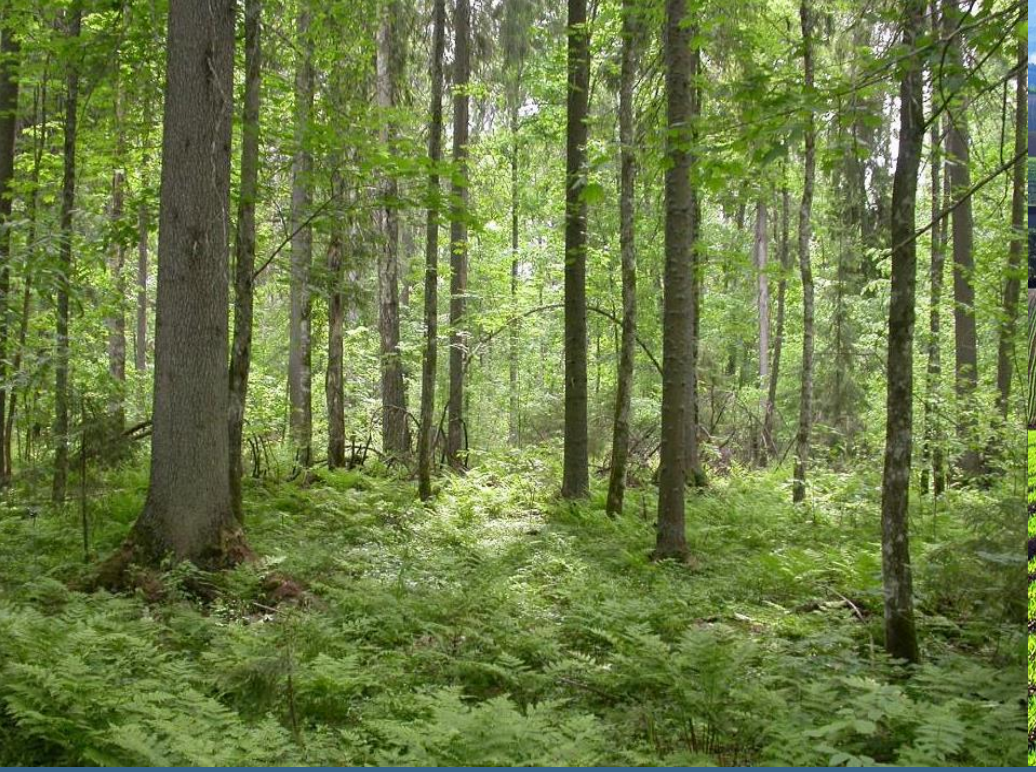

Assessment of stable land cover agroecological conditions using remote sensing data series. Implications toward soil biodiversity

Alexandr Krenke

Chief engineer, Ecomonitoring Agro Ltd

EC Monitoring Consulting
Forest, Agro & More

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Determination of soil biodiversity and land degradation on a regional scale can be considered as a task of identifying uniform contours of agro ecological conditions and related dynamics.

	Tasks	Possible solutions
Objective 	• Evaluate the actual state of soils and its resource potential for sustainable development of agriculture using remote sensing; • Create an information basis for decision making on land using appropriate to local conditions; • Understand of the dynamics of ongoing changes of soils and impacts of economic activity on soil conditions	• Establish relation between soil biodiversity and general agroecological conditions observable via remote sensing; • Spatial determination of different stable agroecological conditions and their internal dynamics; • Identification of agroecological differentiation spatial factors
Issues 	• High variability of soil cover due to human activities • Inability to measure biodiversity directly using remote methods • Insufficiency of field data	• Using remote sensing time series extended over decades. • Methods for processing multidimensional data arrays, determination of invariant states. • Usage of legacy data to improve understanding of observed conditions

“Reverse engineering” using Earth Remote Sensing

2

Earth Remote Sensing

Remote sensing data represents consumption, conversion and dissipation of solar energy. Its character depends on the state of vegetation cover, soil, climate, terrain, etc.

$E^{in}_{\lambda} = E^{SUN}_{\lambda} \cos\theta / \pi d^2$

θ_S

d

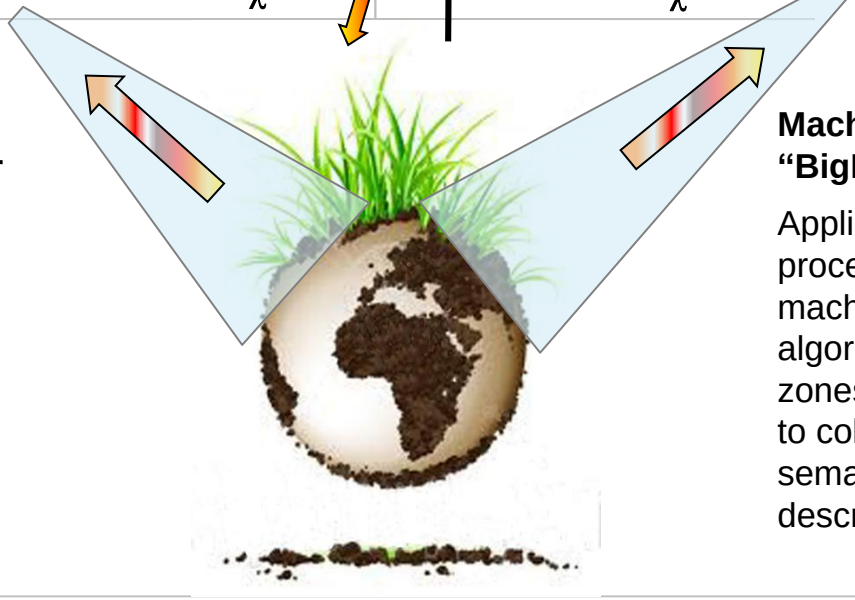
E^{out}_{λ}

E^{out}_{λ}

3

Long-term observation

Multi-year remote sensing data represents time series, describing state and behavior of an ecosystem. Its interpretation allows to determine its structure and functional characteristics.



1

Remote sensing as thermodynamic sensor

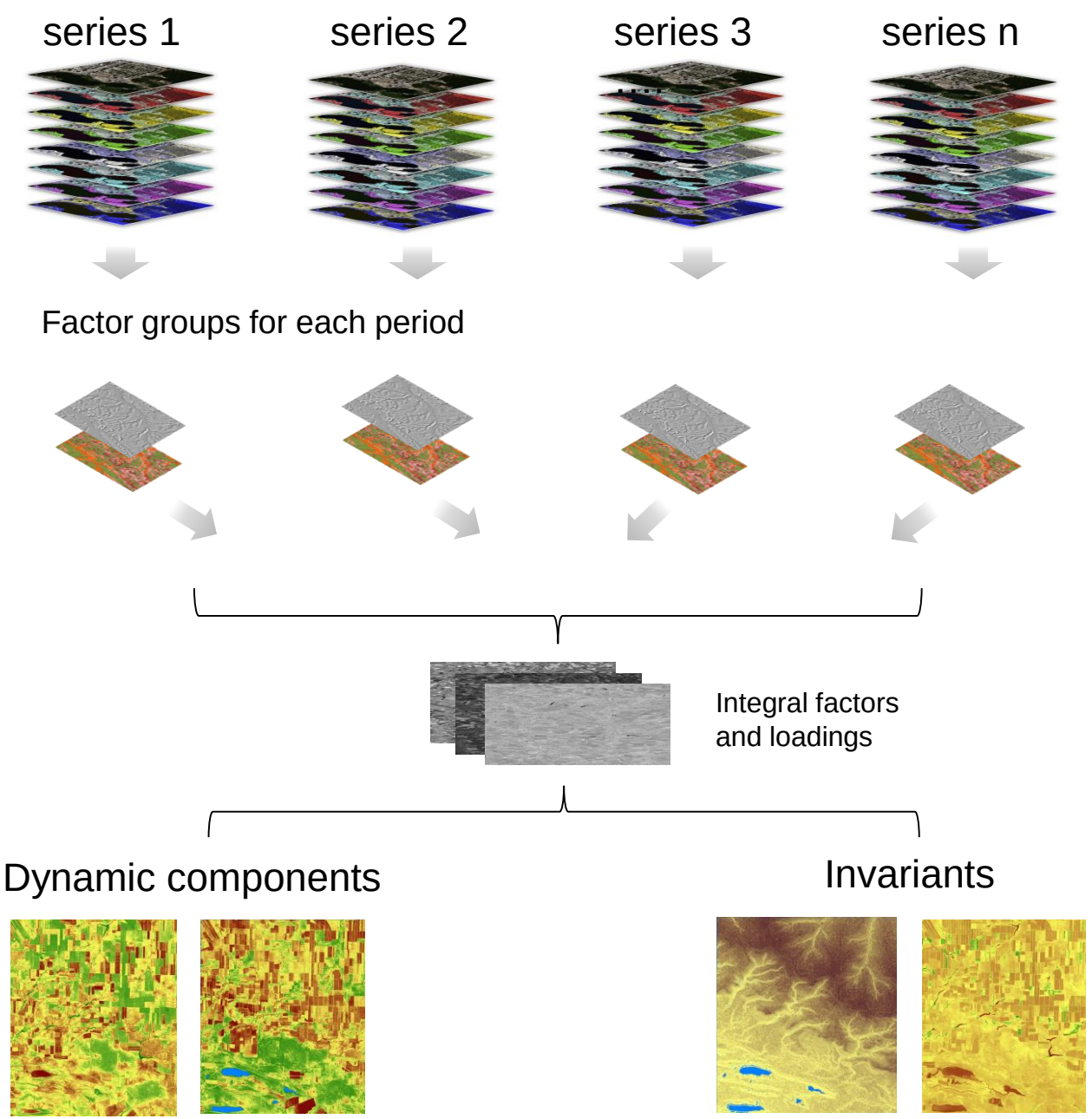
An ecosystem is treated as an open thermodynamic system described by the laws of thermodynamics and by information theory (fundamentals of system ecology)

4

Machine learning and “BigData”

Application of "big data" processing methods and machine learning algorithms allow to identify zones of homogeneity and to collate them with semantics of the described ecosystems.

Hierarchical factor analysis



Time series of multispectral data

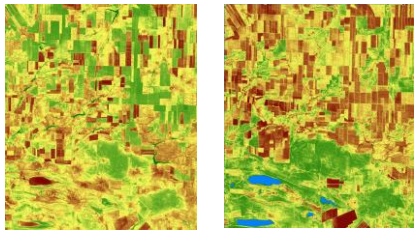
Factor analysis of each time series. Highlighting significant factors

Integral factor analysis of all significant factors

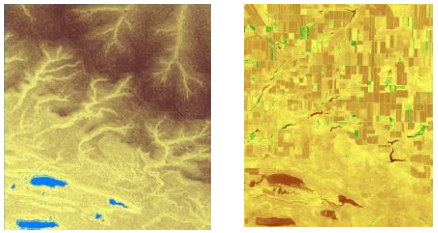
Division of significant integral factors into two groups:
Invariant / dynamic

Segmentation scheme and allocation of semantics of factor space

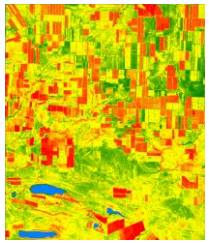
Dynamic components



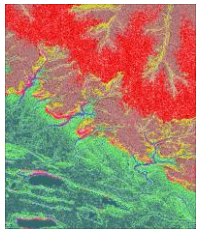
Invariants



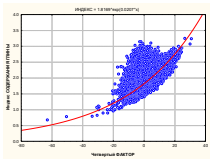
Invariant and dynamic groups of significant factors



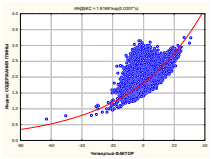
The number of classes is determined using the criterion of maximum entropy relative to the number of classes



Dichotomous k-means classification



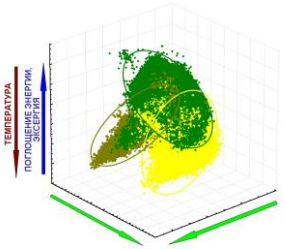
Revealing the "cores" of the classes obtained. Study of the unambiguity of classification in the space of factors and initial variables.



Discriminant analysis of the obtained classes in relation to the initial factors

relations

Physically interpreted indexes based on remote sensing data

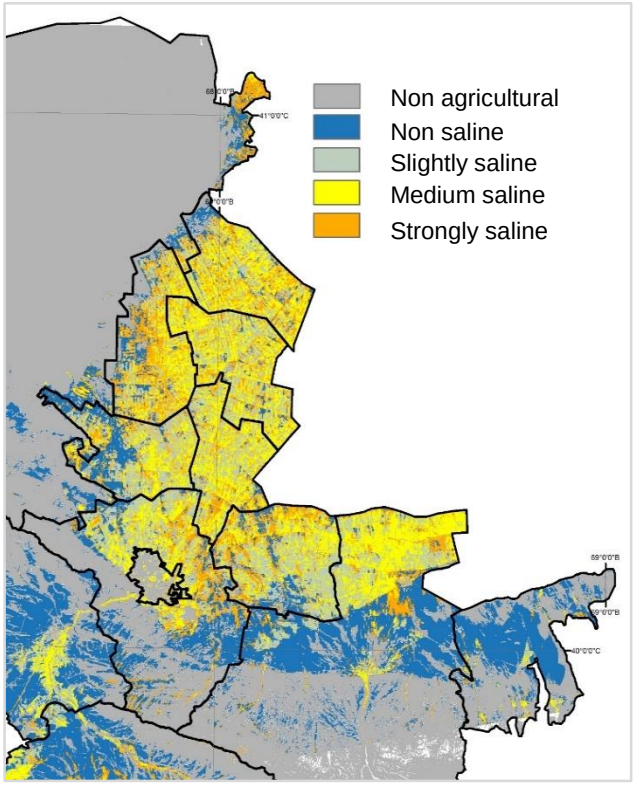


Field data, thematic maps

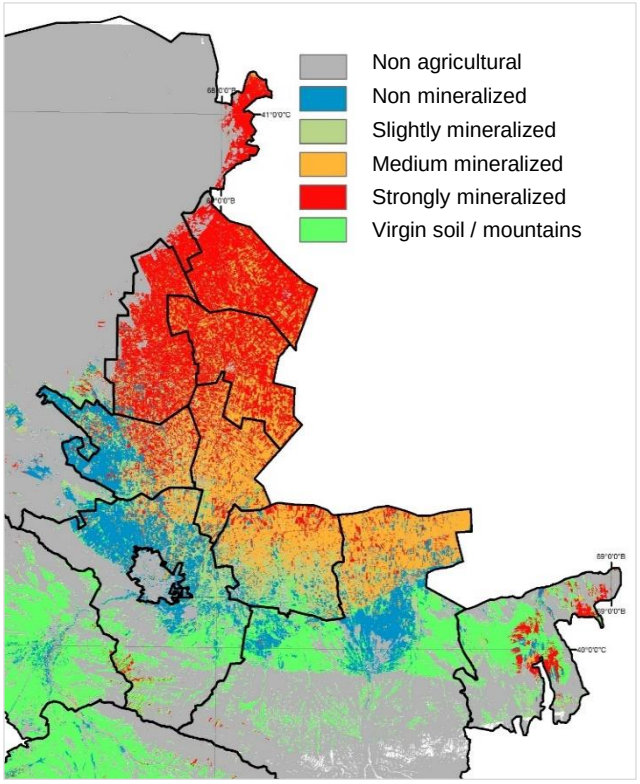
Semantic analysis of the obtained classes and factors. Interpretation based on field data and remote sensing indices

Factor interpretation using field data and remote sensing indices.

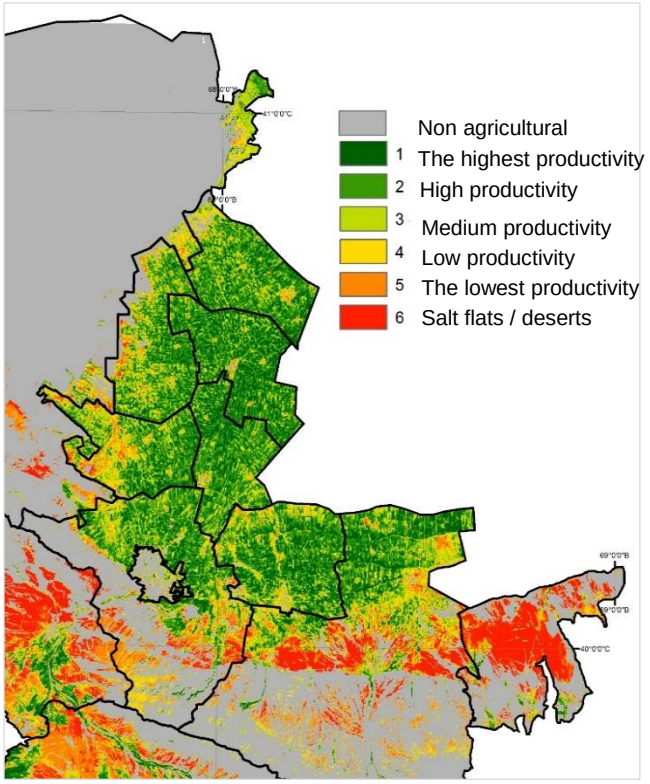
Salinity



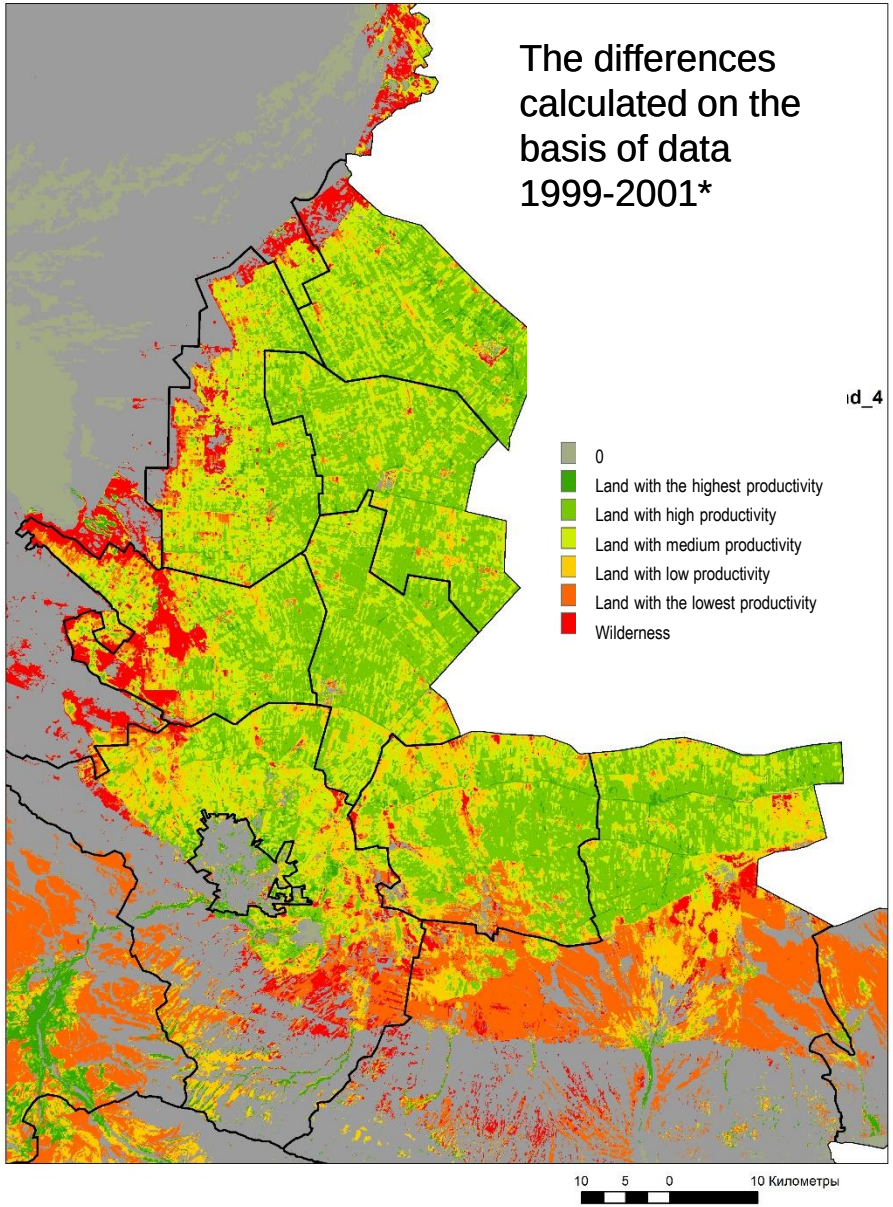
Mineralization

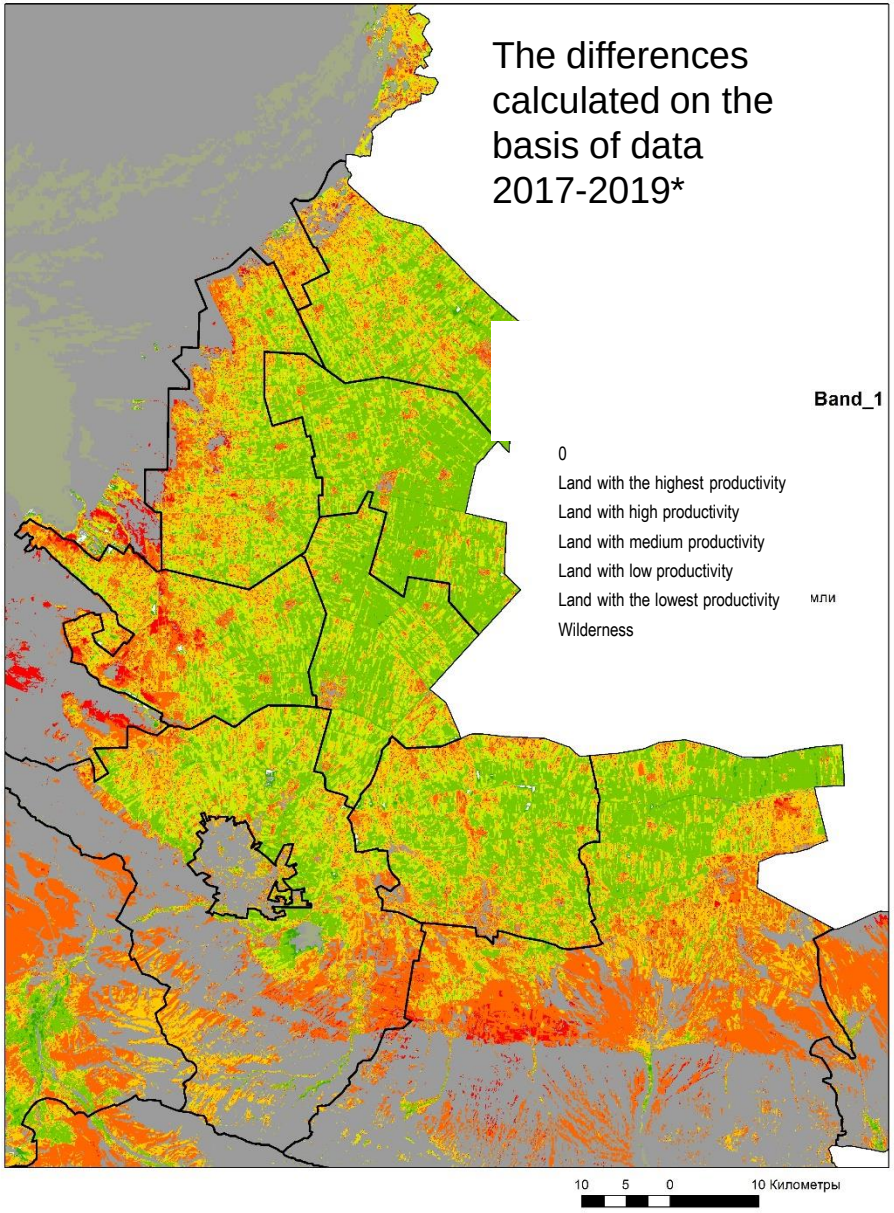


Median NPP

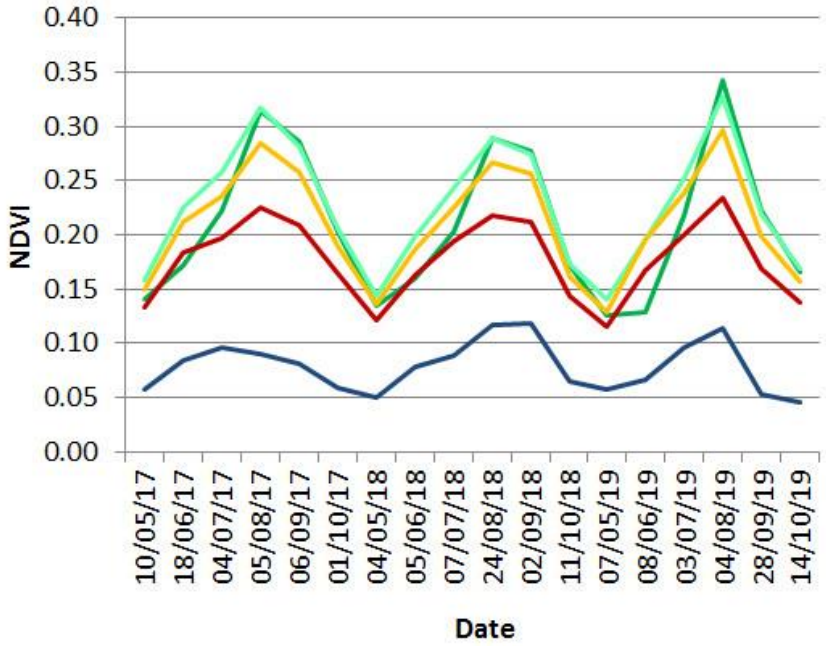


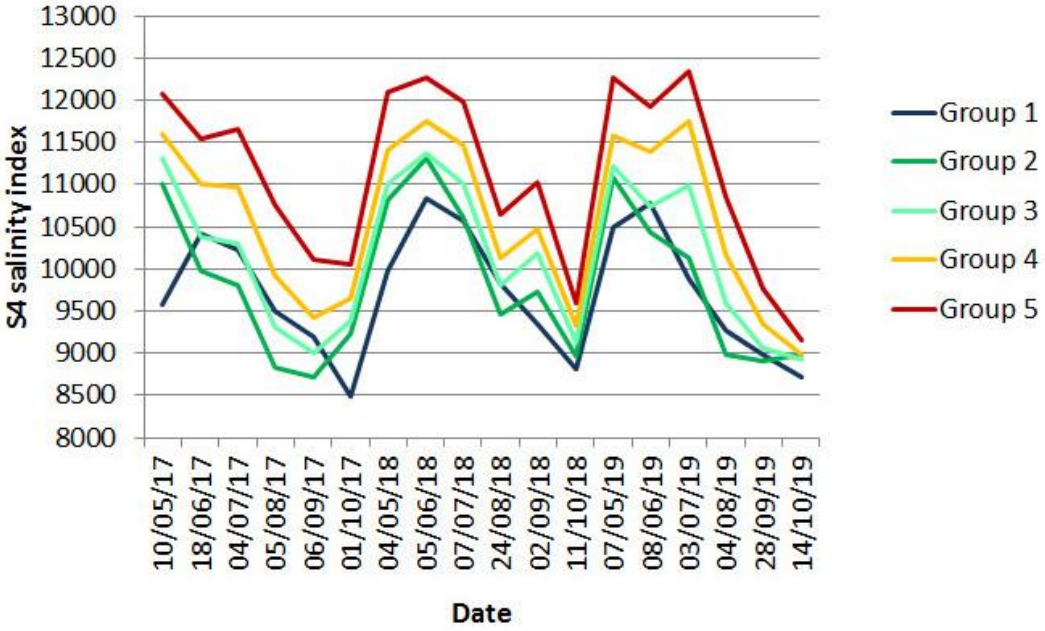
Agroecological segmentation dynamics





** - data from the project of assessment of agricultural lands in the Jizzakh region. Uzbekistan*





Stability of interpretable between groups measurements

The selected groups demonstrate stable behavior

It can be seen that, despite the dynamic nature of the variability of NDVI and S4 over time (i.e., by timing), the classes are organized in order, that is, the classes are not confused depending on the time of observation, while the overall variation is much greater than the variability within one period.

Determination of the stationarity of agroecological states

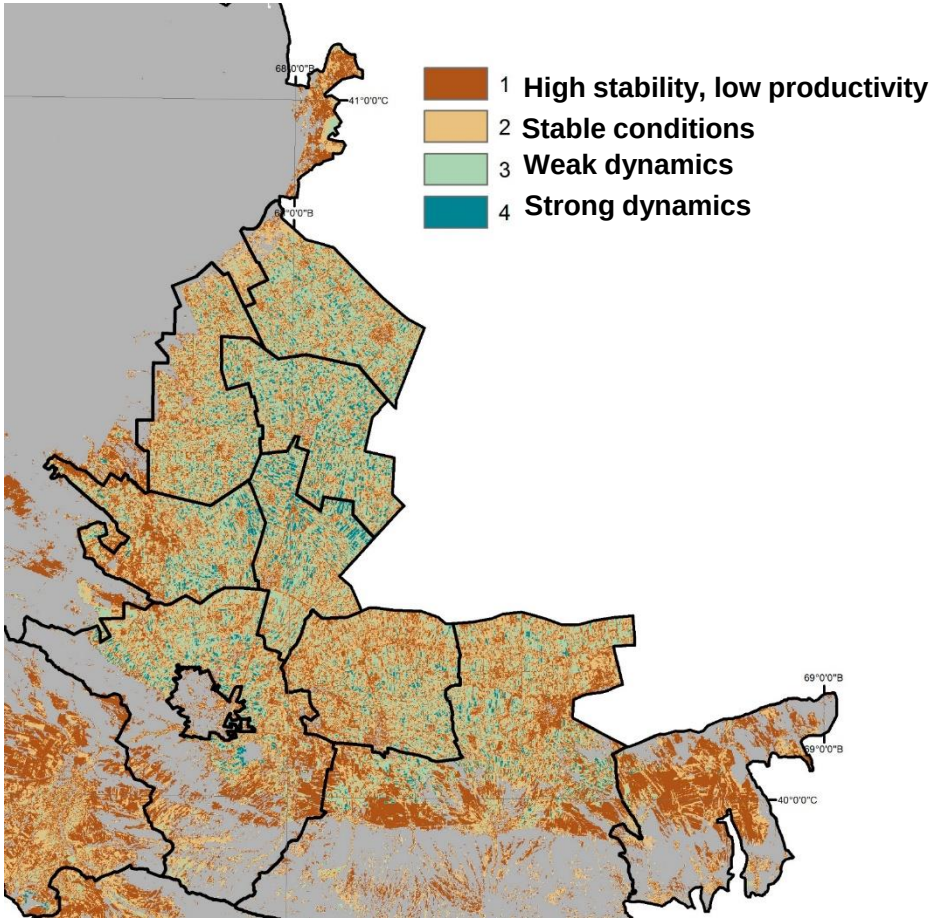
Discriminant analysis is used to identify the degree of stationarity of the identified states using the factor space for different periods of observation.

Percentage (%) of agroecological classes matches for different periods

2020 yy. time series classes	2000 yy. time series classes					
	1	2	3	4	5	6-7
1	71,9	13,4	7,9	3,5	,6	2,8
2	12,4	54,6	25,5	6,0	1,0	,5
3	5,9	35,6	41,0	13,0	2,2	2,3
4	1,8	5,2	15,3	46,2	19,5	12,0
5	0,4	1,3	3,2	14,5	69,3	11,2
6-7	0,7	1,6	5,7	8,4	18,9	64,7

- The same class for the whole period of observation
- Transfer to the next lower class
- Transfer to the next upper class

Stationarity of agroecological states



Conclusion

The presented results show the possibility of identifying stable agroecological conditions in the territories of the regional scale.

The allocated states are in the space of interpreted invariant factors.

Using time series of remote sensing information divided into periods, it is possible to observe the transformation of agroecological conditions and changes in the factor space.

Although the proposed methodology is not a direct means of monitoring soil biodiversity, the identified states can be considered as a “space of conditions” and serve as a basis for extrapolation in the highly variable soil cover environment of agricultural areas.

ECO monitoring, Llc.

E-mail: info@eco-monitoring.org

www.eco-monitoring.org

ECO Monitoring Consulting
Forest, Agro & More