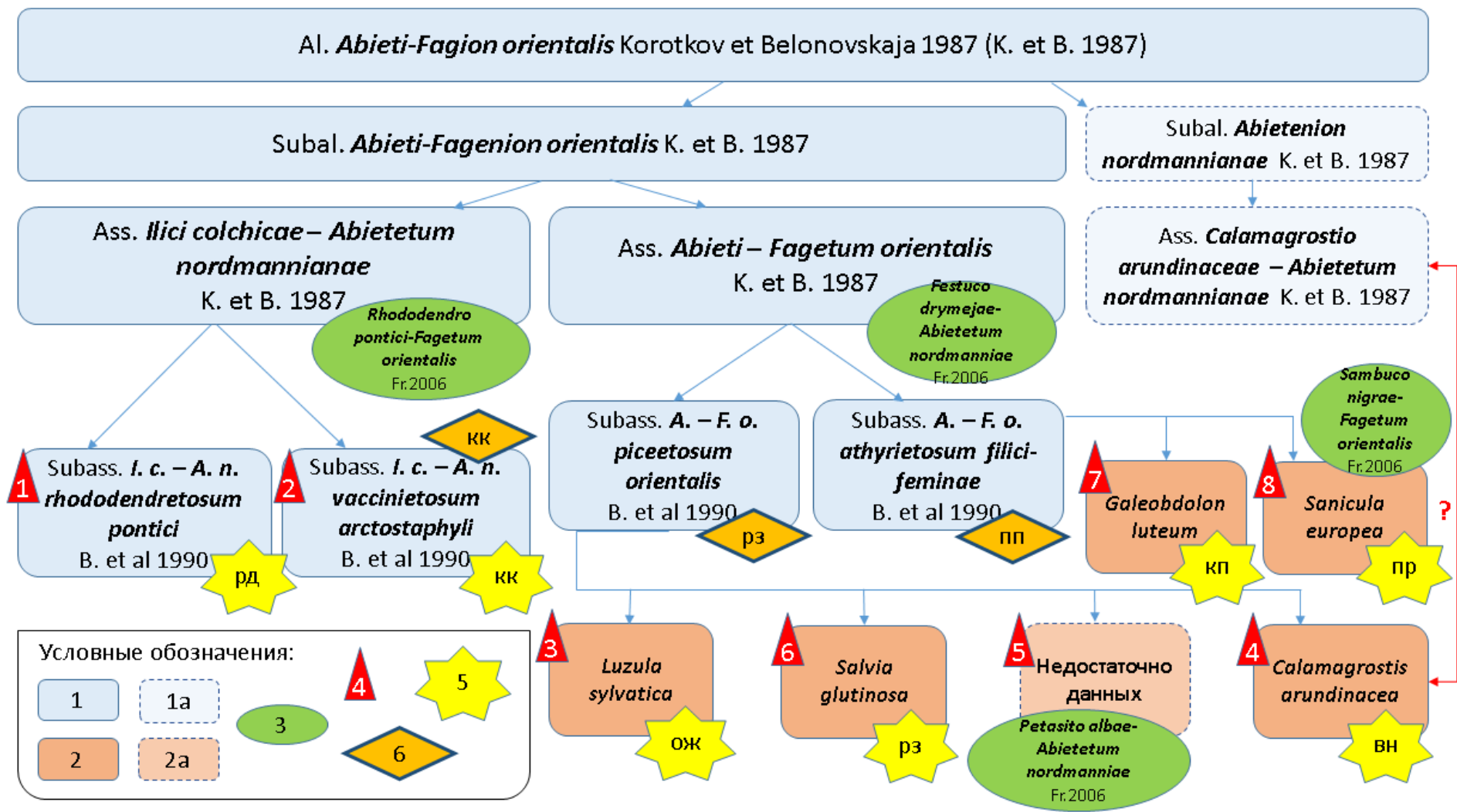
3. Are we able to define syntaxon using RS (and field data)?

RS: ecologicaly-senced parameters;
equal spatial resolution (Landsat 8):

- Spectral bands reflection and vegetation indices
- Elevation, slope, aspect, profile and plan curvature
- Treecover data *(Hansen et al 2013)*

Plan Curvature
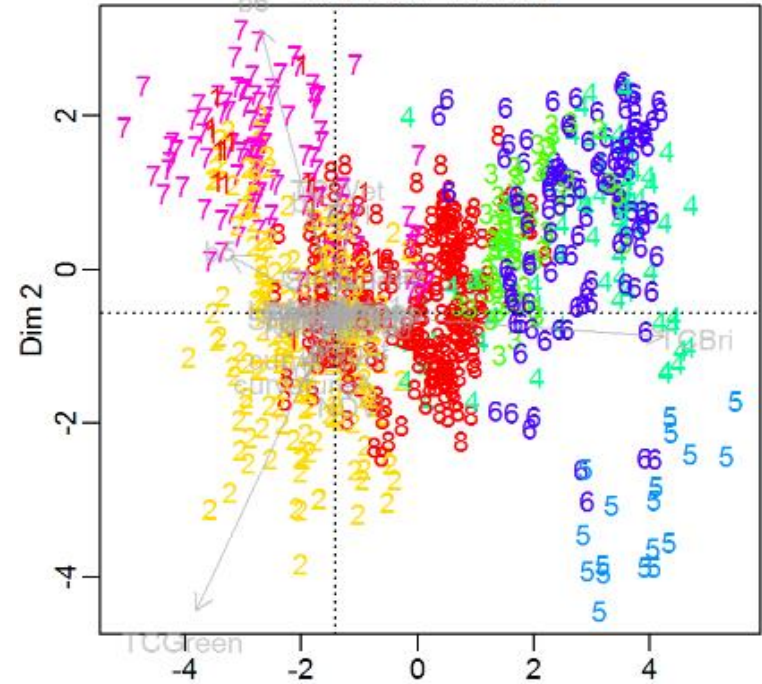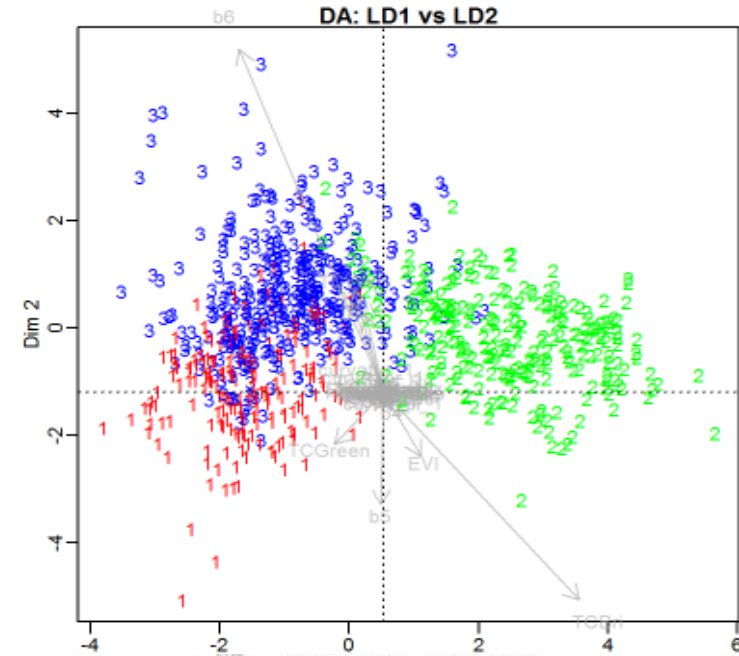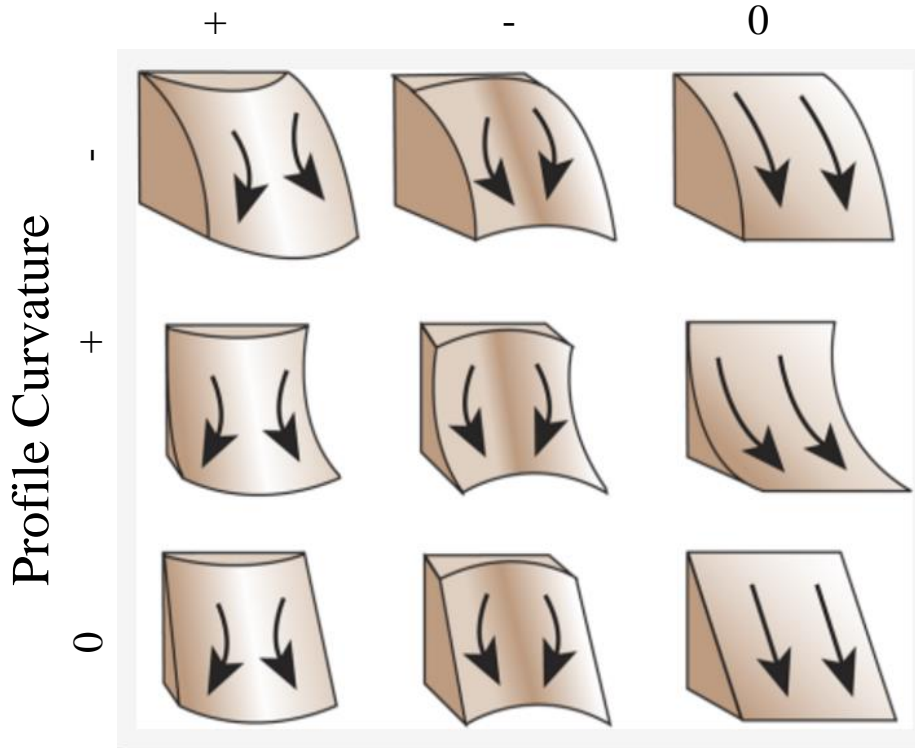
Prediction of syntaxon based on RS data
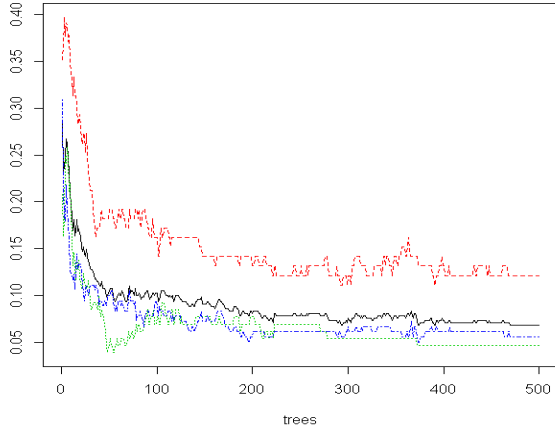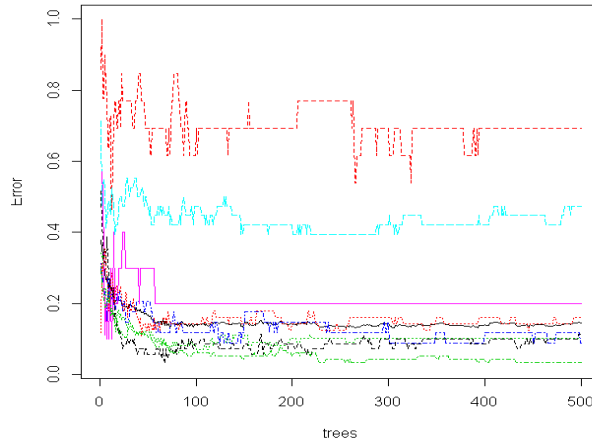
The most important for prediction of both subassotiations and variants are elevation, aspect and blue band reflection

Field data (over 800 points)

Training/validation samples: 1:1

Random Forest

Model Accuracy:

Subassotiation level – **94%**;

Variants level – **86%**

+ Mann-Whitney pair test for each pair of syntaxon
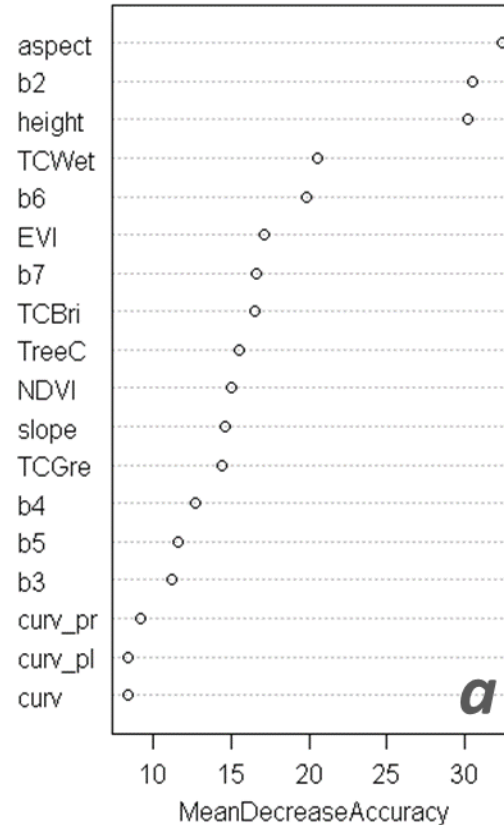
Geomorphometry and community structure characteristics based on RS data
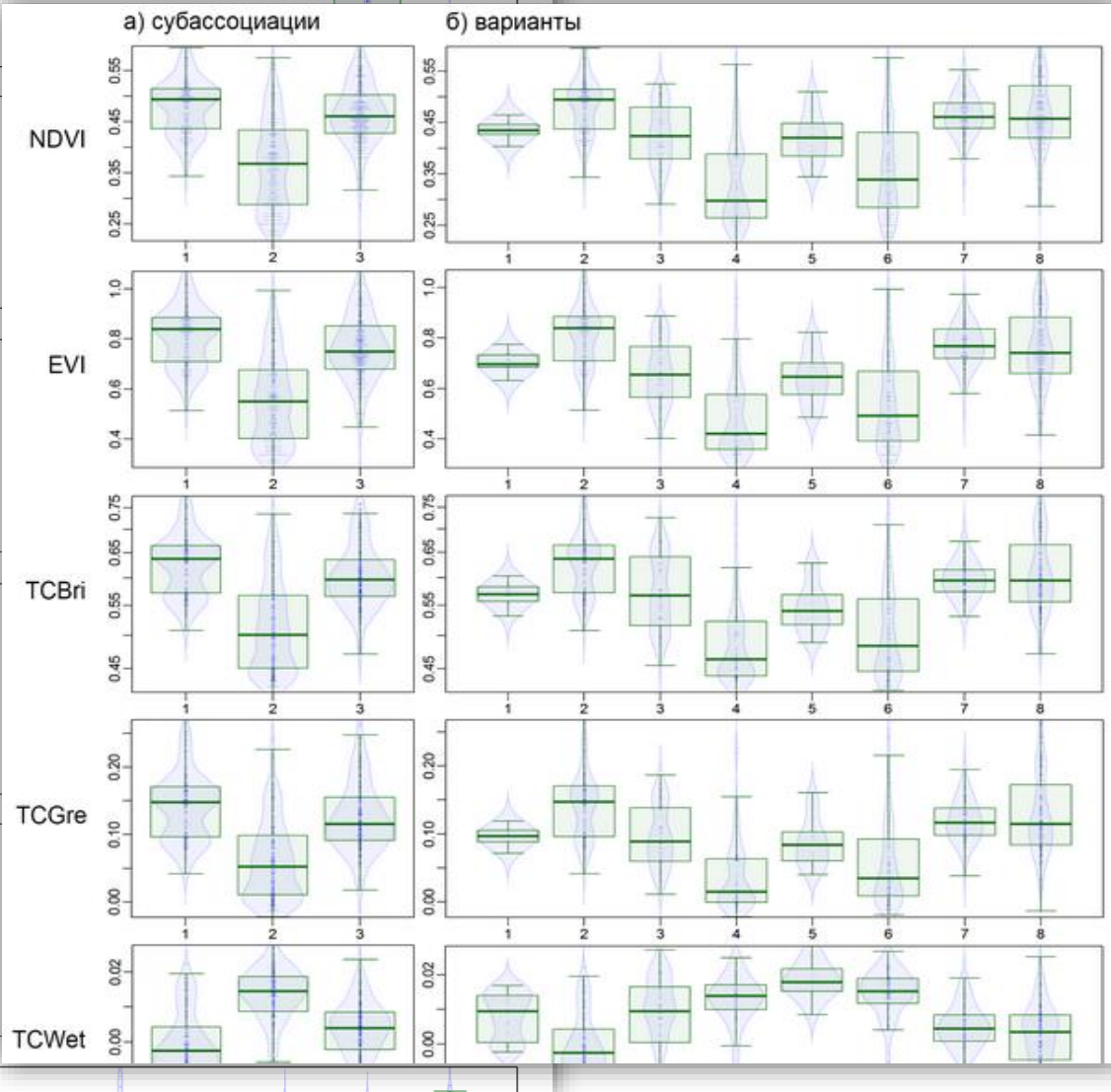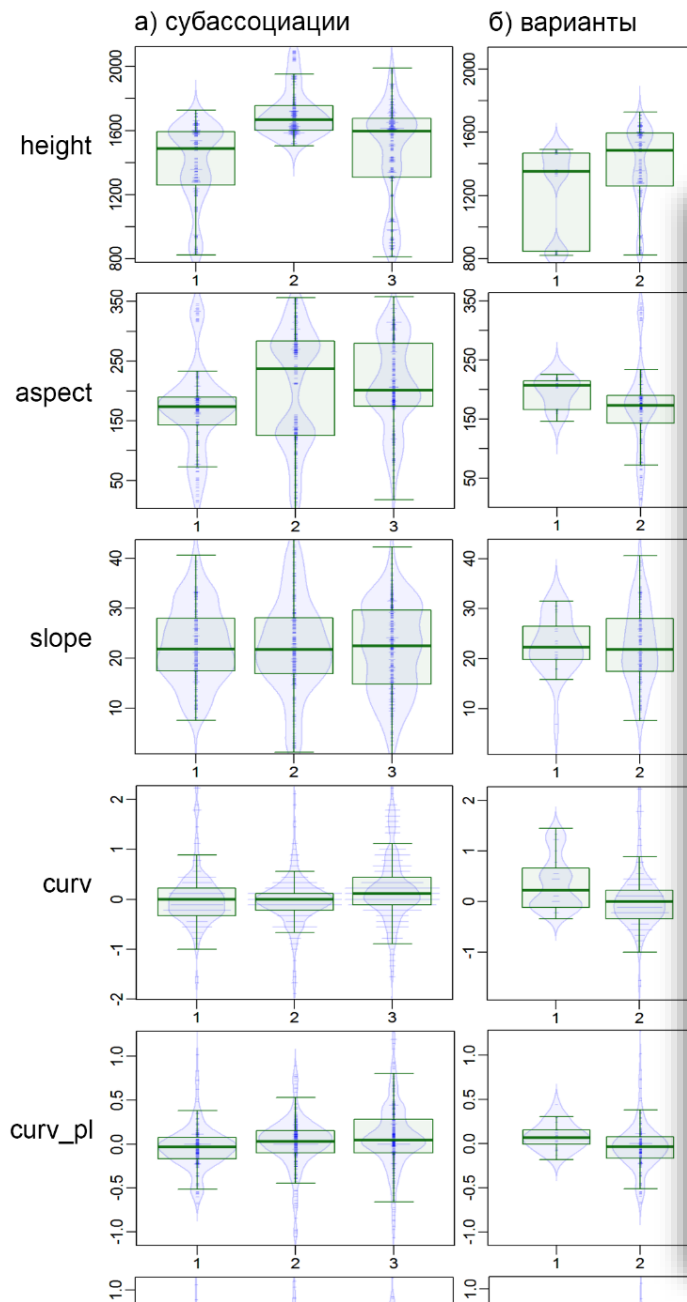
The main characteristics of syntaxons

I. c. – A. n. vaccinietosum arctostaphyli Belonovskaja et al 1990 – lower positions than **A. – F. o. piceetosum orientalis** Belonovskaja et al 1990 и **A. – F. o. athyrietosum filici-feminae** Belonovskaja et al 1990; southern slopes. Many layers

I. c. – A. n. vaccinietosum arctostaphyli Belonovskaja et al 1990 – middle and upper slopes; huge biomass, understocking canopy, Fagus orientalis.

Red Data Book listed species

I. c. – A. n. rhododendretosum pontici Belonovskaja et al 1990 – top of ridges, low elevation; sparse herbaceous ground layer
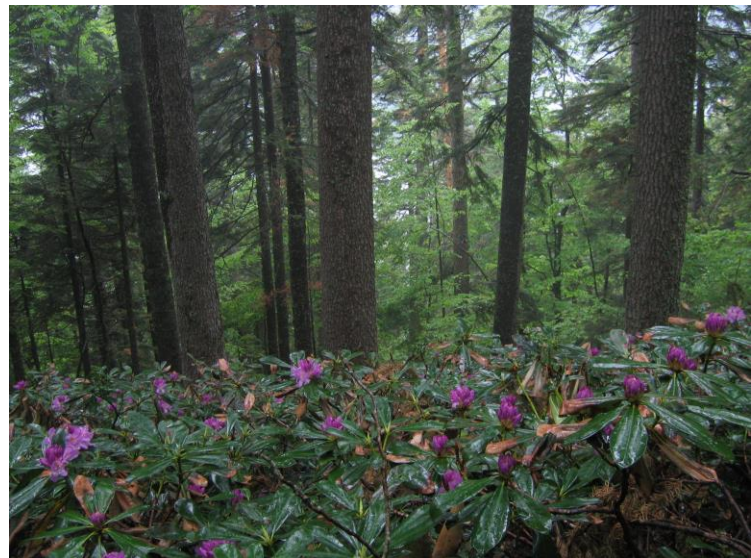
The main characteristics of syntaxons

A. – F. o. piceetosum orientalis Belonovskaja et al 1990 – maximum elevation and fidelity to north and west slopes. Low biomass and reflection (high canopy share of fir; accompanied by spruce)

Salvia glutinosa – typical variant for subassotiation; very assigned to north-west slopes. Sparse canopy (stiff slopes); low biomass (understory layers are also very sparse)

Calamagrostis arundinacea close to typicum variant; extremely stiff slopes, biomass higher than for **Salvia glutinosa** .
Boreal variant: spruce, green mosses

Luzula sylvatica – topography diversity; rather high biomass (herbaceous layer); probably derivative communities

The main characteristics of syntaxons

A. – F. o. athyrietosum filici-feminae Belonovskaja et al 1990 – topography diversity (and also differ from previous subassotiations), characterized by spectral features (high brightness); biomass higher than for ***A. – F. o. piceetosum orientalis***

Sanicula europea – south and west edge slopes (it differs the variant from ***Salvia glutinosa*** и ***Calamagrostis arundinacea***). Sparse treecover, high biomass. *Rich species compositions, rare species (Taxus baccata)*

Galeobdolon luteum - curved inward low-sloped sites (up to 10˚), various aspect. River terraces, low valley (1000 m above s.l.). High treecover density and biomass.

Potapov et al. The last frontiers of wilderness: tracking decadal loss of Intact Forest Landscapes from 2000 to 2013 Science Advances – 2017. – V. 3, №. 1. – e1600821

http://advances.sciencemag.org/content/3/1/e1600821.full.pdf+html

http://intactforests.org/data.ifl.html

Что такое малонарушенная лесная территория (МЛТ)?

Эталонные участки дикой природы в пределах лесной зоны, которые испытывают минимальное воздействие со стороны хозяйственной деятельность человека и достаточны для того, чтобы поддерживать высоко биологическое разнообразие на своей территории
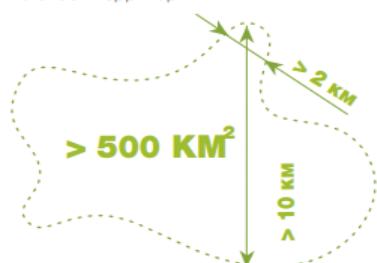
> 500 КМ²
> 2 КМ
> 10 КМ

① БОЛЕЕ 500 КМ²
② МИНИМУМ 10 КМ В САМОМ ШИРОКОМ МЕСТЕ
③ МИНИМУМ 2 КМ В УЗКИХ МЕСТАХ

КОМПОНЕНТЫ ЛЕСНОЙ ТЕРРИТОРИИ

ЛУГА
РЕДКОЛЕСЬЯ
ЛЕС СОМКНУТЫЙ И НЕ СОМКНУТЫЙ
СКАЛЫ
БОЛОТА
ОЗЕРА И РЕКИ

Деградация МЛТ

Фрагментация
МЛТ может быть разделена на менее крупные участки дорогами и другой инфраструктурой

Обезлесивание
Обезлесивание может быть вызвано вырубками, расчистками под сельское хозяйство, ростом населенных пунктов, пожарами и добычей п/и

ИНФРАСТРУКТУРА
Инфраструктура (н-р дороги, крупные реки, трубопроводы и т.д.) считалась нарушением и выделялась с буфером 1 км

УЗКИЕ ПЕРЕШЕЙКИ
Узкие участки МЛТ (менее 2 км в ширину) считались нарушением, также как и маленькие по площади участки МЛТ за ними

ПОЖАРЫ
Сгоревшие территории считались нарушенными только если были привязаны к инфраструктурным объектам

ЕСТЕСТВЕННЫЕ НАРУШЕНИЯ
Естественные нарушения (ветровалы, эпидемии вредителей и болезней леса) не считались факторами деградации МЛТ

Результат анализа деградации МЛТ

ОСТАВШАЯСЯ МЛТ

ФРАГМЕНТИРОВАННЫЙ ЛЕС
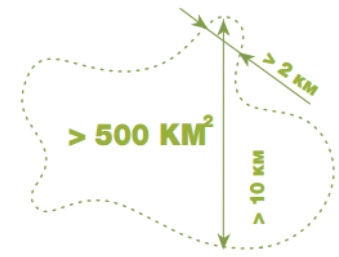
ДЕГРАДИРОВАННЫЙ / В ПОЛЬЗОВАНИИ ЛЕС

НЕЛЕСНАЯ ТЕРРИТОРИЯ

Intact Forest Tracts (IFT)

*Block size needed to sustain some important conservation functions.***

> 2 КМ
> 500 КМ²
> 10 КМ

Intact Forest Tracts (IFT)

- regional **supplement** for IFL

Softer and regional adopted criteria:

50 th ha -> **1 th ha**
1000 m -> **25-500 m**
2000 m -> **500 m**

IFL

Preservation of the potential for local migration in response to long-term change in the landscape (e.g. due to climate change).

Protection of the inside of blocks from the effects of recreation and poaching.

Maintenance of viable populations of large vertebrates (forest reindeer, wolverine, eagle owl, and others).

Maintenance of fully undisturbed small rivers and lakes, for reference.

Maintenance of natural patterns of large-scale disturbance - pest outbreaks, massive wind throw, large fires, etc.

Keeping negative edge effects at a marginal level - e.g. the effect of clearcuts on the edges of surrounding mature forest.

Maintenance of natural patterns of small-scale disturbance - wind throw, small fires, etc.

Area, thousand ha   1   10   100   1000   10 000   100 000

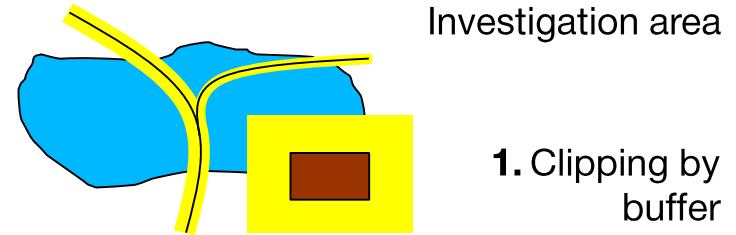**Minimal area of IFL – 50.000 ha**

*Yaroshenko A.Yu. et al. The Last Intact Forest Landscapes of Northern European Russia. — M.: Greenpeace Russia, 2001. — 74 p.

IFT: local approach and methodology

IFT = **core** + **matrix**

Fir forests

Unfragmented area

Investigation area

Buffer

1. Clipping by buffer

2. Manual check

3. Fragmented area deleting (500 m), **4.** Filtering (1000 ha)

IFT

5. Result layer attributing *(IFL, coniferous >10%)*

Object type	OSM Data layer	OSM attributes	Buffer	Comments
Main roads	highway	Tertiary, tertiary_link, secondary_link, primary, primary_link, road	100 м	
Secondary roads	highway	unclassified track service residential	25 м	Only visible on Landsat
Railroads	railway		100 м	
Settlements	settlement-polygon	city, town	500 м	
		village, hamlet	100 м	
	settlement-point	village, hamlet	100 м	Except laying inside settlement-polygon layer

IFLs & Intact Forest Tracts

56,6%
29,4%
8,1 %

Legend (Условные обозначения):
- Границы регионов
- Населенные пункты
- Автомобильные дороги
- Железные дороги
- Территория исследования
- Береговая линия

Категория МЛМ
- 1
- 2
- 3
- 4
- 5
- 6

Coordinate System: Central Russia Albers Equal Area Conic
Datum: WGS 1984; central meridian: 45,0000
Топографические данные © участники проекта OpenStreetMap, ODbL
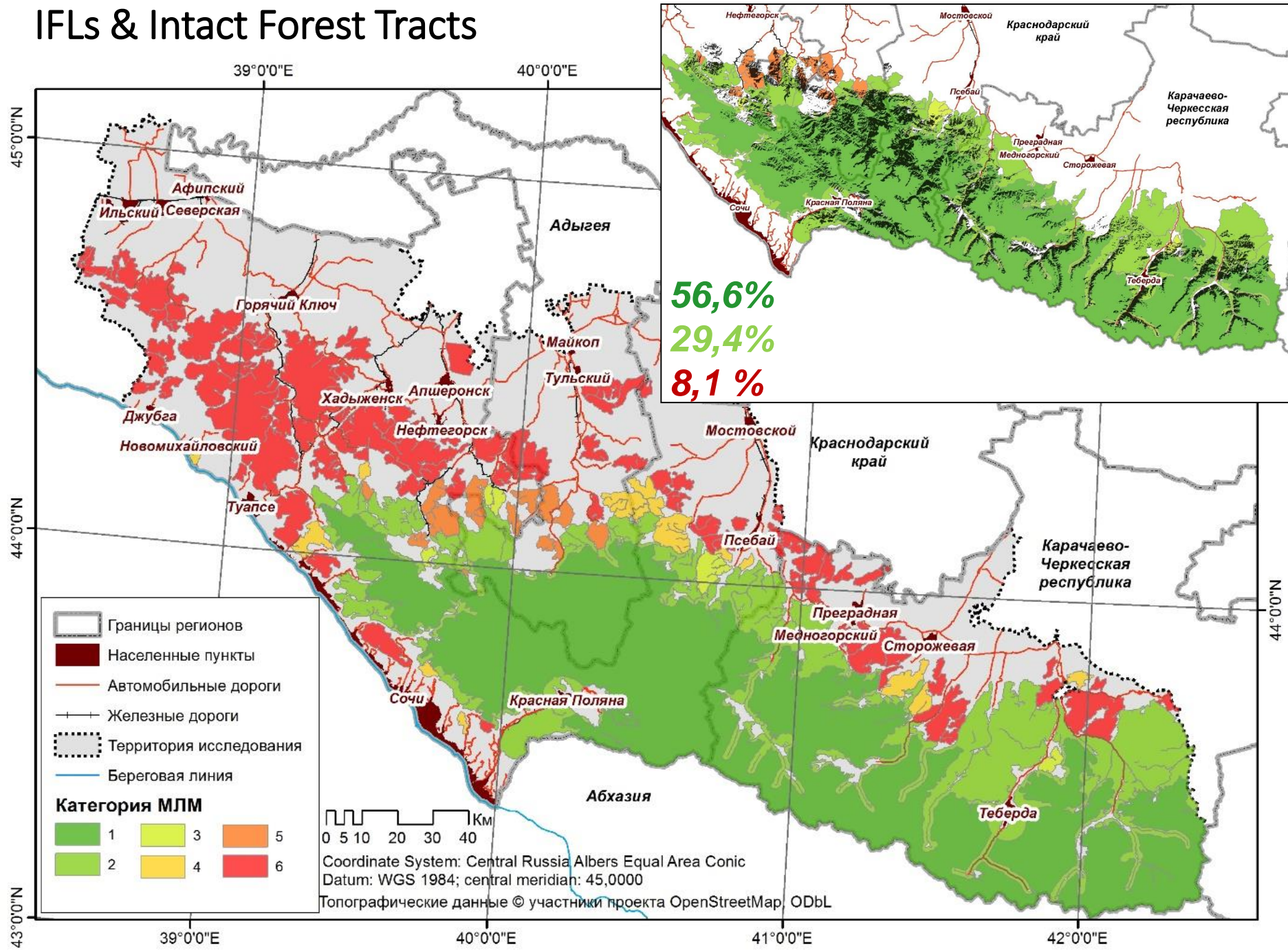
Conclusions

1. Fir forest map: accuracy of NeRIS = 96%; fir canopy share map: accuracy of NeRIS = 72%. Total area of fir forests - 237 Kha; 12% of all forest of the region.

2. Spatial analysis based on fir forest map and SRTM: fir forests are mostly located on north and west slopes over 30˚, elevation 1300-2200 m above s.l.; optimum elevation – 1600-1900 m above s.l.

3. Lower-level syntaxons can be defined with Random Forest algorithm; accuracy (subassotiation level) = 94%, accuracy (variant level) = 86%. Syntaxons are detailly characterized with RS data.

4. 57% of fir forests are located within IFL and 29% - within IFT.

Data & Methodology

1. *http://intactforests.org/data.ifl.html* - IFL layer

2. Fir forest layer

3. Intact Forest Tracts

4. Syntaxonomy data

5. Methodology is partially published in Russian

Follow up

1. Publications (?)

2. Fir forest layer – should be published at hcvf.ru

3. Intact Forest Tracts – should be published at (?)

Thank your for attention!

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