REMOTE SENSING AND GIS TECHNIQUES TO ANALYZE INVASION INTO GRASSLAND OF THE SPECIES PTERIDIUM AQUILINUM (L) KUHN

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Abstract

Pteridium aquilinum (L) Kuhn is one of the most aggressive invasive species that invades grassland habitats of many hilly areas of Banat, in western part of Romania. This study aims at identifying and delimiting the areas occupied by the species Pteridium aquilinum (L) Kuhn by techniques of remote sensing and Geographic Information Systems. For the analysis of the study area were made observations in the field, under which, through specific methods was developed detailed analysis. Remote sensing images were preprocessed and proper analysis, was done on the basis of spectral classifications, It is applied both unsupervised classification and supervised classification. From the area of 251.64 hectares of grassland, Pteridium aquilinum (L) Kuhn occupies 22.95%, which is 58.73 hectares, with relatively uniform spatial distribution, among near wooded areas; were highlighted two types of spectral response, this species was "surprised" in the two different phases of vegetation. From total area qualified as "pasture", useful area is 130.85 ha, which represents only 52% of the total. This information demonstrated scientifically and statistically validated, can be seen as a warning on the conduct and across protection measures and improvement of grasslands.

Keywords: invasive species, grassland, identification, remote sensing, technique.

INTRODUCTION

Grasslands, "pole of attraction" for more and more scientific domains, presented since distant periods of the history, great importance in terms of socio-economic and even cultural, given the "support" that gives of local communities as a source, direct and indirect, of food, as "support" of biodiversity, as a form of property and exchange, but as a core element of pastoral and traditional culture, in general.

Scientific and technical progres, in recent decades, currently allows "satellite" analysis, implicitly automated of the area used as grassland, both quantitatively and

qualitatively, replacing thus part or all "classic" methods of investigation, but the results are superior.

Development and diversification of the means of acquisition of satellite and aerial images, results, currently a wide range of images of high spatial, spectral and temporal resolution, ensures an impressive amount of scientific data and information, being undertaken with low effort, in "real time", complex research and analysis in different environmental conditions or socio-political situations. Examples include: monitoring the status of "health" of the grasslands (XULIN *et al.*, 2008), intensity of use in order to establish conservation measures (FRANK *et al.*, 2012), detection agricultural practices in grasslands (DUSSEUX *et al.*, 2014) etc.

In terms of "plant couverture", were developed a number of "agricultural index" on which various scientific analyses can be undertaken, unquestionably important, both theoretically and practically (ROMEO *et al.*, 2013, MEYER and NETO, 2008).

Of particular importance is the use of remote sensing techniques and methods for the identification, delimitation of habitat and invasive species monitoring, research in this respect is increasingly numerous and complex (HUANG and ASNER, 2009, BRADLEY, 2014, ROCCHINI *et al.*, 2015 etc).

Based on previous research, technical and specific means by this study aims at identifying and delimiting the areas occupied by the species *Pteridium aquilinum* (L) Kuhn (fern), "enshrined" in the hilly areas of Banat, invasive species, inefficient economic evolving "space-time" fast, which reduces the useful area of the grasslands and thus productive capacity to the surface considered.

MATERIALS AND METHODS

Grassland area analysed is located in the hilly area of Caras-Severin County, in the administrative-territorial unit (ATU) Brebu, on the surface of 251.64 hectares.

In developing of this study were used:
- Documents and cadastral maps (scale 1:10000) taken from the local administration of Brebu

- Thematic maps (limit of administrative territorial units of Romania, limit of physical and geographical units) free downloaded from the website www.geospatial.org
- Digital Elevation Model (EU-DEM) with spatial resolution of 25 m, available free of charge on the website of European Environment Agency

(http://www.eea.europa.eu/data-and-maps/data/eu- dem)

- Orthophotomap at spatial resolution of 0.5 m, taken over the Archive of the Office of Cadastre and Land Registration Timis.

For pre-processing, processing and analysis results were used the software Idrisi Selva and ArcGIS 10.0.

For identifying and delimiting the area occupied by fern in the grassland, study area considered, was followed methodology shown schematically in Fig. 1.
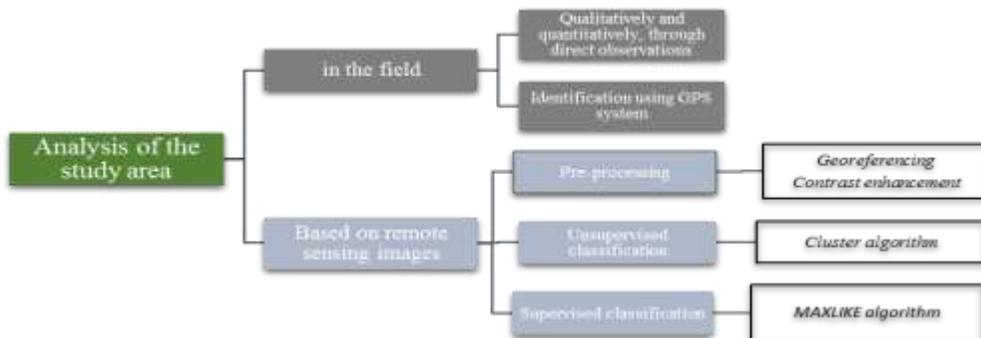

Fig. 1. The working methodology

"Visits" on the field were aimed at:

- determining the structure and typology of prevalent vegetal formations

- quantitative and qualitative evaluation of vegetation

- identify and locate in "coordinate" of areas with fern by GPS system; because these areas have large dimensions, topographical "lift" was done with eXplorist 610 GPS device, in the coordinate system Stereo 70, points collected is subsequently used in the classification process and data validation.

Based on remote sensing images, aerial images, respectively orthophotomap from the area of interest, were made:

- Pre-processing and contrast enhancement, with linear saturation algorithm, according to the methods described by GARETH (1999)

- Unsupervised classification, which involves grouping the types of spectral response without knowing a priori what is classified; in this case it was used cluster algorithm, which makes the selection of the image histogram peaks and represents the minimum thresholds of separation between different classes (http://web.pdx.edu/~nauna/resources/IDRISI-tutorial.pdf)

- Supervised classification, which involves the following operations: developing training zones (representative samples for each category of use or land cover),

generating spectral signatures (analysis pixel in each category and obtaining specific spectral signatures) and the classification itself (each pixel is assigned to a class set in the previous step by comparing the spectral signature of

Identifying the land use and cover it with different plant species or classes set in classification of images was performed based on

that class by specific statistical methods); In this case, supervised classification was done using maximum likelihood method - MAXLIKE (Idrisi Selva Tutorial, 2012).

observations in the field, by „placing" points with known coordinates and based on cartographic materials.

RESULTS AND DISCUSSIONS

The study area is located in the the central southern part of the ATU Brebu, Caras-Severin County, in Banat hilly area, with altitudes between 230 - 420 m and inclination of slopes between 0 - 23° or 0 - 43%.

After the "work visit" on the field, was found the presence and abundance of species *Pteridium aquilinum* (L) Kuhn (fern, great fern), on surfaces considerable parcel of grassland under study. Accurately calculating in the field, the area occupied by this invasive

species and the possibility of generalizing, it is very difficult. On this reason, some surfaces "flooded" with sufficient size, were located by GPS system, making samples in the analysis and classification of the entire spectral plots, the identification and delineation becoming one automated. The points on the field in the Stereo 70 system have been loaded into ArcGIS 10.0 software and overlapping on orthophotomap from the study area (Fig. 2).
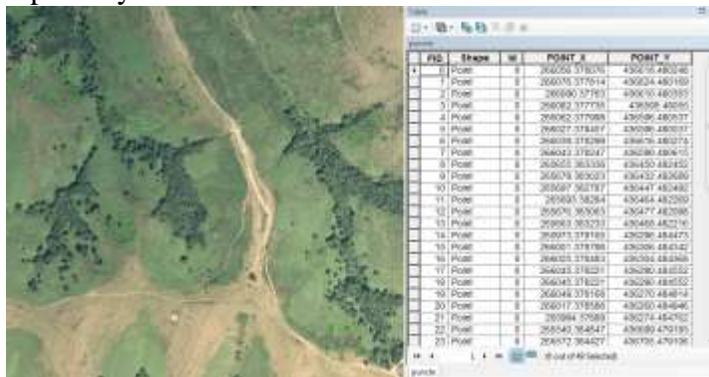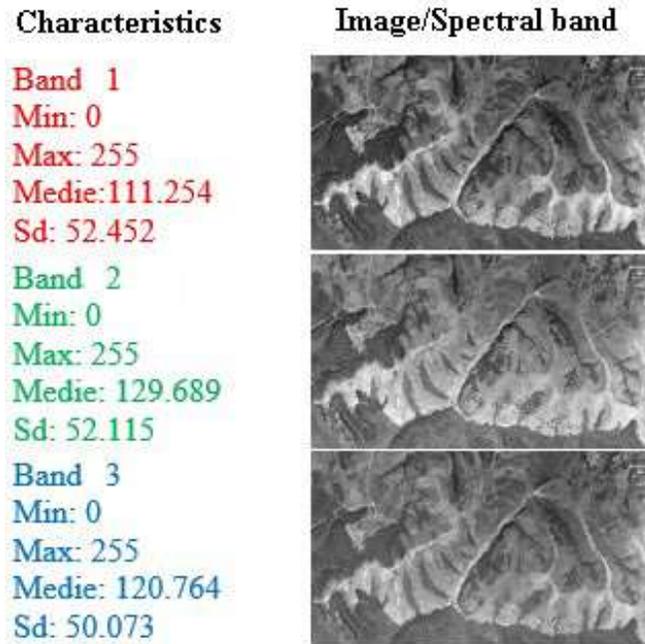

Fig. 2. *Pteridium aquilinum* (L) Kuhn location by GPS system

Aerial image selected for analysis is orthophotomap, an RGB image (with three spectral bands) with spatial resolution of 0.5 m, this image is processed, in the first stage, with the software specialist Idrisi Selva and ArcGIS 10.0, in terms of improving contrast and parcel of grassland extraction (Fig. 3).

Characteristics   **Image/Spectral band**

Band 1
Min: 0
Max: 255
Medie:111.254
Sd: 52.452

Band 2
Min: 0
Max: 255
Medie: 129.689
Sd: 52.115

Band 3
Min: 0
Max: 255
Medie: 120.764
Sd: 50.073

Legend: Min - minimum value, max - maximum, Sd - standard deviation
Fig. 3. Characteristics of RGB bands

The RGB image pixels were analysed 34310178. To describe the relationship between the three spectral bands, it was appealed regression statistical procedure type.

In the three cases shown in Fig. 4 correlation coefficient (r) indicating strength (size) and direction of association between two variables, it is, for images considered positive (proportionally) in all cases be above 0.90, which suggests a very high degree of correlation because low reflectance of vegetation, especially in the red and blue bands (JIN *et al.*, 2013).
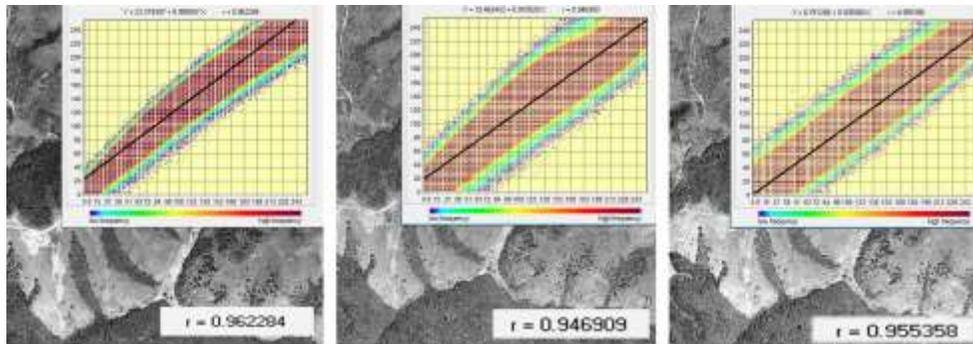
Fig. 4. Regression analysis between the different spectral bands

To identify common areas covered with fern, the main objective of this study, was applied method called spectral classification, which means assigning each pixel in the image to one of the classes of land use (MIAO *et al*, 2014). In the following, the results will be presented by three of the methods of remote sensing image classification. Unsupervised classification is used in this case as a "exploratory" tool (MATHER, 2004). With this method, the computer analyzes all spectral signatures of all the pixels in the image and identifies areas that have similar values. For unsupervised classification was used software Idrisi Selva, Cluster module, which using a selection technique of the histogram peaks. Once the peaks have been identified, all possible values are assigned to the nearest edge. Thus, divisions between classes tend to fall midway between peaks.

Unsupervised classification results are shown in Fig. 5.

Code/field category	Characteristics	Result of unsupervised classification ("rough")
1 – grassland vegetation with small size and medium reflectance	No. entities classified: 230845 Surface: 99.71 ha (39.62%)	
2 – trees, shrubs, underbrush	No. entities classified: 231000 Surface: 55.73 ha (22.14%)	
3 – bare field or vegetation growing in small quantities	No. entities classified: 166002 Surface: 81.15 ha (32.26%)	a
4 – forest vegetation	No. entities classified: 81303 Surface: 15.05 (5.98%)	
Total	No. entities classified: 709150 Surface: 251.64 (100%) Ds: 0.99	b

Fig. 5 a - Unsupervised classification results ("raw" mode), b - subarea of orthophotomap

Following unsupervised classification, analysed grassland area has been grouped into four categories of land cover, in general, according to reality, but the number of details is reduced and the spatial distribution of species identification is uncertain. Therefore, the breakdown of the results, it was turned to the "fine" unsupervised classification, which results in a larger number of spectral classes (Fig. 6).

Code	Characteristics	Result of unsupervised classification ("rough" and „fine")
1	No. entities classified: 263171 Surface: 51.48 ha (20.45%)	
2	No. entities classified: 314858 Surface: 57.51 ha (22.85%)	
3	No. entities classified: 297164 Surface: 39.81 ha	

|	
	(15.82%)
4	No. entities classified: 200461 Surface: 35.31 ha (14.03%)
5	No. entities classified: 296863 Surface: 19.89 ha (7.90%)
6	No. entities classified: 81303 Surface: 15.22 ha (6.04%)
7	No. entities classified: 141540 Surface: 15.84 ha (6.29%)
8	No. entities classified: 59202 Surface: 11.89 ha (4.74%)
9	No. entities classified: 97863 Surface: 4.69 ha (1.88%)
Total	No. entities classified: 1752425 Surface: 251.64 (100%) Sd: 2.22
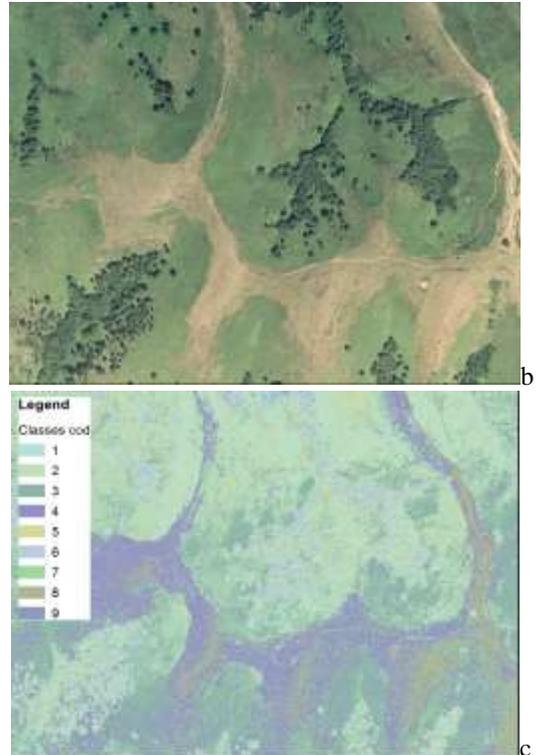
Fig. 6 a. Unsupervised classification results ("raw" mode), b - subarea of orthophotomap, c - unsupervised classification results ("fine" mode)

Result of "fine" unsupervised classification is more detailed compared with the "raw" (Figure 6), but in this case, the issue is to association of class with reality on the ground. In addition, some classes can be compressed, such example is the case of wooded areas around each tree is another class which is actually its shadow. On this reason, to achieve the highest possible accuracy and precision of the results, it turned to supervised classification. Regarding the supervised classification (BRAD, 2003), it applied the method "classical" which involves: developing training zones, generating spectral signatures and classification itself, by the method *maximum likelihood - MAXLIKE* (IDRISI, 2012). In applying this method, the major advantage is the existence of data collected from the study on the field (qualitative assessment, comments on land use,

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photographs, detailed topographical surveys, etc.), information which ensures a high degree of precision in choice/digitizing samples on which will make the entire image classification. Supervised classification result is shown in Fig. 7.

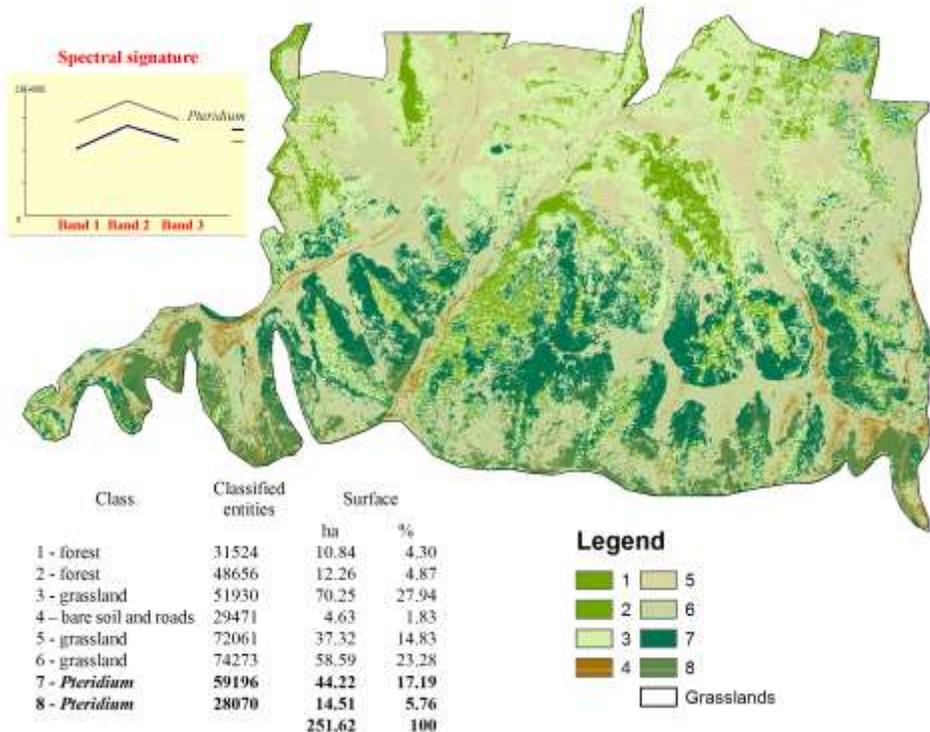| Class	Classified entities	Surface	
		ha	%
1 - forest	31524	10.84	4.30
2 - forest	48656	12.26	4.87
3 - grassland	51930	70.25	27.94
4 – bare soil and roads	29471	4.63	1.83
5 - grassland	72061	37.32	14.83
6 - grassland	74273	58.59	23.28
7 - *Pteridium*	59196	44.22	17.19
8 - *Pteridium*	28070	14.51	5.76
		251.62	100

Legend: 1, 2, 3, 4, 5, 6, 7, 8, Grasslands

Fig. 7. Spatial distribution of areas occupied by *Pteridium aquilinum* (L) Kuhn (supervised classification result)

Area analysed in this study consists of plant species characteristic of grassland (Classes 3, 5, 6), areas covered with trees (Classes 1, 2), bare field of vegetation and roads (class 4), "goals" in the configurations of vegetation and invasive plant species (Classes 7, 8), in this case *Pteridium aquilinum* (L) Kuhn. The existence of multiple classes within a category of land use due to different spectral response of the components analysed, involving different plant species. Representation and analysis of the land use by means and methods of remote sensing, its focus and in previous research (COJOCARIU *et al*, 2015), but also the opportunity to highlight the "invasion" of species in the grasslands surface, constitute a real progress and a starting point in analysing future presentation on the effects and evolution of those areas, both quantitatively and qualitatively.

CONCLUZII

Without disputing the importance and usefulness of empirical, enshrined, "classic" methods, this study supports and demonstrates the usefulness and appropriateness of applying methods "modern" based on Geographic Information Systems and Remote Sensing techniques in quantitative analysis, qualitative and "spatial distribution" of formations constituting the grasslands. Following field research (later used as a tool for validation of data obtained by spectral classification) and by applying specific methods of remote sensing, were found the following:
-       From the area of 251.64 hectares of grassland *Pteridium aquilinum* (L) Kuhn occupies 22.95%, which is 58.73 ha, with relatively uniform spatial distribution, among near wooded areas; were highlighted two types of spectral response, this species was "surprised" in the two different phases of vegetation

-       An area of 23.10 hectares, or 9.17% is occupied by trees and shrubs and 1.83% of the area is covered by roads and areas without vegetation.
       Using images of high spatial resolution allows identify different plant species, in the case of invasive species with great destructive potential, then based on these analyses the possible establishment of countermeasures, but also areas in which they will operate. After more research conducted revealed that, of the total area of 251.64 ha qualified as "*pasture*", useful area is 130.85 ha, which represents only 52% of the total.
       This information demonstrated scientifically and statistically validated, can be seen as a warning on the conduct and across protection measures and improvement of grasslands, while respecting sustainable development principles.

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