Automatic Analysis of the Tree Crowns Through Image Processing

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Abstract

In these article we present resuls of research work about estimation of tree stands using digital images of tree crowns. We have concluded that using of combination of automatic image processing and visual analysis is a best solution, in these case. The condition of trees can be correctly estimated if we will use semiautomatic image processing for defoliation measurement and visual analysis of arrangement of needles on the branches and analysis of crown dieback. We presented methods of expression of tree stands condition using special indexes. We developed special scale for tree stand assessing and created a map of forest condition.

Introduction

Now we have a lot of methods for tree condition assessment. For tree condition assessment we can use many parameters. For example: We can calculate count of needles on tree branches, we can measure annual growth, we can use physiological parameters (concentration of metals or sulfur content).

This approach can give us stable and very accurate results (data). But we must spend too much time, to get results.

Other way to estimate trees condition is visual methods. Morphometric characteristics are quite to describe and assess tree condition status. As example: Crown density, Transparency of Foliage (Defoliation), Crown discoloration, Crown dieback. However, the result of visual assessment depends on observers [1]. Visual parameters may be overestimated or underestimated.

Last time we see many interesting publications devoted to using digital images of crowns in tree state assessment [2,3,6]. These methods should be tested and developed.

The goal of this research work was to improve visual assessment of tree condition, using digital images of tree crowns.

Methods

Research area is placed around Middle Ural Copper Smelter factory. The Main tree species are: Pinus sylvestris, Picea abies, Betula pendula, Populus tremula.

On research area we placed sixty two temporary sample plots. Sample plots were placed in oldest pine stands. Minimum distance from sample plot to nearest road or railway was one hundred meters. Radius of each sample plot was fifty meters. Inside each plot we selected ten trees. To select trees, we used several requirements:

a)Minimum intersection with neighboring trees;
b)The tree must have average size.

To get crown images, we used a digital camera Canon EOS D350 with automatic settings. Distance from tree to photographer was equal to height of tree.

On each photo we studied the upper part of the crown. In the analysis of photo, three parameters were determined:

1) Crown density (We call it Defoliation index),
2) Arrangement of needles on the branches,
3) top of crown dieback (degree of drying tree top).

To measure crown density (or defoliation) we used special software for analysis of digital images. SIMAGIS

Research (Developers are SIAMS company(Russia) and Smart Imaging Technologies (USA)). We measured each crown photo. On first step we have identified silhouette of crown (threshold segmentation, gaps revealing algorithm) [3].

On second step using "threshold segmentation" function we have found gaps in crown.

And finally, to get Defoliation index we divided area of gaps in crown into general crown area. The defoliation index is expressed in relative units (for example 0.04, 0.02).

All the set value of the index of defoliation was divided into four categories.

Some images of tree crown were preprocessed before defoliation measurement. We manually removed neighboring trees branches (Fig 1 A). In case of strong degree of defoliation and crown dieback we manually defined contour of tree tops (Fig 1 B).

a b

Fig 1. Tree crown images preprocessing

A – manual removing of neighboring trees branches ; B – manual definition of tree top contour.

Arrangement of needles on the branches is the parameter that is connected with reduction of needles lifetime and reduction of growth.

If tree has growth reduction, the distance between the needles is reduced. Bottom part of branches is free from needles. As result tree has needles located at the top part of branches.

If growth of tree is normal, needles is located on the branches evenly.

Using this parameter we defined two types of trees (Fig. 2):

a) needles are located at the top part of branches;
b) needles are distributed uniformly.

Crown dieback the other parameter we have used.

Using this parameter we defined three types of trees (Fig. 3):

a) Crown has no dieback;
b) Crown has some dead branches;
c) Top of Tree is dead.

Crown dieback and arrangement of needles on the branches were defined visually using photos.

On these grounds, all trees were categorized into four groups indices of visual assessment (VA):

1. healthy trees - needles distributed uniformly, crown has no dieback
2. weak trees - needles located at the top part of branches, crown has no dieback
3. very weak trees - needles located at the top part of branches, crown has some dead branches
4. dries out trees - needles located at the top part of branches, top of tree is dead

Then we used four visual assessment categories an four defoliation categories to build table of combined indices of tree condition (CIC).

Table 1. Combined indices of tree condition according to defoliation categories and visual assessment categories

Defoliation categories (DC)		Visual assessment categories (VA)			
		1	2	3	4
normal	1	1	2	3	4
weak degree	2	1	2	3	4
strong degree	3	1	2	4	4
very strong degree	4	2	3	4	4

Combined index of tree condition is equal to visual assessment category

- when tree has normal , weak degree of defoliation,
- or when tree has strong degree of defoliation, but visually tree is assessed as healthy and weak

We did it because it is better to use visual assessment data if top of tree is dead, but crown is very dense. Or if tree is visually healthy but has weak degree of defoliation.

Combined index is increased by one, if visually tree is healthy or weak but has very strong degree of defoliation.

We assessed the condition of stand on each sampling plot. We used the median value of a range of Combined index. After we defined four categories of stand condition:

1. good condition, if median value on plot is less than 1.5;
2. satisfactory condition - median value on plot is from 1.5 to 2.4;
3. bad condition - median value on plot is from 2.5 to 3.5;
4. very bad condition - median value on plot is more than 3.5.

Results

We made two plots of dependence of the state of trees and distance from copper smelting factory. One plot for western direction and one plot for eastern direction.

We can see that forest condition indices are reducing if distance from copper smelting factory is increasing. It means that forests health is better if distance from factory is longer.

Pearson corellation coefficient is -0.586 for eastern direction and -0,645 for western direction. The significance level of the Pearson correlation coefficient is 5%.

Creation of a map of forest condition is next step of our work. To get it we made statistical surface using our plots and interpolation function in geographical information system. Then we defined zone boundaries (Fig. 3).

Biggest part on this map is zone of satisfactory condition. Forests with good condition placed in the northern, southern, western, and eastern border. Forests in bad condition placed around the cooper smelter factory. Zone of very bad condition is located to the northeast of factory, at a distance of 2-3 km. I guess the reason is prevailing winds from west. This result correspond to previous research works[7,8].

a b

Fig. 2 Tops of tree: a - needles are located at the top part of branches; b — needles are distributed uniformly.

a b c

Fig. 3 Tops of tree :a) has no dieback; b) has some dead branches; c) is dead

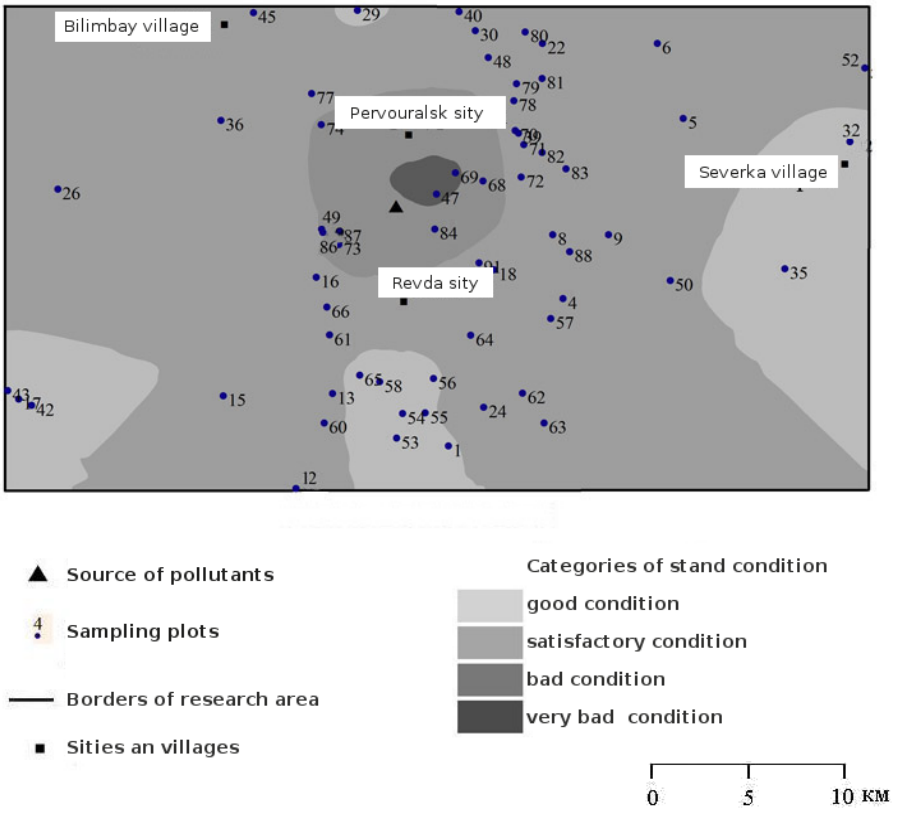

Fig. 3 Map of forest stands condition (we used combined index of crown condition to build this map)

Conclusion

Digital images of pine tree crowns can be used for correct estimation of tree stands condition. Best choice is combination of automatic image processing and visual analysis of the crown characteristics. Combined indices of tree condition allows us to define four categories of stand condition and special scale bar of stand condition. This method and geographical interpolation procedure allow us to get a map of stand condition.

Bibliographic list

1] Muukkonen P., Lindgren M., Nevalainen S Accuracy of visual tree defoliation assessment: a case study in Finland, Working Papers of the Finnish Forest Research Institute, 2014

[2] Nakajima, Kume, Ishida, Ohmiya, Mizoue, Evaluation of estimates of crown condition in forest monitoring: comparison between visual estimation and automated crown image analysis, Annals of Forest Science 2011, 68 (8).

[3] Fomin V.V., Popov A.S., Kapralov D.S., Kryuk V.I., Avtomatizirovannaya otsenka sostoyaniya derevyev s ispolzovaniyem sistemy analiza izobrazheniy [Automatic estimation of trees condition using image analysis system] Lesnoy jurnal, №1 2008

[4] Afanasyeva L. V., Kashin V. K., Mikhaylova T. A. Vliyaniye promyshlennogo zagryazneniya na nakopleniye sery v khvoye sosny obyknovennoy (Pinus sylvestris I.) v yugo-zapadnom Zabaykalye [Influence of air pollution on sulfur accumulation in scotch pine needles, Khimiya ustoychivogo razvitiya [Sustainable development chemistry], 2005. №13. p.461- 467.

[5] Kovylina O. P., Zarubina I. A., Kovylin A. N. Otsenka zhiznennogo sostoyaniya sosny obyknovennoy v zone tekhnogennogo zagryazneniya [Estimation of scotch pine trees condition in air pollution zone], Khvoynyye borealnoy zony [Coniferous forests of boreal zone], XXV. 2008. № 3 – 4. p. 21-28.

[6] Shevelina I.V., Nizametdinov N.F., Kuzmina E.O., Lamanova K.A., Metodika otsenki sanitarnogo sostoyaniya derevyev sosny obyknovennoy po fotosnimkam v gorodskikh usloviyakh [Tree condition assessment method using digital images in the city forests], Nauchnoye tvorchestvo molodezhi – lesnomu kompleksu Rossii[], Ekaterinburg, USFEU, 2016

[7] Fomin V.V., Shavnin S.A. Ekologicheskoye zonirovaniye sostoyaniya lesov v rayonakh deystviya atmosfernykh promyshlennykh zagryazneniy [Ecological mapping of tree stands condition in industrially polluted areas], Ecologia[Ecology],. 2001, № 2., p. 103 – 107.

[8] Fomin V. V., Morfofiziologicheskaya otsenka sostoyaniya sosnovykh molodnyakov v zone deystviya atmosfernykh zagryazneniy Pervouralsko-Revdinskogo promyshlennogo uzla Diss. kand. s./h. nauk. [Morphophysiological estimation of forest state in industrially polluted areas Doct. Diss.]. Ekaterinburg, 1998. 25 p.