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Short communication

Use of UAVs and multispectral images in the examination of phytocenoses in logged areas

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Abstract. The study analyzes high-resolution multispectral images obtained via unmanned aerial vehicles (UAVs) to assess the state of phytocenoses in logged areas that were cleared seven years ago. The clearcut site represents an irregularly shaped area of 13 hectares, on which seed trees are left as large patches of 0.2–0.3 hectares each. The images obtained from UAVs in the visible range and in the synthesis of NIR-GRE-RED channels determine the qualitative and quantitative characteristics of coniferous and deciduous trees in seed patches, in forest edges adjacent to the logged area and in rows of forest crops. In the eastern part of the logged area between the rows of forest crops, deciduous trees are represented by single specimens, conifers prevail, and in the western and northwestern parts of the logged area, natural renewal of deciduous trees prevails. The obtained information about the structure and condition of young forests can be applied in the development and updating of forestry regulations, objective documentation, and forest management plans.

Keywords: assessment methods, unmanned aerial vehicle, Scots pine, natural forest restoration

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Краткое сообщение

Использование БПЛА и мультиспектральных снимков при обследовании фитоценозов на вырубках

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Аннотация. Анализируются мультиспектральные снимки высокого разрешения, полученные с помощью БПЛА для оценки состояния фитоценозов на вырубке 7-летней давности. Вырубка представляет собой участок неправильной формы площадью 13 га, на котором оставлены семенные деревья в виде куртин большого размера – по 0.2–0.3 га. На снимках, полученных с БПЛА в видимом диапазоне и в синтезе каналов NIR-GRE-RED, определяются качественные и количественные характеристики хвойных и лиственных деревьев в семенных куртинах, в примыкающих к вырубке стенах леса и в рядах лесных культур. На восточной части вырубки в междурядьях лесных культур лиственные породы представлены единичными экземплярами, преобладают хвойные породы, а в западной и северо-западной частях вырубки преобладает естественное возобновление лиственных пород. Полученная информация о структуре и состоянии молодняков может быть использована при разработке и обновлении объективной документации, лесохозяйственных регламентов, лесного плана.

Ключевые слова: методы оценки, беспилотный летательный аппарат, сосна обыкновенная, естественное восстановление леса

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Introduction

The use of unmanned aerial vehicles (UAVs) is a promising modern tool for monitoring of forest management efficiency (Filatov et al., 2022; Kabonen et al., 2022; Olkhin et al., 2022, 2023; Skudneva, 2014). UAVs enhance the accuracy of quality assessments and reduce the labor intensity of the tasks performed (Filatov et al., 2022; Kabonen et al., 2022; Olkhin et al., 2023). The main benefit of UAVs lies in their ability to cover large, inaccessible, and remote territories, whose existence in taiga zones slows down the advancement of forestry (Briger et al., 2019; Gavrilova et al., 2020; Kabonen and Olkhin, 2020; Kulha et al., 2018).

Multispectral imaging using the near-infrared channel and the high spatial resolution of images enhance the capabilities for comprehensive assessment of forest resources. Remote sensing methods make it possible to identify species composition, taxation characteristics of stands and to detect outbreaks of pests and diseases affecting forest phytocenoses (Akovetskiy and Afanasyev, 2020; Kabonen and Olkhin, 2020; Olkhin et al., 2023). Moreover, unmanned aerial vehicles enable the assessment of the success of natural regeneration in clearings of any area and condition category, as well as the safety of forest crops and characteristics of logged areas (Filatov et al., 2022; Kabonen et al., 2022). Studying the growth patterns of young trees of both natural and artificial origin in logged areas is an important element of forest management, especially with the use of modern technologies (Filatov et al., 2022; Maslakov, 1984; Neuville et al., 2021; Olkhin et al., 2023; Sokolov, 2006).

The aim of the research is to assess specific characteristics of phytocenoses developing in logged areas with seed patches, utilizing unmanned aerial vehicles (UAVs).

Materials and methods

Aerial photography of the experimental sites was conducted using a fixed-wing unmanned aerial system on June 29–30, 2020, from an altitude of approximately 200 meters. The aerial photo shooting was done with a SONY DSC-RX1R camera in the visible range (RGB) and with a Parrot Sequoia camera in both visible and near-infrared ranges (RED, REG, GRE, NIR). The spatial resolution in the visible range was less than 5 cm, while in the visible and near-infrared ranges it was 19 cm.

The research subject of 13 hectares is located in compartment 96 of the Veshkelitsa forest district (the Suoyarvi region, the Republic of Karelia). Following the cutting of a lingonberry pine forest in 2013, a heather-type logged area was established there. The soils are light, super-sandy and iron-illuvial.

The obtained materials were processed using special software (Agisoft Metashape Professional). As a result of the image processing, a high-resolution orthophoto map was created with a resolution of 4.84 cm/pixel.

Results and discussion

An aerial image of the study area with highlighted logged area contours and seed patches is presented in Fig. 1. The areas of seed patch S1, S2 and S3 were 0.24, 0.27 and 0.2 hectares, respectively.

Tree species are easily identified in the multispectral aerial photographs and the orthophoto map not only in patches and in forest edges adjacent to the logged area, but also in rows of forest crops. The spectral characteristics of tree species as well as the sizes of crowns, shadows and their shapes are well read. The projections of the crowns of seedlings, windfall, and broken trees are clearly visible.

Fig. 2 presents a synthesized multispectral image NIR-GREEN-RED of the seed patches and the elevation map. Scots pine is deciphered better than other tree species: the rounded shape of the crown is reflected in its own shadow. The projection of the pine crown in the multispectral image is highlighted in greenish gray. Aspen, birch, and alder reflect yellow-green, yellow-orange, and reddish colors. Birch is particularly easy to decipher, as in oblique projections of trees in the visible range, this species is clearly distinguished by the white color of its trunk.

Deciduous species are particularly distinctive in yellow-orange color in the forest edges, in areas of natural regeneration and in small groups along the road in the northwestern part of the logged area (Fig. 2). Isolated projections of pine crowns in seed patches and in rows of forest crops are well recognized in the images. In conclusion, the plantations are in satisfactory condition; the survival rate of the plantations seven years after establishment is around 90%. Overall, there is no risk of species change at the time of inspection in this experimental area.



Fig. 1. Contours of the logged area with seed patches (S1, S2, S3).

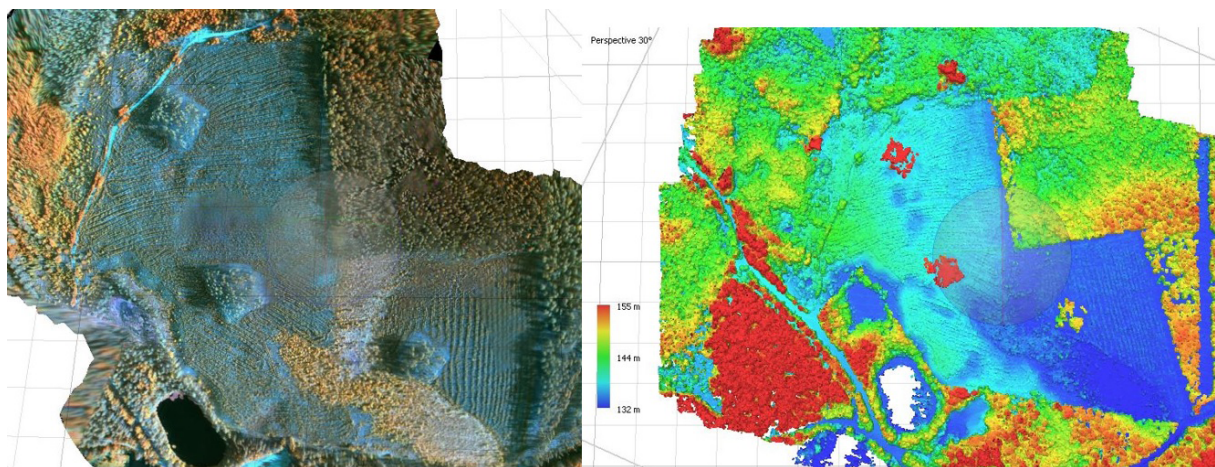


Fig. 2. Multispectral synthesized NIR-GRE-RED image of the logged area with seed patches and height map.

Forestry practice in the taiga zone shows that natural regeneration by coniferous species on light sandy soils is generally successful. However, in this case, the creation of forest crops in the logged area is obviously due to the insufficient quality of natural renewal of pine left in seed patches. In the images, both in the visible range and in multispectral synthesis, a large number of fallen trees are noticeable, and dead standing pine specimens are deciphered in seed patches (Fig. 3).

The total area of seed patches is about 0.7 hectares (less than 5% of the logged area). Natural regeneration primarily occurs between the rows of forest cultures. This is more pronounced in the western part of the clear-cut, where deciduous species dominate within the young trees. (Fig. 2). The proportion of self-seeded coniferous species on the left side of the logged area exceeds 10%. On the eastern half of the clear-cut, natural regeneration of coniferous and deciduous species is represented by single specimens, which can be explained by specific soil conditions.

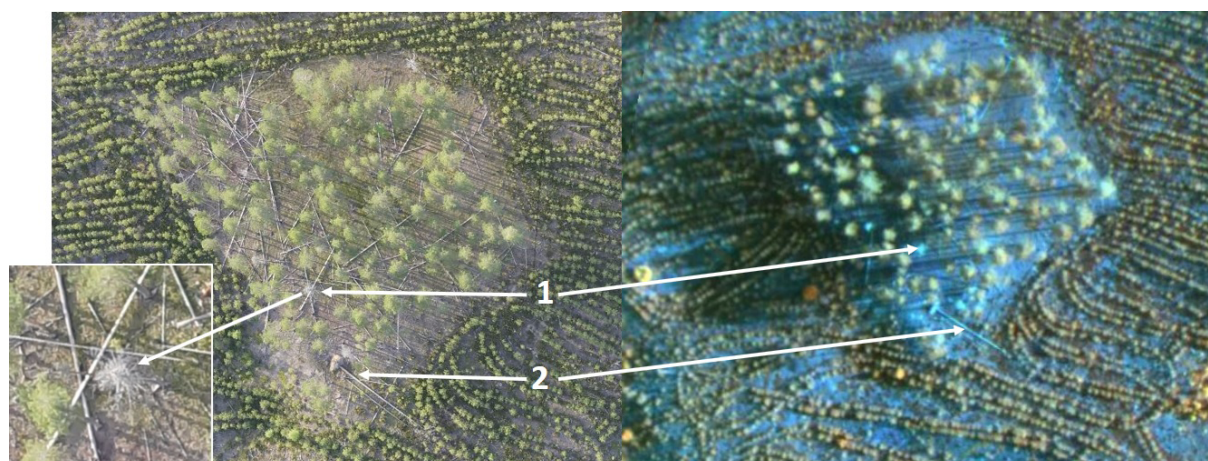


Fig. 3. Image of the S2 seed patch in the visible range and in the synthesis of NIR-GRE-RED channels (1 – standing deadwood, 2 – downed deadwood).

Data obtained using UAVs can also be used to determine the biometric characteristics of individual trees, for instance, the crone diameter or height. The processing of images using the photogrammetric software Agisoft Metashape Professional made it possible to obtain a dense cloud of points, a map of heights, a 3D model of the object, and an orthophoto map. Thanks to the navigation support of aerial photography, the materials were not only georeferenced in longitude and latitude, but also in height. Previously, we measured the heights of the trees in seed patches on the basis of a height map and a 3D model (Olkhin et al., 2023). Points at the tops of the trees and points on the ground near the projections of the crowns of these trees were identified. The height of the trees was calculated as the difference between the elevations of the tops of the trees and the elevations of the earth's surface.

Thus, the use of UAVs and multispectral images allows us to achieve more detailed information about the structure and condition of forest phytocenoses. The main characteristics of young growth are particularly easy to decipher. Additional information about plant communities of any structure can also be obtained from the orthophoto map. However, on dry, poor soils, all characteristics of the phytocenosis are identified in greater detail compared to more complexly structured phytocenoses growing on relatively rich soils.

Conclusion

Specific examples demonstrate that the use of UAVs allows collecting objective data on young growth of forest crops. The use of multispectral images makes it possible to determine with acceptable accuracy not only the composition of young growth but also the condition of forest crops and the tree species distribution characteristics across the area. Aerial photographs make it easy to identify the admixture of coniferous and deciduous species of natural origin, which is important for objectively assessing the success of forest regeneration. The obtained materials can be used in the educational process, for converting young growth to forested lands, for developing forest management projects, preparing and updating forestry regulations, and other normative documents.

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