



# GIS-analysis of ground transport accessibility of fire stations at regional scale

Ekaterina Podolskaia , Dmitriy Ershov , Konstantin Kovganko

*Centre of Forest Ecology and Productivity, Russian Academy of Sciences (CFEP RAS)*

<http://cepl.rssi.ru/en/>



# Introduction



- Fire-chemical stations play a key role to organize an access and to extinguish the forest fires in Russia
- Test region - Irkutsk region. One of the most dangerous regions of Russia in terms of number and area of forest fires detected annually (long-term datasets)
- Various aspects of transportation problem are considered on the example of the Irkutsk region
- GIS analysis serves as a continuation of our study *to create the shortest ground access routes* for the forest fires data, published in 2017-2019 (Podolskaia et al., 2017, Podolskaia et al., 2018; Issues of Forest Science, 2019)

# Knowledge on the topic



- There are examples of publications devoted to locate new fire stations in cities (Habibi et al, 2008, Wahab, Khayyat, 2014, Topolsky et al., 2016)
- Works on location analysis using various software products and GIS are known from Russian (Tarantsev, 2013, Tarantsev, 2015) and international (Canada, <https://resources.esri.ca/ann-stories/sustaining-canada-s-forests-using-spatial-analytics>, Liu et al, 2006) scientific and industrial practice

# Research goal and tasks

The purpose of the study is to analyze the ground transport accessibility of special equipment from the fire stations when moving to the forest fires by special transport (fire trucks)

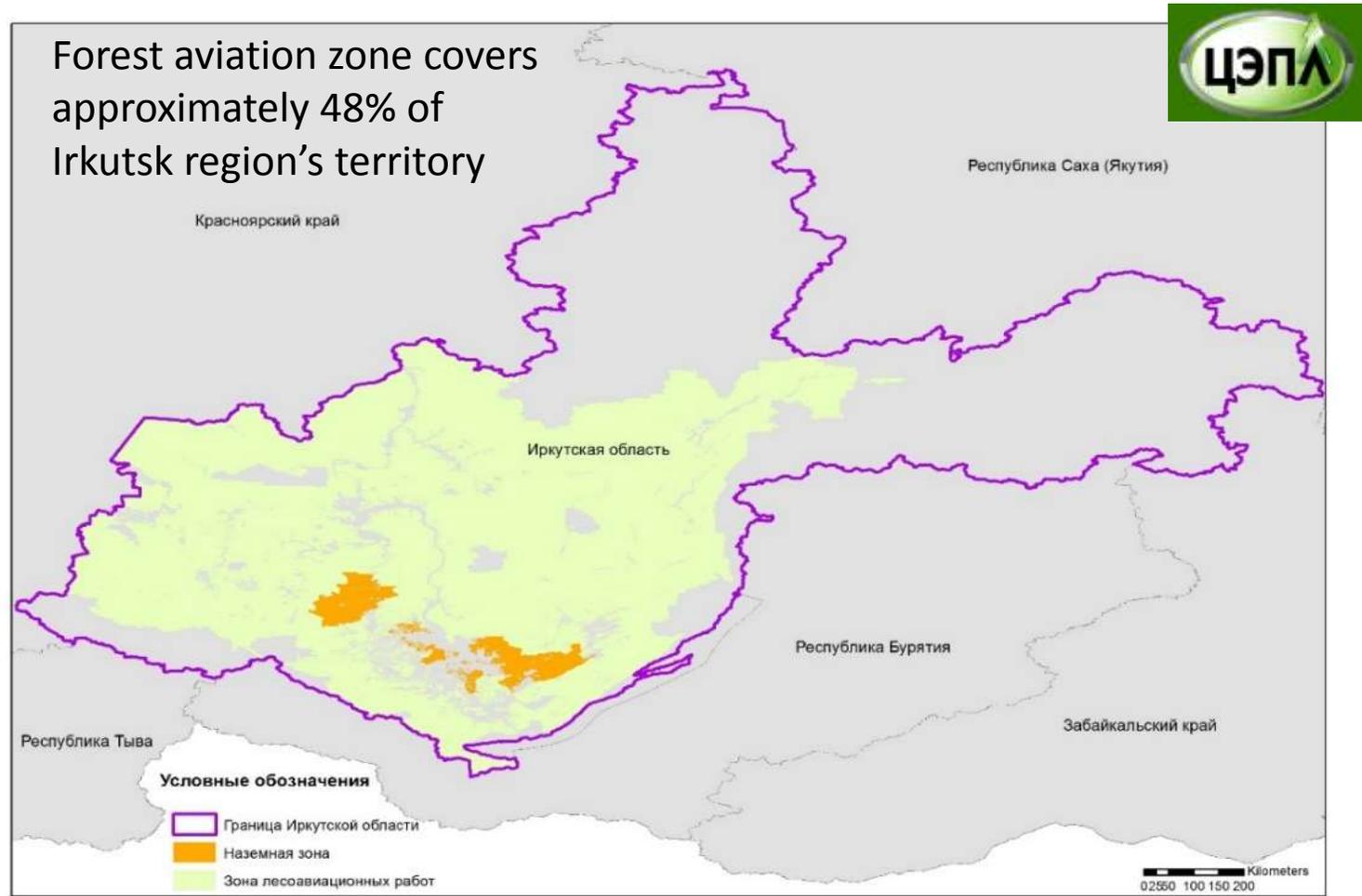
To achieve it, the following tasks have been formulated:

1. development of the most important criteria for evaluating the effectiveness of fire stations' location to organize an access to the forest fires,
2. evaluation of location for the existing stations for the forest fires detected by satellite methods, Irkutsk region, time period 2002 - 2017

# Test region



<https://tourout.ru/map/up/1948.html>



- Irkutsk region is characterized by a long fire hazard season
- Fire season in the region varies from 140 to 160 days, from the beginning of May to November

# Research methodology



Parameters of GIS analysis to evaluate the spatial location of stations at the regional level:

1. Characteristics of the road network: its presence, length and density of roads.  
Configuration of roads and geographical features of the region
2. Data on the detected forest fires: their number and spatial distribution relative to the fire stations (time period to group the data is the full fire season)
3. Service area of fire stations: Russian standards to place the stations depending on the speed of special transport (forest fire trucks)

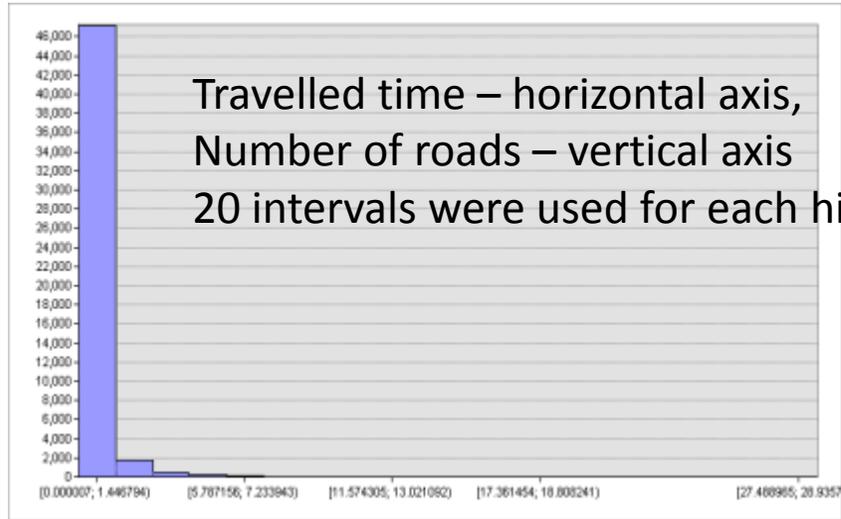
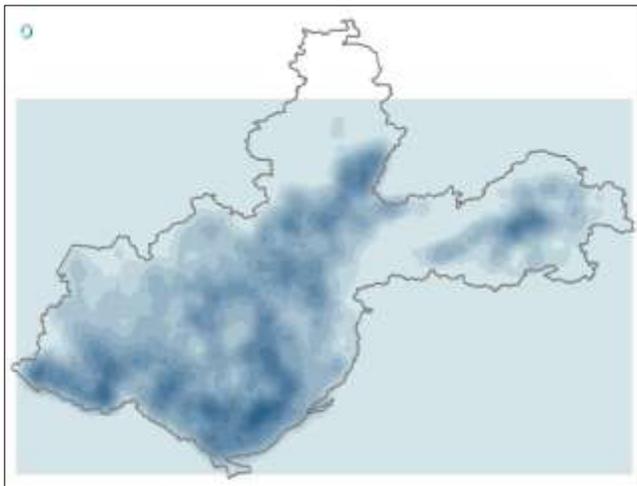
# 1: Characteristics of the road network: its presence, length and density



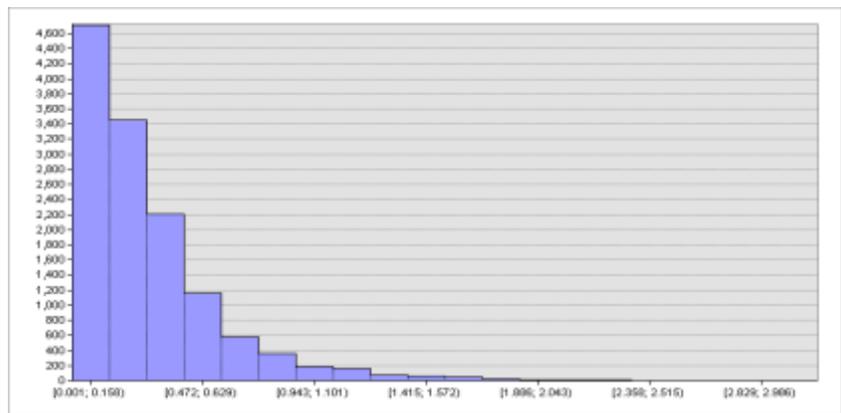
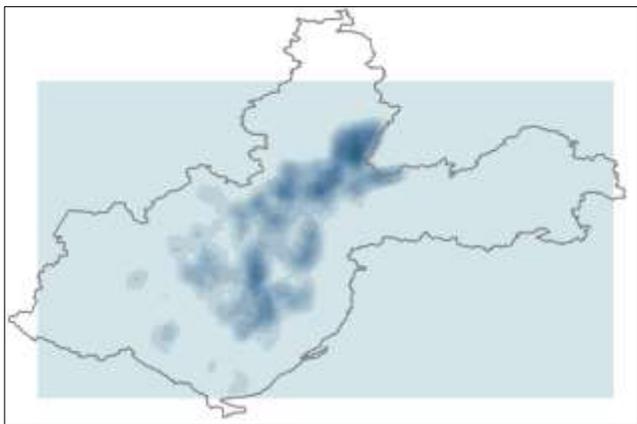
Roads by classes (geodatabase of 1: 200,000 scale)

Road type	Road density (km per km <sup>2</sup> )	Distribution of roads by the travelled time on road's sections
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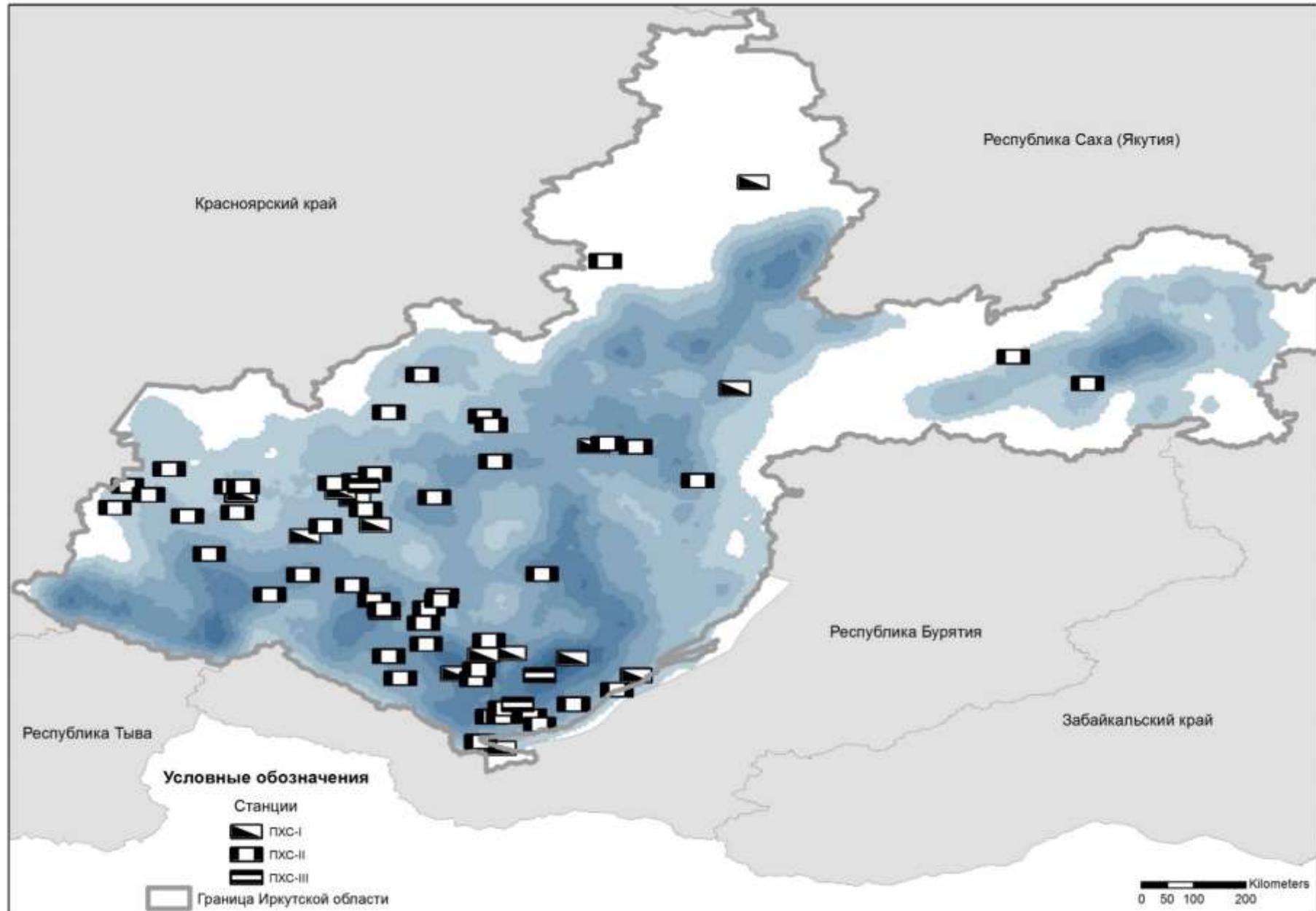
Roads of different types



Forest glades



# Roads density and fire stations: visualization at regional scale

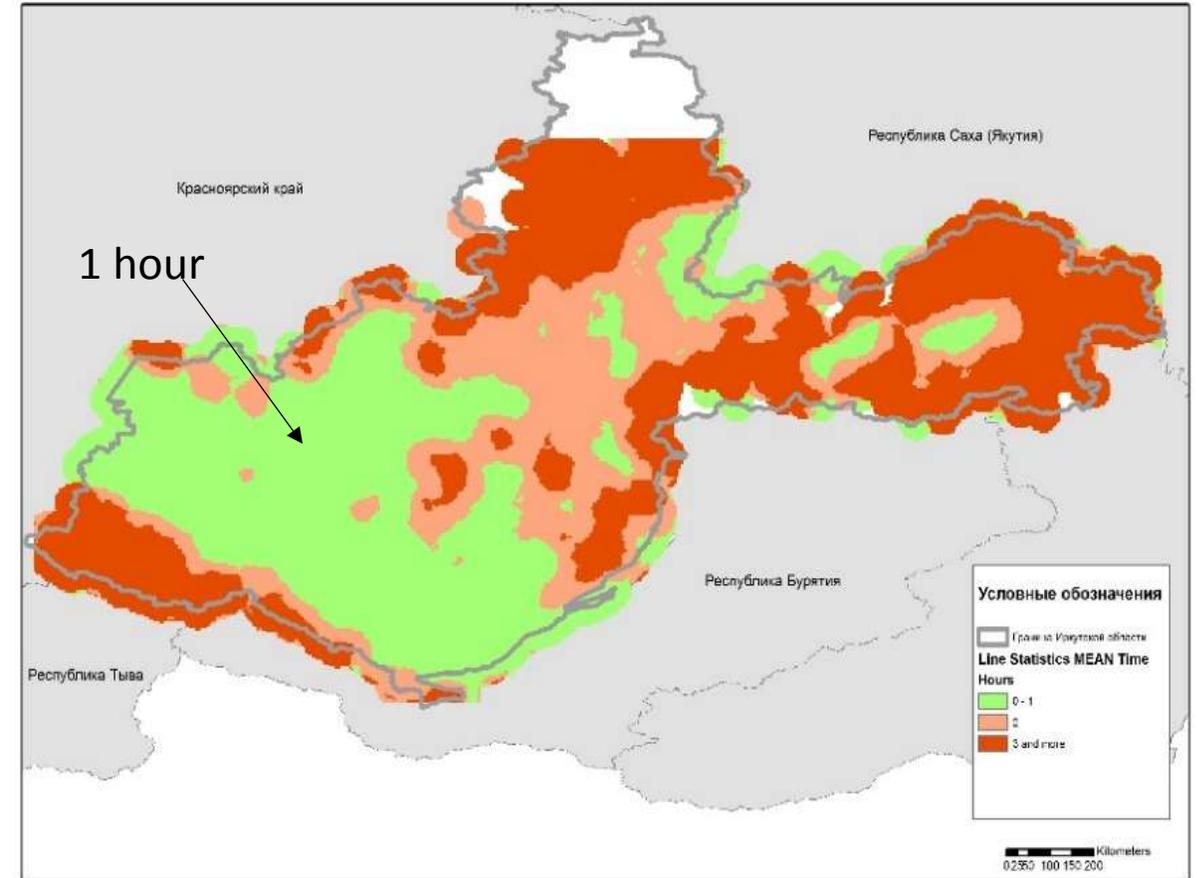
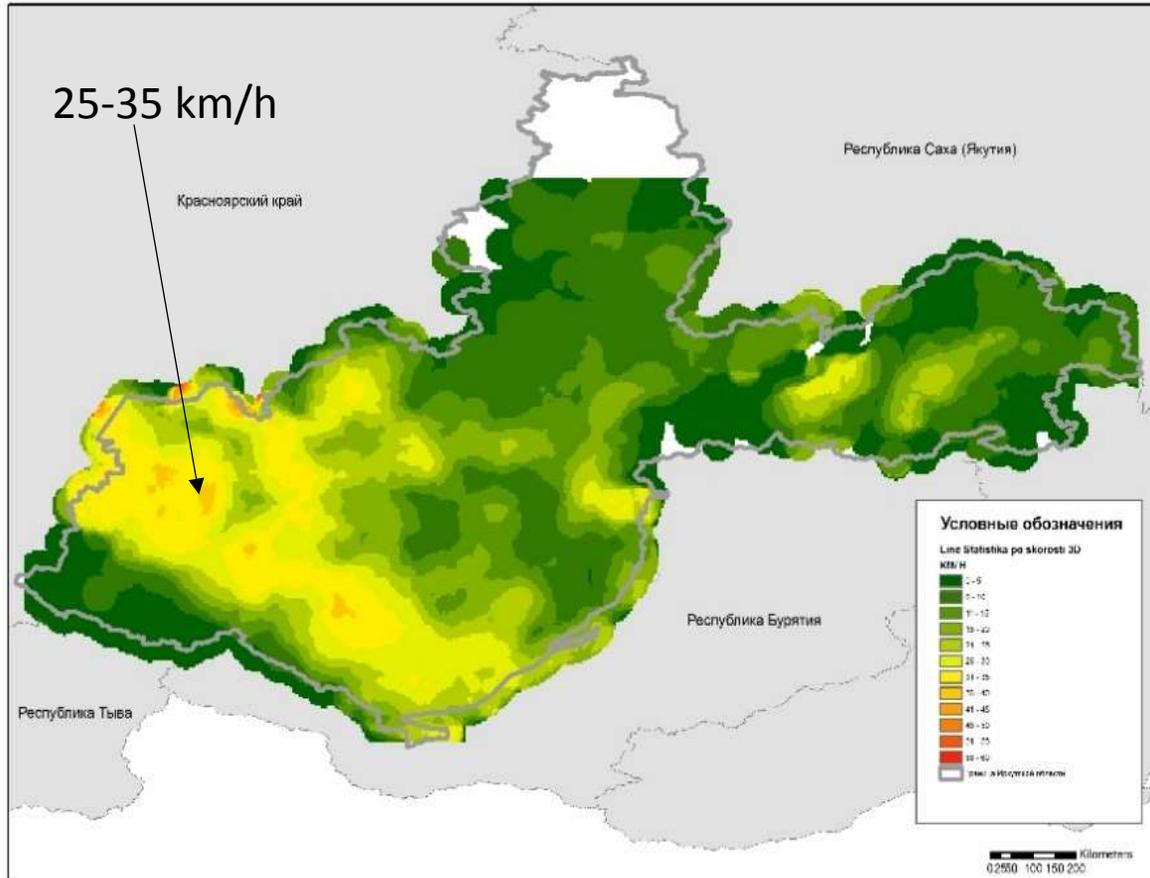


# Calculated values of roads speed, taking into account relief (a) and travelled time of special transport (b) across the Irkutsk region



Line Statistics (Spatial Analyst Tools/ Neighborhood)

Dataset: Roads of different types



60 km/h – maximum speed for a fire truck

(a)

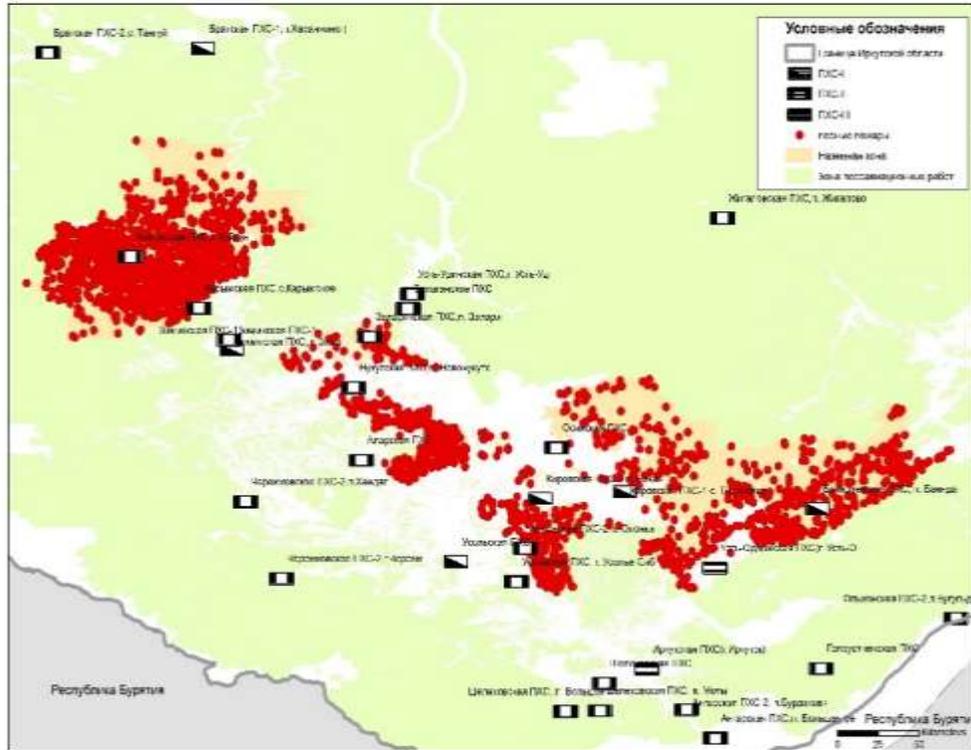
(b)

# 2: Data on the detected forest fires: their number and spatial distribution relative to the fire stations

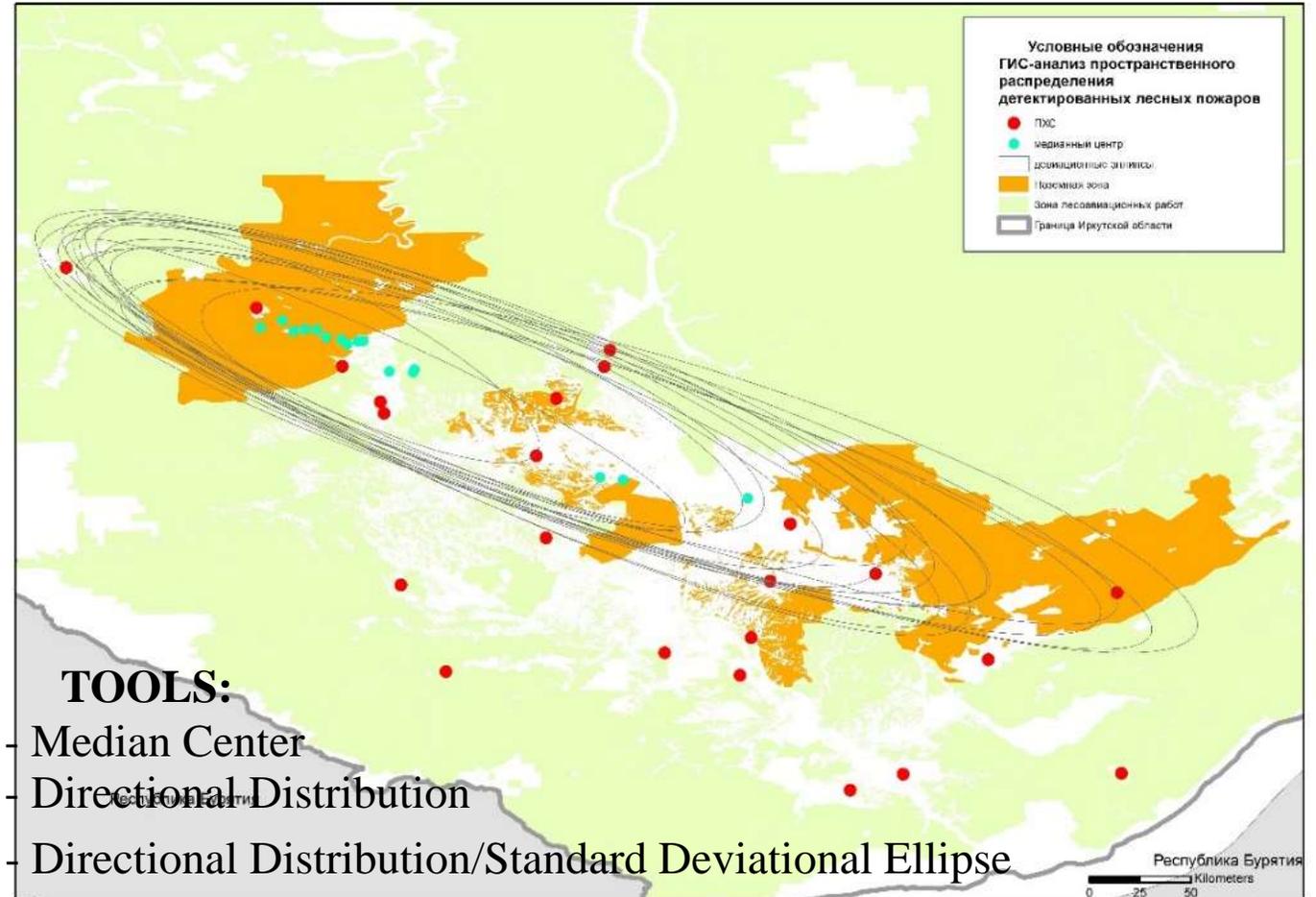


Spatial distribution of forest fires detected within the ground protection zone and fire stations

Analysis of the displacement of the center of the groups of detected forest fires and ellipses of their spatial distribution



Datasets: 2701 forest fires



### TOOLS:

Median Center

Directional Distribution

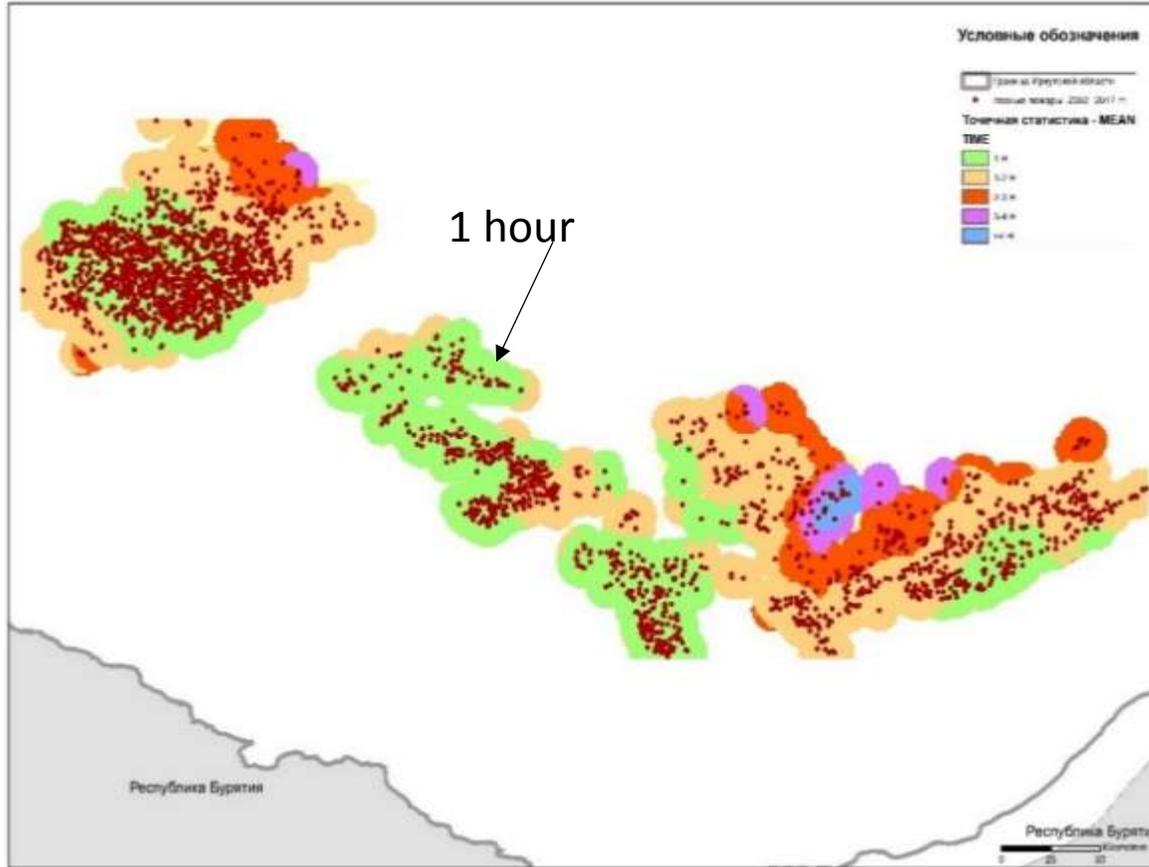
Directional Distribution/Standard Deviational Ellipse

# Estimated time of transport movement in hours (a) and route's length in km (b) within the ground protection zone

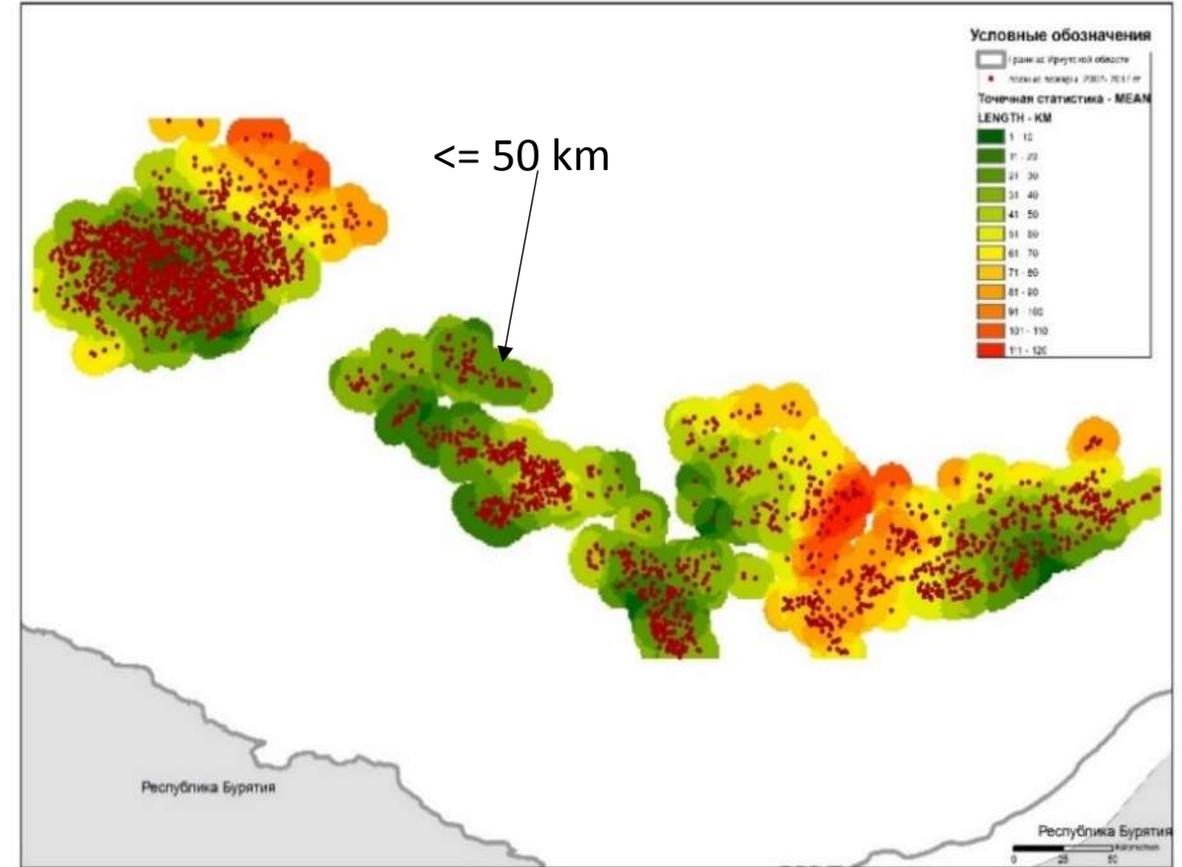


Point Statistics (Spatial Analyst Tools/ Neighborhood)

Datasets: 2701 forest fires, created routes



(a)



(b)

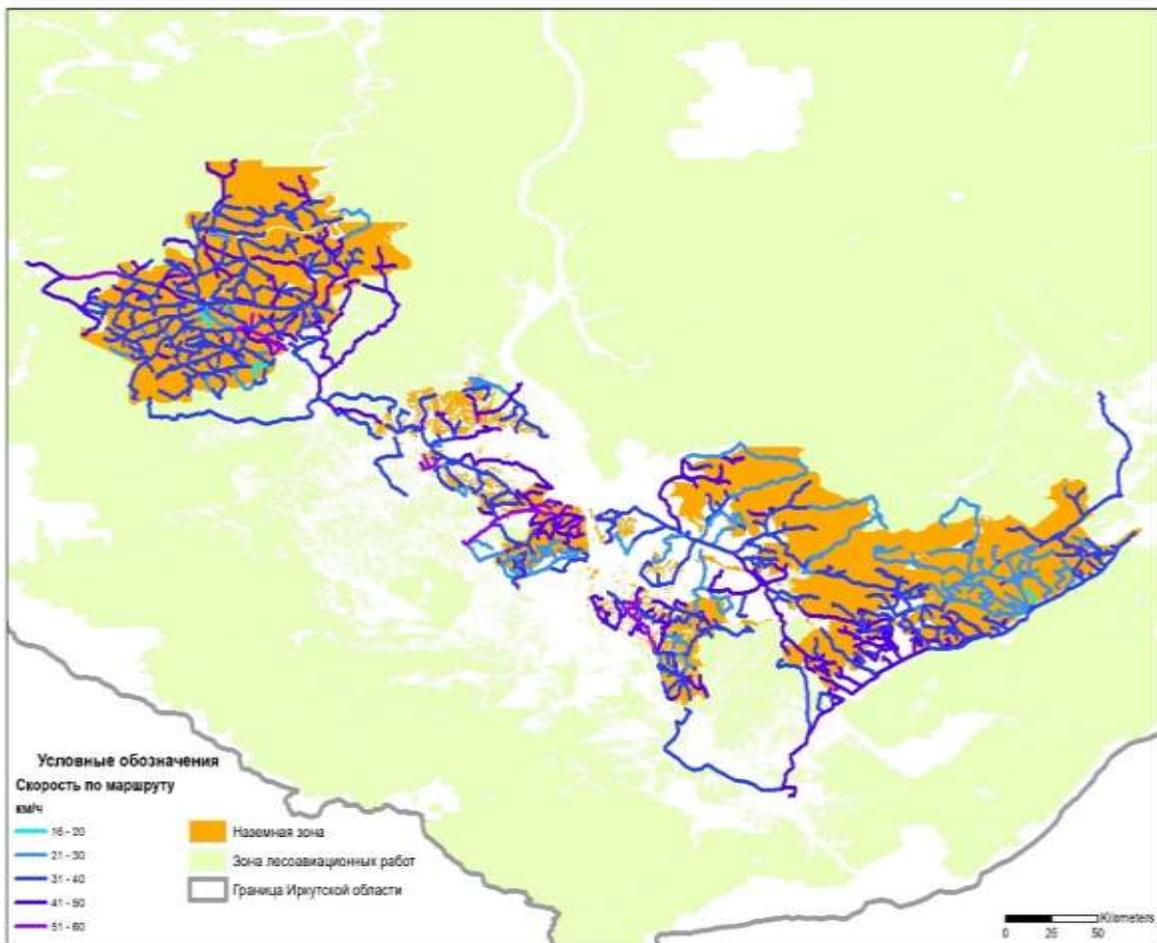
Value of raster cell - time to move along the route (a) and the route's length (b)



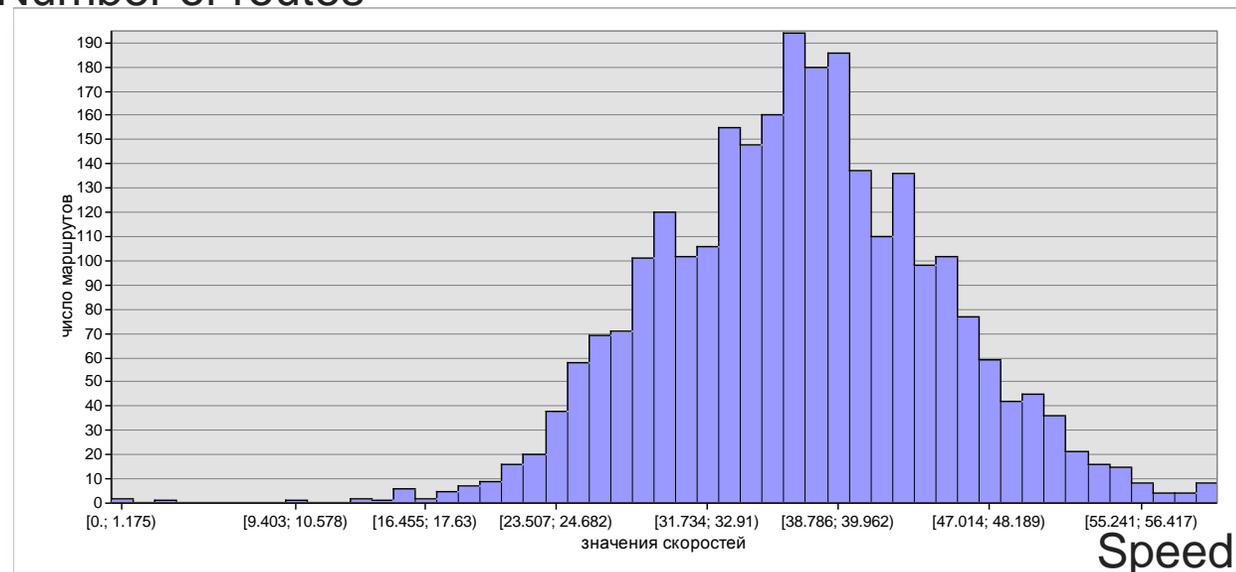
# 3: Service area of fire stations. Standards of stations location depending on the speed of special transport (forest fire trucks)

Paper for reference: Using of transport network model to estimate travelling time and distance for ground access a forest fire

Original Russian Text © 2019 E.S. Podolskaia, K.A. Kovganko, D.V. Ershov, P.P.Shulyak, A.I. Suchkov, published in Forest Science Issues [Vol. 2, No. 1, pp. 1-24](#). DOI 10.31509/2658-607x-2019-2-2-1-22



Number of routes



Histogram best corresponds to the intervals 25–30 km / h and 40 km / h

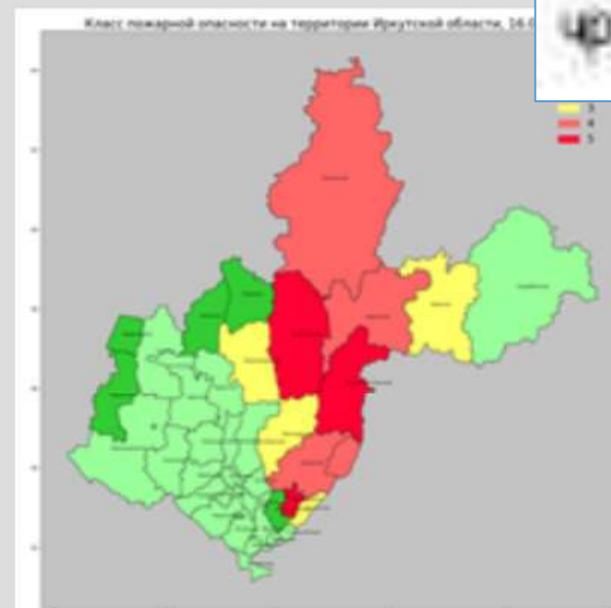
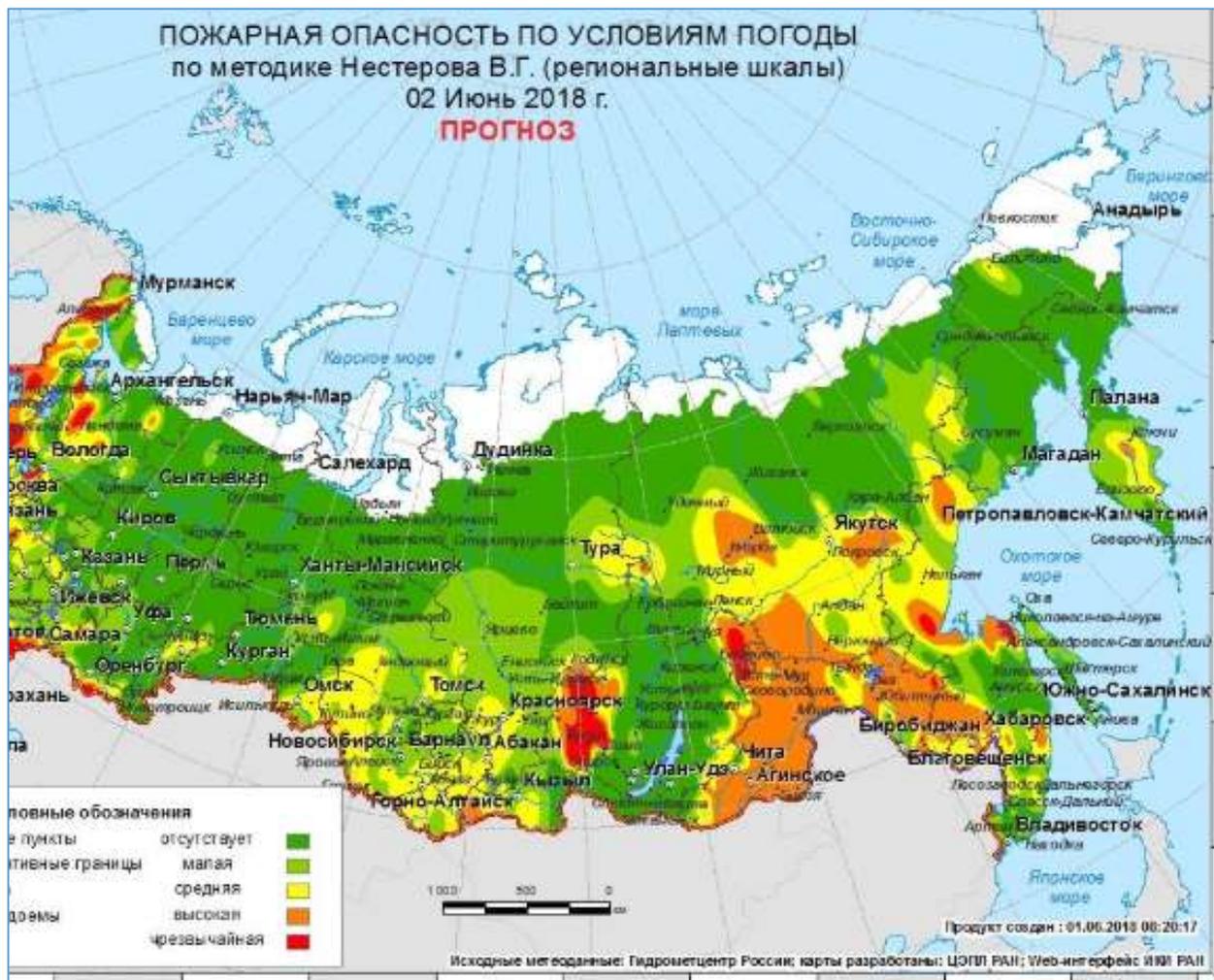
With such values of speeds, almost all detected forest fires were within the fire stations accessibility

*Our data: created access routes...*

# Russian standards: Fire hazardous classes



<https://nebezopasno.com/klassy-pozharoopasnosti-lesov/>

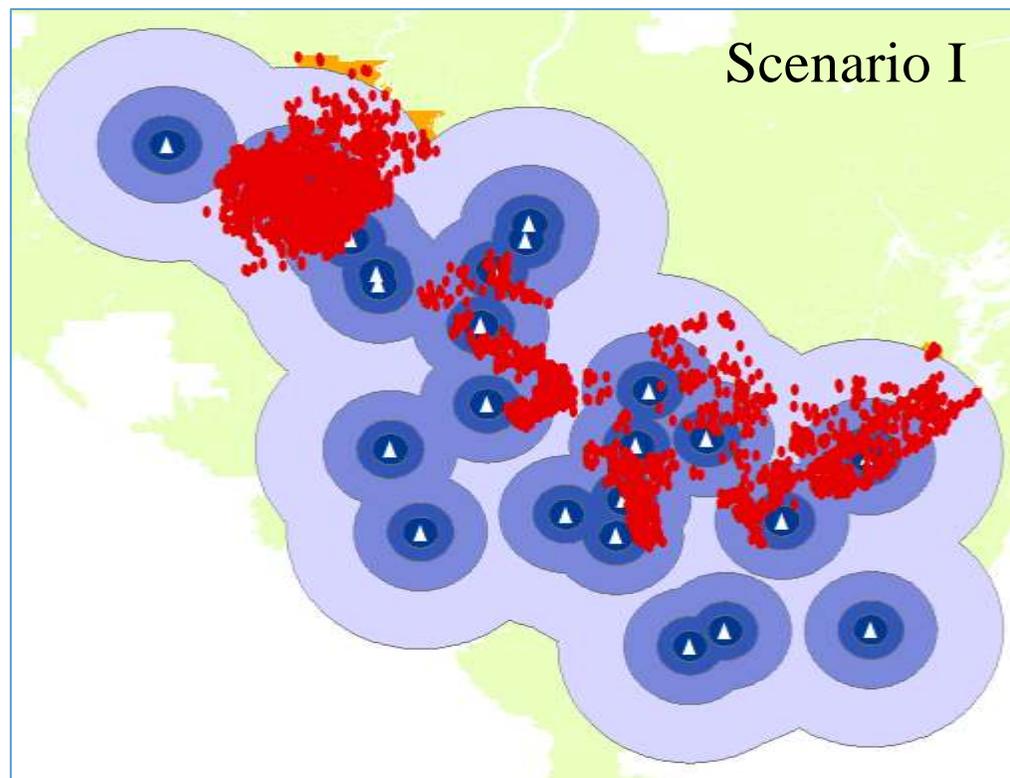


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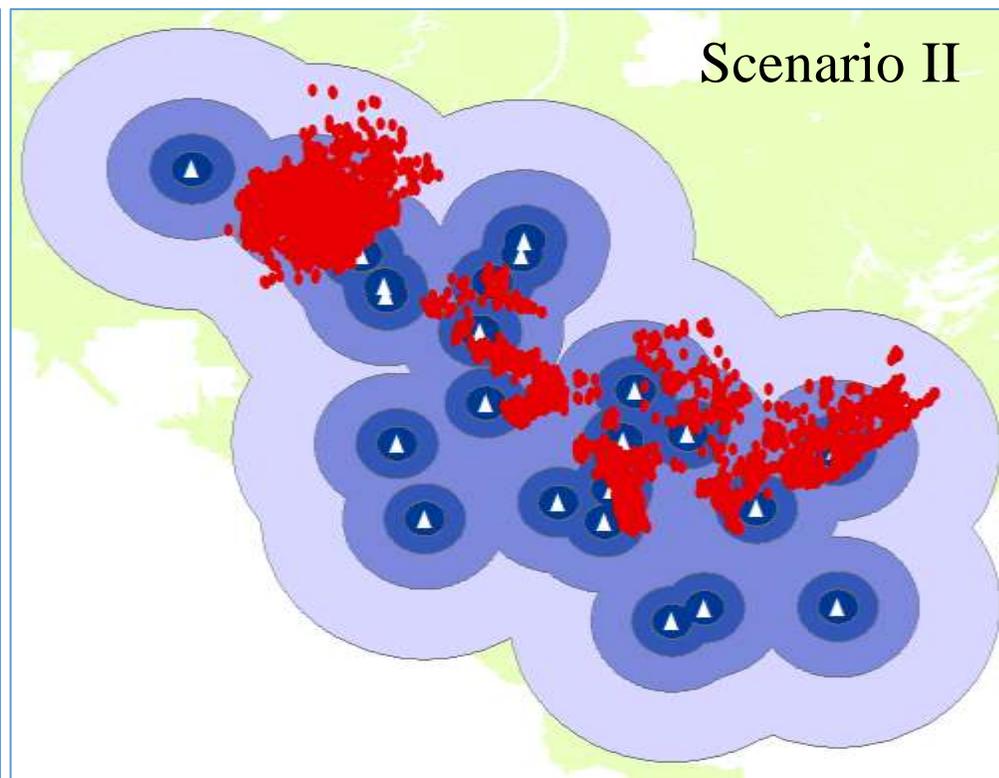
## Service areas for the stations depending on the fire hazardous classes (5 values)

Average transport speed 25-30 km/h (\*)

Average transport speed 40 km/h (\*)



Scenario I



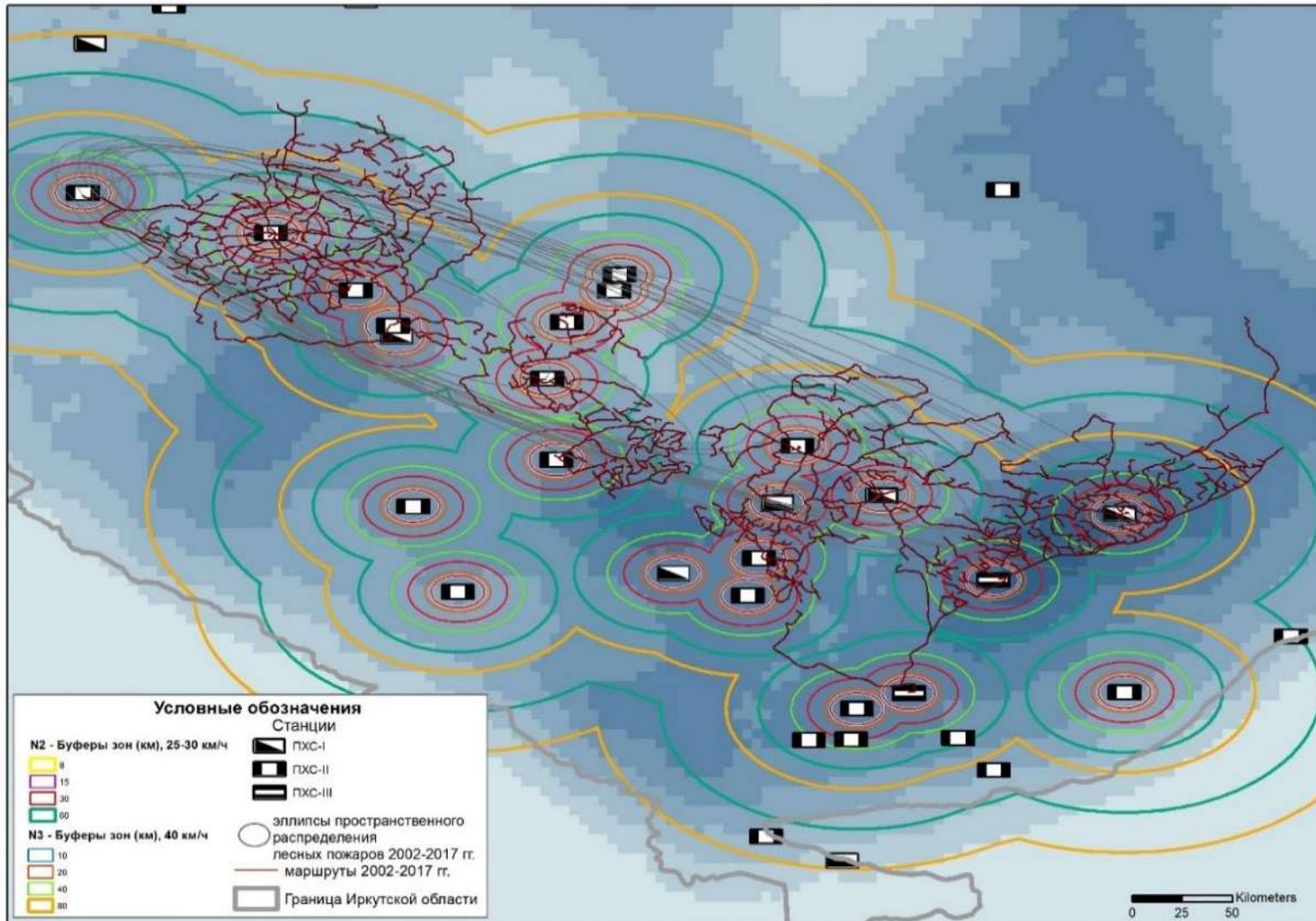
Scenario II

Buffers 8-15-30-60-60 KM

Buffers 10-20-40-80-80 KM

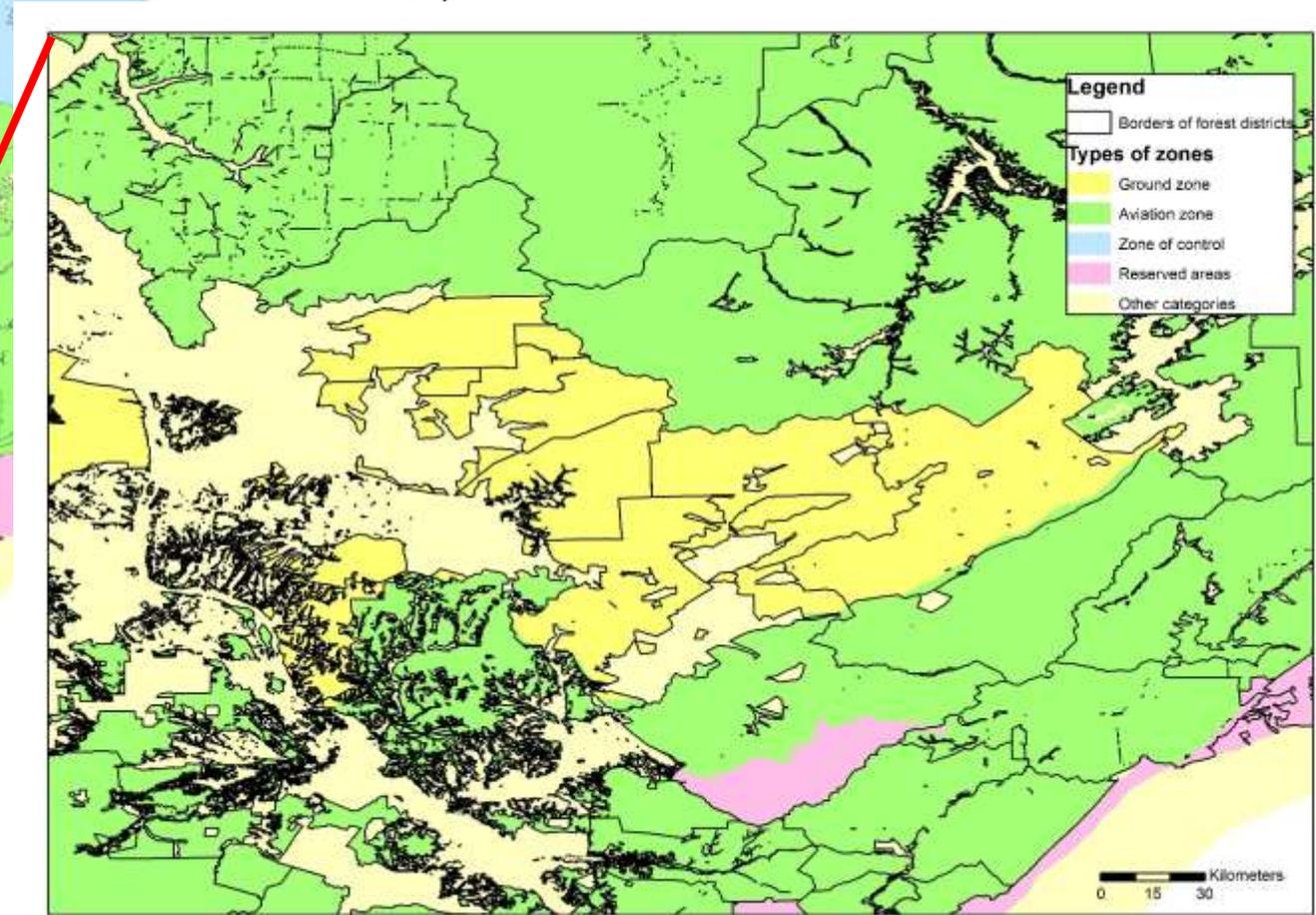
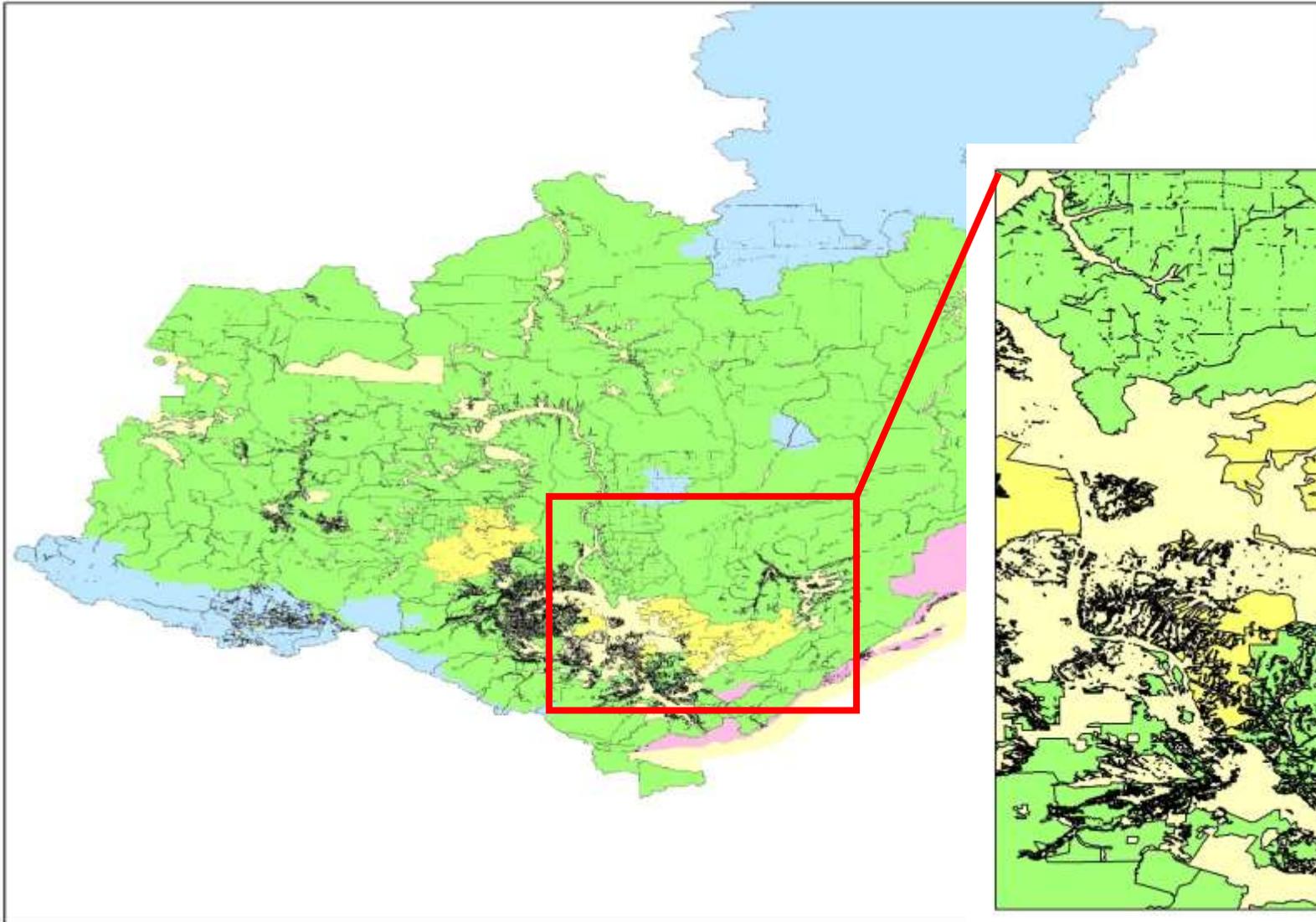
(\*) Data for the buffers values are from: Теребнев В.В., Артемьев Н.С., Грачев В.А., Сабинин О.Ю. Противопожарная защита и тушение пожаров (леса, торфа, лесосклады). Книга 6. М., 2006

# Assessment map of fire stations location (ground forest protection zone of the Irkutsk region)



- Figure shows a sufficient spatial dispersion of fire stations, covering the ground forest protection zone, located in the most inhabited part of the Irkutsk region
- Most of the forest fires are located within 60 km from stations. Created routes are within the 60 km access zone (speed 25-30 km / h)
- This result indirectly confirms the correctness of created routes  
(*Podolskaia et al., 2019*)

# Forest districts of Irkutsk region: spatial unit for future research



# Conclusions



- We have discussed the criteria to evaluate ground transport accessibility of existing fire stations by special firefighting vehicles
- Location assessment of fire stations for the forest fires detected within the ground protection zone in 2002-2017 was evaluated based on the datasets of Irkutsk region
- It is advisable to conduct an analysis of fire stations' placement as a preparatory step just before and after the end of fire-hazardous season to summarize the effectiveness of extinguishing the forest fires in the region
- Proposed analysis was based on the assumption that stations of all types have the same weight. Different weights can be attached to the stations types
- Additional factors of influence can be the location of protected natural areas with their access mode, state and seasonality of road use, economic criteria, placement of stations within the settlement , etc.

## Acknowledgements

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