

# **Baseline assessment of ecosystem services in respect of remote information, terrain digital models and field values**

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## **Summary**

Methodical basis is stated of the baseline assessment of ecosystem services in respect of multispectral remote information Landsat TM and terrain digital model ETM+ with the 30 m resolution and field values. As the model territory to estimate ecosystem services it is offered to use low-disturbed territories having scientific and research infrastructure – conservancy areas and reserves. Computation of energy balance and energy features components by remote information allows estimating set of supporting and regulating services: exergy, bound energy, enthalpy, net production index and other services connected with landscape regulating mesoclimate.

Terrain influence on the regulating services is estimated by the terrain digital model. For such valuations, the terrain is divided to separate variables for different levels of the hierarchic organization – morphometric definitions. The definitions and their classifications allow marking surfaces with various levels of humifying and solar radiation coming – the basis to estimate cost of providing direct and oblique services. Productivity, humidity, temperature of the active surface and other dimensional characters estimated by data of remote sensing are the function of vegetation, terrain and lithology. Estimation of dependence of these dimensional characters on terrain features at the various hierarchic levels of organization gives their potential values on the hypothetic surface devoid of vegetation.

Direct measurement of vegetation properties and soil with exact georeference give assessment of providing and regulating services. Evaluation of their state is built on the basis of statistic models connecting results of field measurements with remote information and terrain features. The possibilities are

demonstrated to estimate supplying services, for example, power of humous and organic horizon as the key figure of carbon stock, stand and projective cover of berry beds. Also, the possibility is shown to estimate quality of habitat for hunting and commercial species and the common species land capacity on the basis of remote data, terrain features and field consideration of animal traces.

## **Abstract**

### **1 Introduction**

Quantitative aspects of various functioning forms of each component of ecosystem are the part of the basis of ecosystem service assessment. The component is described via its properties or functions. Set of these functions is defined by current ideas on set of services able to render by the component. A property measurement is held in physical units of energy, mass, entropy (variety), density, quantity and so on. These assessments could be defined as “basic assessments of natural ecosystem services”. They should be built for various hierarchic levels and give the basis for integral and differential assessments. The model territories with low-disturbed properties of environment and infrastructure and conditions for scientific and research works – conservation areas and reserves should be the basis for the baseline assessment of natural ecosystem services. The assessments obtained for the model territories could be extrapolate to economic regions with the same natural conditions. Transition from the baseline assessments to assessments of the services themselves supplying search of optimal decisions to use recoverable and related resources and conditions is the great challenge within ecological economy.

The research was held on the territory of the Central Forest State Nature Biosphere Reserve located in the western part of the Valdai Hills (Russia), in the boreal zone (32°53'E, 56°46'N). On the territory of the reserve, the researches had been conducted for already more than 70 years. The landscape properties are in many respects unique (moraine ridge height with boreal spruce and

complex spruce forest in a combination with bogs, windfalls, cutover patches and fields), create a basis for comparing properties of various types of surface and their territorial combinations.

Baseline assessment of the ecosystem services for various scales is possible only on the basis of remote sensing data and the terrain digital models. Variety of the remote sensing data creates all conditions for its use as the tool to measure the main functional features of the landscape cover. Ecosystem thermodynamics (Jorgensen, Svirezhev, 2004) opens the new level in using remote information. The remote data use aimed at the thermodynamic analyses of ecosystems allows estimating constituents of ecosystem energy balance and evaluating scale of regulating the mesoclimate by it. (Sandler'skiy, Puzachenko, Kozlov, 2007). Technologies of the hierarchic organization analyses and computation of morphometric features give the possibility to estimate variation of the terrain properties and lithologic content of rocks for various scales. For already a few years on open access, there have been DEM with the spatial resolution from 90x90m practically for the entire world (GTopo, SRTM), which considerably simplifies developing. And finally, it is recognized that development of technologies to collect field data (new ware and techniques), which together with development of analyses new ways (discriminatory analyses, neuron nets) establishes good opportunities to chart properties of the landscape cover measured afield.

## **2 Baseline assessment of ecosystem services**

Figure 1 shows the taxonomy scheme of the main ecological services with comments, briefly describing methods of their estimation.

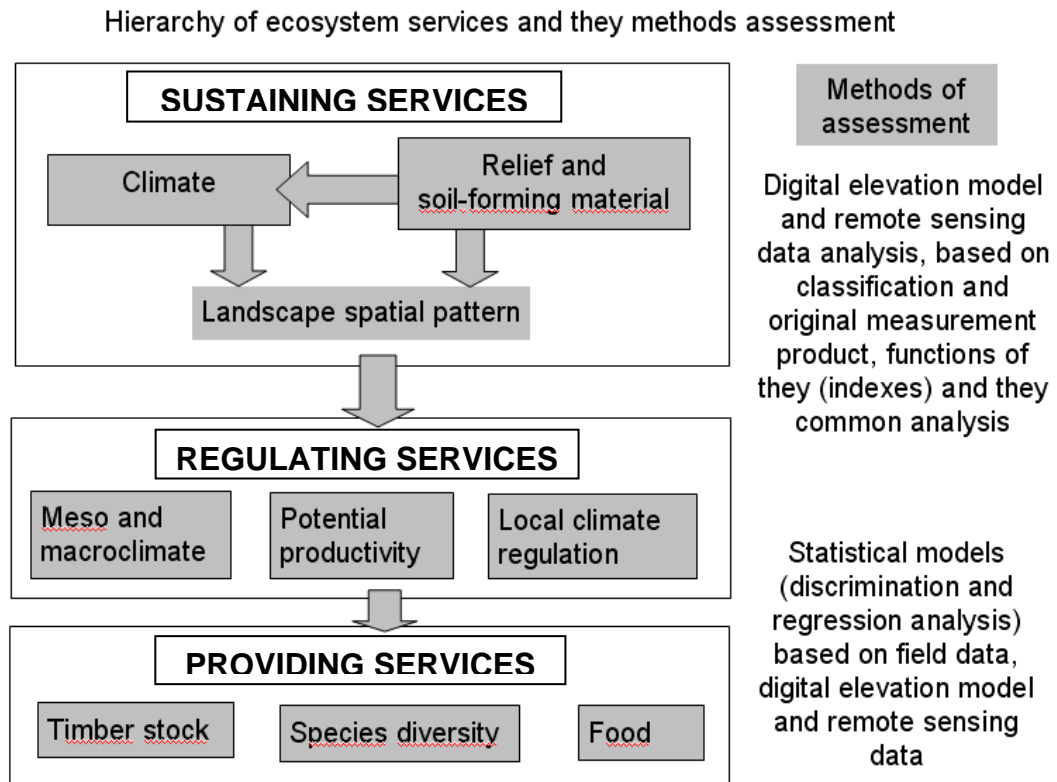


Fig 1. Hierarchy of ecosystem services and methods of their assessment

The key regulating service is the net biological product, phytomass store and carbon reserves in soil. The phytomass determines possible capacity of ecosystems and possible level of accumulating matter and energy. On the other side, the bigger is the phytomass, the higher is heat input for vapor and the lower is heat flux. Thus, the active phytomass appears as the real energy capacity and the regulator of heating rate, dregs and drain in the scale of the mesoclimate. Accordingly, the phytomass stabilizes the level of the net product also. The cost of this regulating service connected firstly with the extent of the territory foresting is assessable by analogy with expenses to supply similar scales of regulating with engineered features. In different regions the necessity of such regulation is various, which defines the relevancy of regional-differential assessments. The direct use of forest resources decreasing phytomass store down the acceptable capacity lowers regulating functions and at the limit could lead to qualitative change of vegetation cover structure and the content itself.

Biochemical functions of the net product and phytomass are of the great importance. The higher is the product, the higher is oxygen evolution and the larger is the phytomass, the higher is the whole air cleaning of dust and partially of pollution. But oxygen enrichment is held mainly at the expense of the big net product and decreases under a phytomass rise. Correlation of the net product and organic oxidation rate entering the soil determines the carbon equilibrium amount. This amount appears as the regulator of the carbon content in atmosphere, increasing its output under a rise in production, for example, in result of warming and lowering this output under cooling. As dependence of the net product on temperature and dump and the dead organic matter combustion from it have various dimensional characters, then some regions are stocks and other ones are additional sources of carbon to atmosphere, which determines continental and global character of this regulating service.

The product and structure of the vegetation cover are the function of supporting services: climate, terrain and soil-forming rocks. In their turn, they usually are not the matter of management, but in their combination they determine the cost of the final supporting direct and oblique services. Their cost could be estimated via regulating services, but also has independent component parts. Influence of the terrain on esthetic, recreational, transportation, construction and other services is evident. The terrain often defines the scenario choice to use all other services. Also the soil-forming rocks provide the similar influence, predetermining the spatial structure of dissemination and use of recoverable resources.

Variety of terrain influence on the rest constituents of ecosystems (redistribution of heat and damp, erosion, action on transport infrastructure etc.) demands development of the multidimensional assessment. At that, this supporting service acts in various hierarchic scales. Variety of terrain influence on regulating services makes it wise to reflect its value through those properties of climate, product, erosion, carbon reserves, on which it influences directly or indirectly. For that, the terrain is divided to separate variables: gradient, a form

of the surface (Laplacian operator), luminance for different hierarchic levels of its organization.

The landscape structure determined by the terrain, the soil-forming rocks and organization of vegetation cover, directly or indirectly dictates the level and potential cost of practically all the types of supplying services and scenario choices to use them. Moreover, the landscape structure could be changed in such a way to increase the level and capacity of services having the greatest importance in the presumed scenario of development.

The multispectral remote information from the Landsat satellite gives measurements of solar radiation reflected from the Earth surface in six spectral channels and heat flux in the infrared channel. Basing on this, taking into account the solar constant, it is possible to compute a summary absorbed radiation, exergy (yield connected with vapor and photosynthesis), to approximately estimate energy going to photosynthesis, index connected with the net product (NDVI), surface temperature, key figure of damp content in ecosystem and a number of other figures with the 30x30m resolution afield. All these values are the function of state of vegetation cover, terrain and mechanical content of soil. Computation of their dependence on the terrain characteristics gives reflection of potential values on the hypothetic surface devoid of vegetation. Such assessments give direct information on potential content of damp, temperature and the net product. The appropriate maps are made up for the reserve's territory and they could naturally be built for any part of dry land. These assessments of the supporting services allow practically uniquely selecting the development scenario for similar territories: development of forestry and game husbandry, berry and mushroom production. Agriculture can supply the necessary foods to only local population, prosperity of which is defined by use of ecosystem services.

Passage to the baseline assessment of the supplying and some regulating services is conducted on the basis of measuring their state immediately in the field with georeference. Assessment of their state for any section of the territory

is built on the basis of statistic models connecting results of the field measurements with remote information and the terrain features. Overwhelmingly, such models are reliable enough and allow giving the baseline assessments of the state at majority of the supplying services' bearers. For the studied territory, the possibilities are demonstrated of the following maps: wood stock for the main rocks, projective cover of the main commercial non-wood resources (berry beds), carbon reserves, quality assessments of habitat for the main commercial species of animals and their potential number.

### **3 Conclusion**

It is shown that the remote sensing data, the terrain digital models and field measurements of the landscape cover properties give the possibility to estimate some ecosystem services. The necessity is underlined of using such assessments of the territories combining disturbed and undisturbed ecosystems. Using states variety of ecosystem properties, both without direct impact of man and under existing forms of exploitation, it is possible to develop the most representative models of ecological services assessments on the basis of combining field measurements of terrain properties and remote information. In all cases, the obtained assessments are auditable and updateable, which secure their reliability. Existing relations between various services essentially allow building the model of their changes under various strategies of socioeconomic regional activity development.

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