Advances in ragweed identification by remote sensing

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Content

Introduction

- Ragweed in Hungary
- Hungarian Ragweed Information System (HRIS)

Traditional Methodology, Results and Problems

- Ragweed identification by optical data (HR time series)
- Results in 2011
- Accuracy assessment, ground control
- The pollen counts compared with different parameters (land use, ragweed distribution, crop and soil types)
- What is trouble with ragweed identification by remote sensing

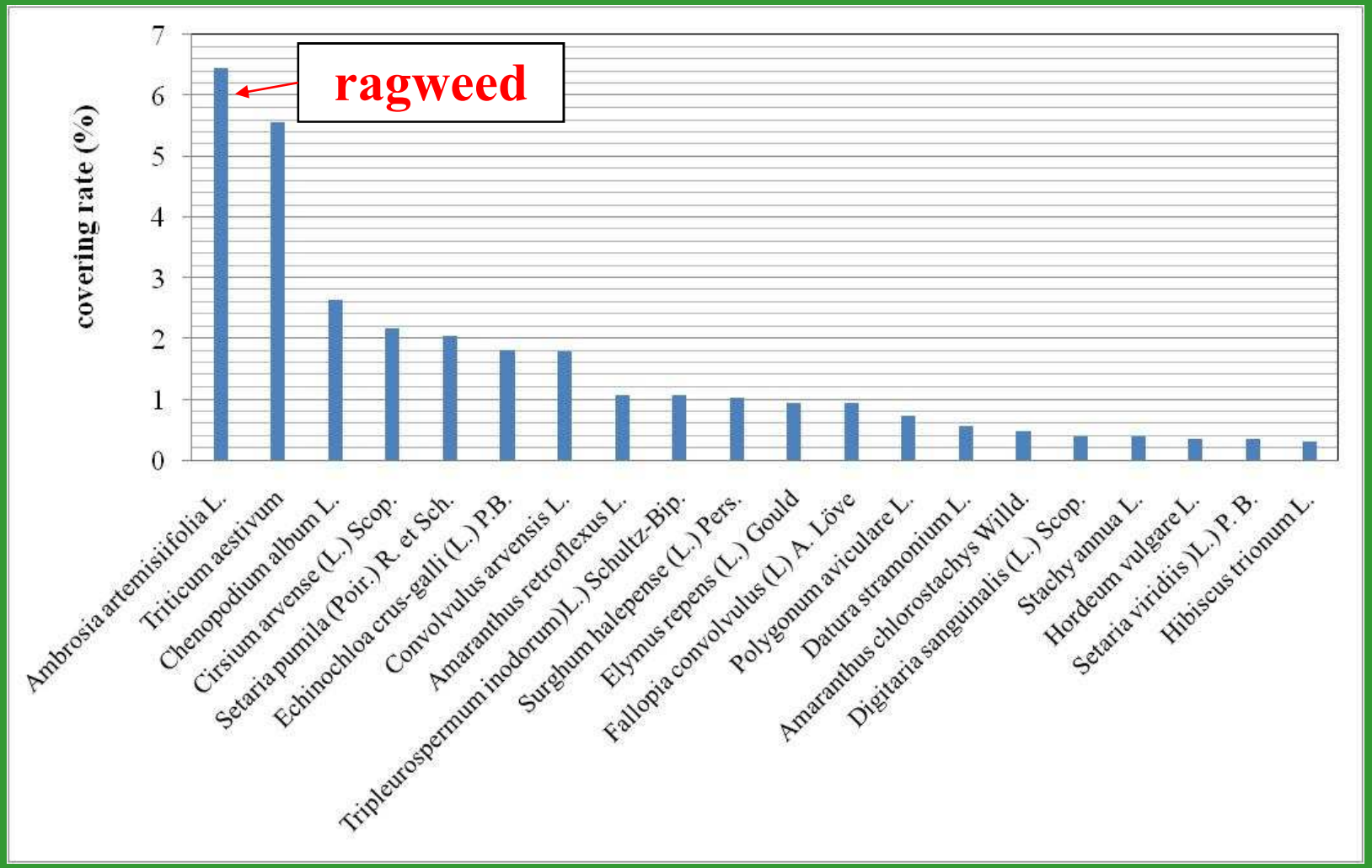
Advances, The New Horizon (VHR, Radar)

Summary & Conclusions

Spread of ragweed in Hungary

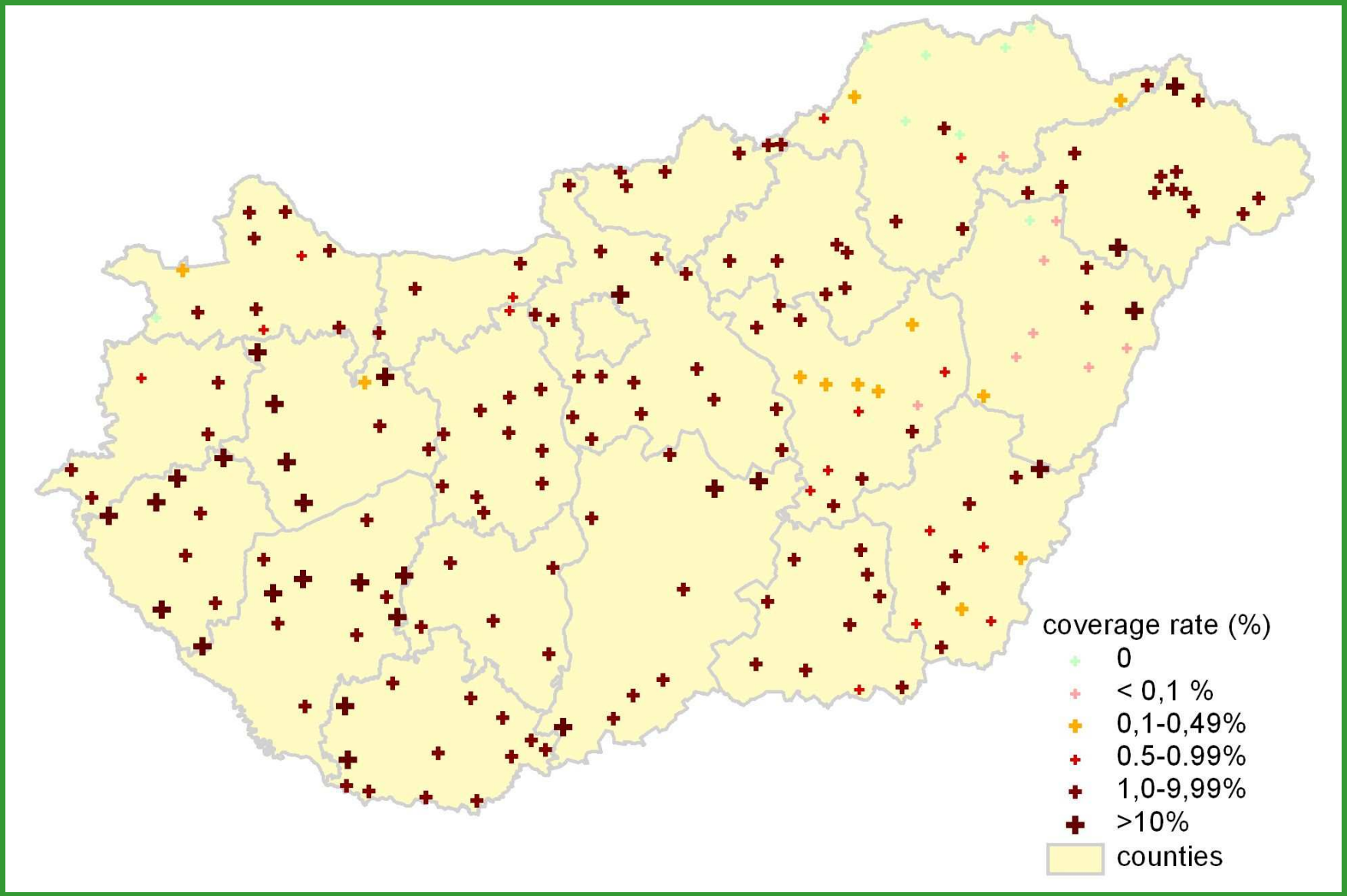
- First appear in Hungary: 1920
- Gradual increase of ragweed areas speeded up after 1990
- 5 million hectares (~85%) of the Hungarian agricultural area are endangered by ragweed
- Around 0,7 million hectares are strongly infected by ragweed. It is 7,5 % of the total Hungarian territory.
- Ragweed itself causes around 120-130 million €/year loss of the agricultural GDP

The most frequent weed plants of cereal stubbles



Source: 5th National weed assessment (2007-2008)

Ragweed infection map of Hungary



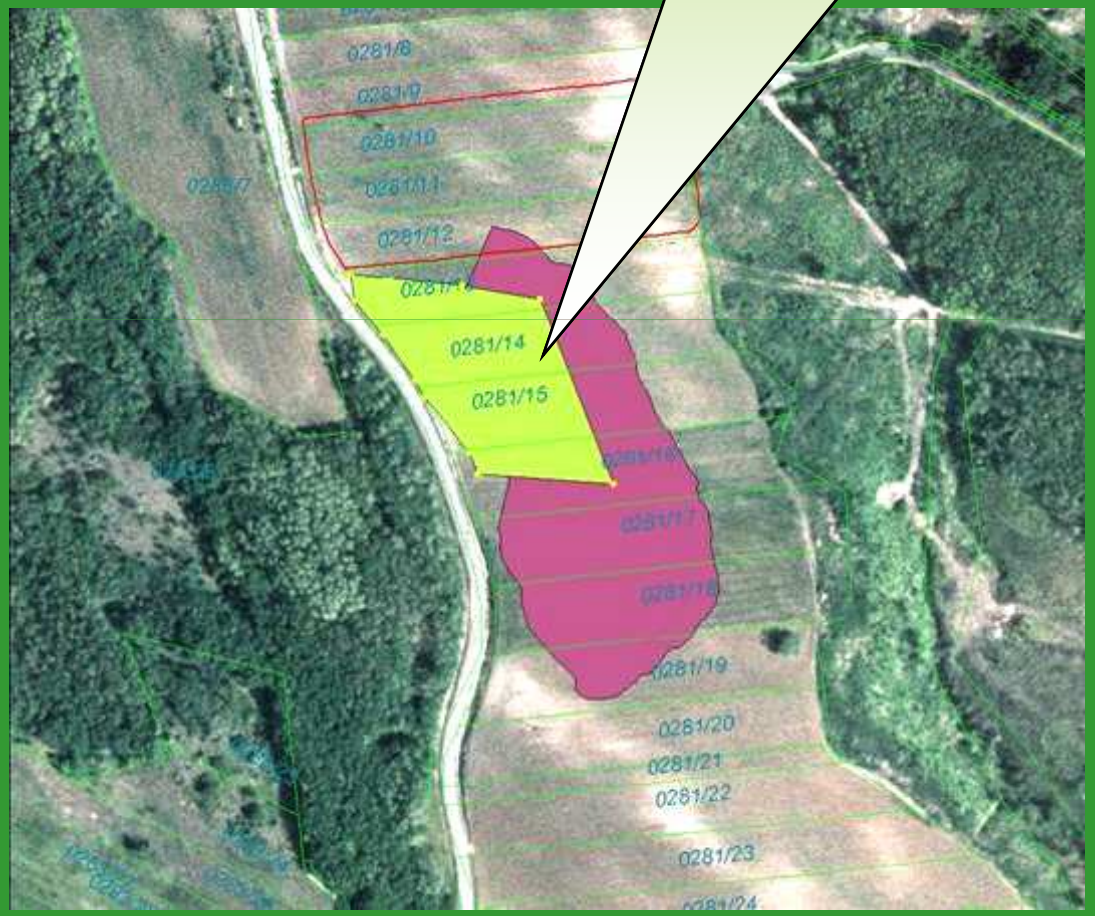
Source: 5th National weed assessment (2007-2008)

In situ recording of ragweed data

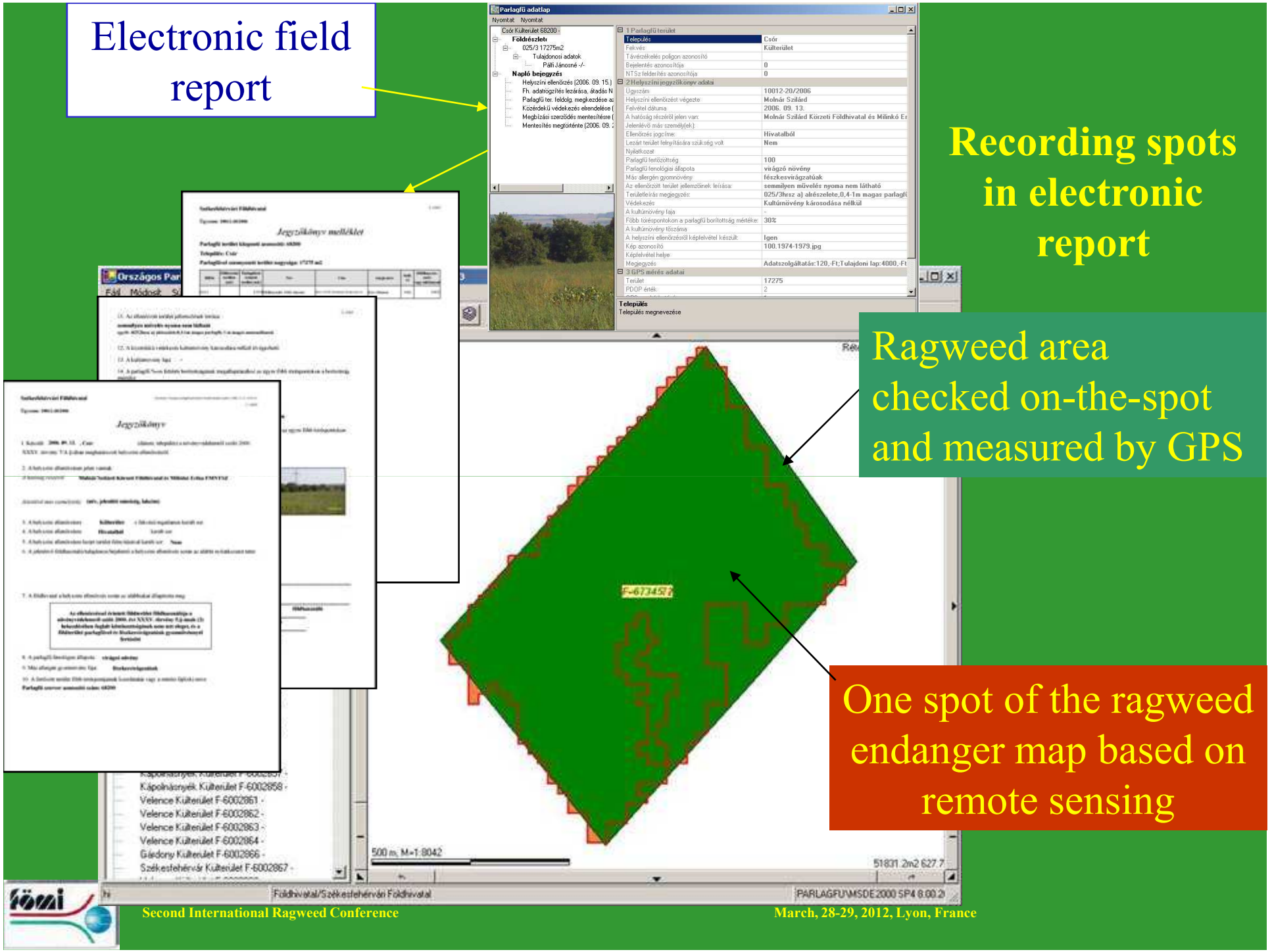
Land Offices Network
~150 persons, local expertise

Palmtop +
GIS software + GPS

Spot subdivision by cadastre / landuser



Electronic field report

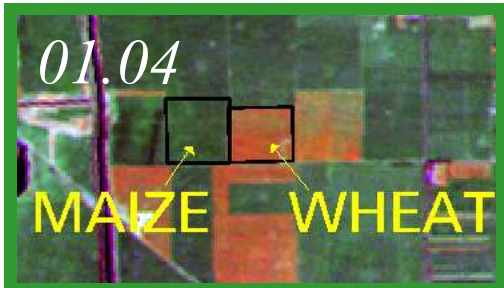


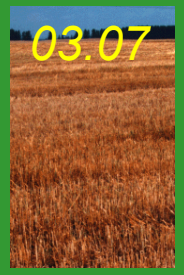
Recording spots in electronic report

Ragweed area checked on-the-spot and measured by GPS

One spot of the ragweed endanger map based on remote sensing

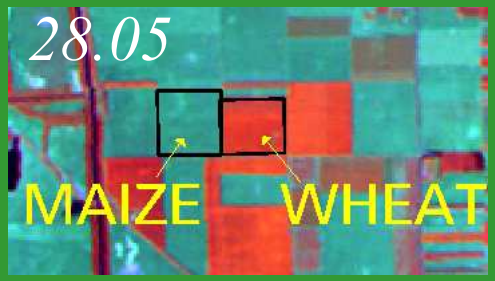
Remote Sensing of cultivated crops

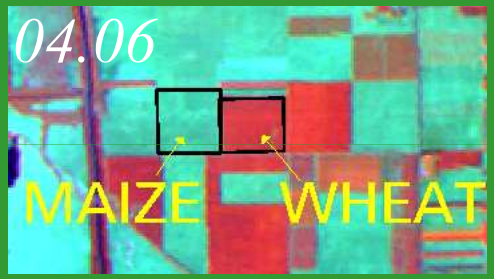




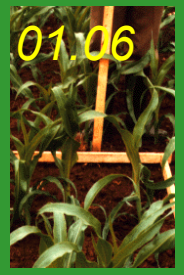
Wheat

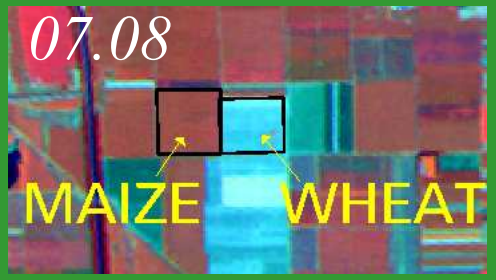
Time

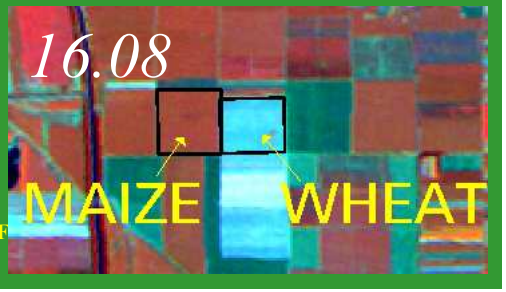




Maize







Ragweed development and remote sensing

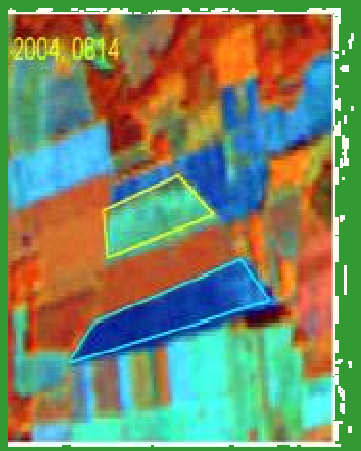
Emergence

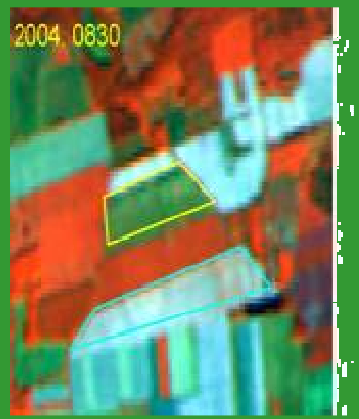
Spreading pollen

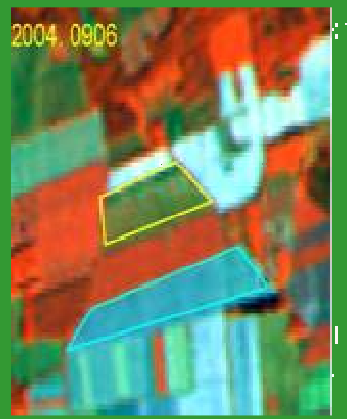
Production

- the ragweed recognition and accurate delineation is much harder than those of the crops:
- mixed and spottiness
- heterogeneous plant composition and the non-characteristic spectral- temporal behaviour

Ragweed infected cereal stubble





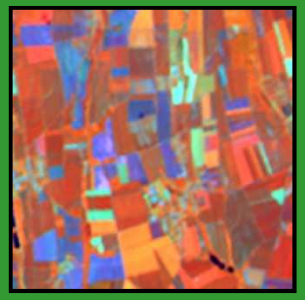


Not infected cereal stubble

Remote sensing is used for ragweed exploration, and spots delineation

Automated image processing using a very sophisticated and unique ragweed recognition methodology was developed

IRS P6 AWiFS



Pixel size:
56m x 56m

0.3 ha

Landsat TM5

Pixel size:
30m x 30m

0.09 ha

SPOT 4

Pixel size:

20m x 20m

0.04 ha

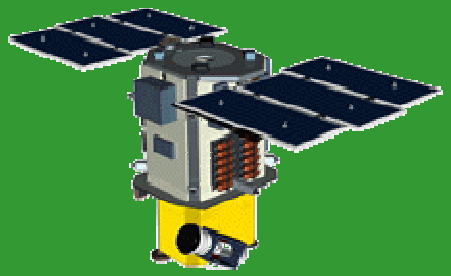
SPOT5

Pixel size:

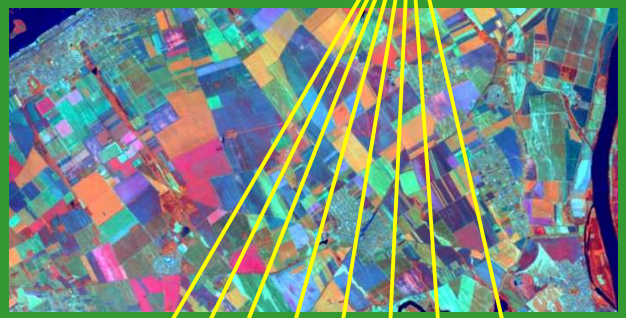
10m x 10m

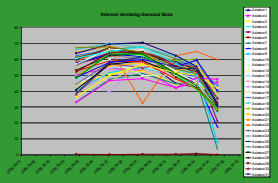
0.01ha

Process of remote sensing ragweed risk maps

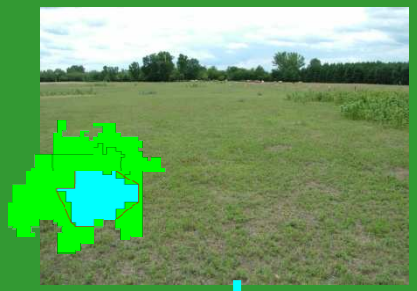


Application process

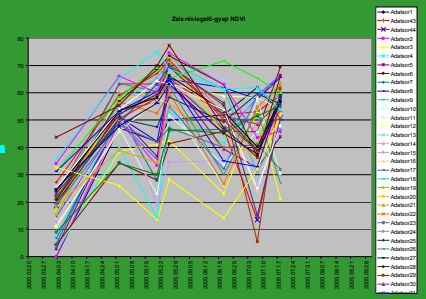


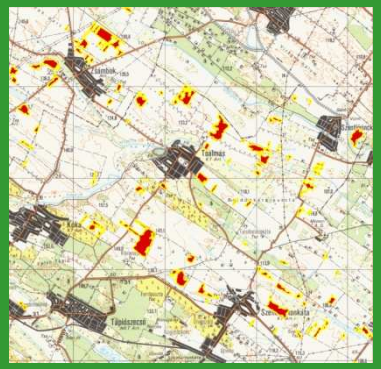


Ground validation



Enhancement calibration



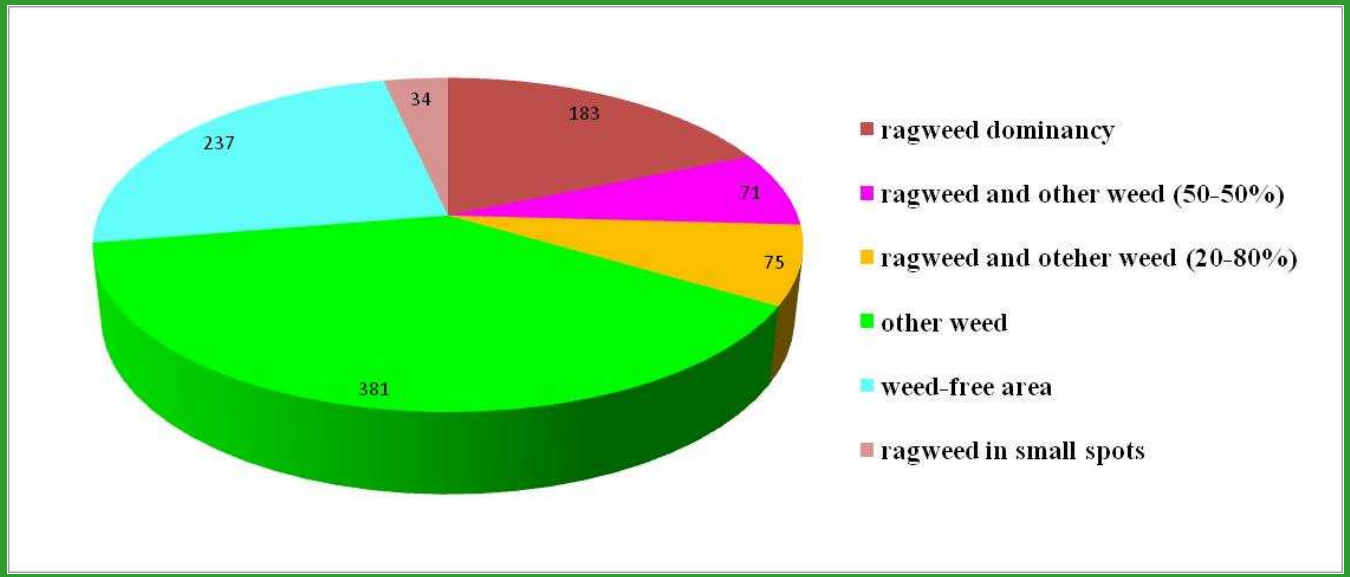


Ragweed risk map

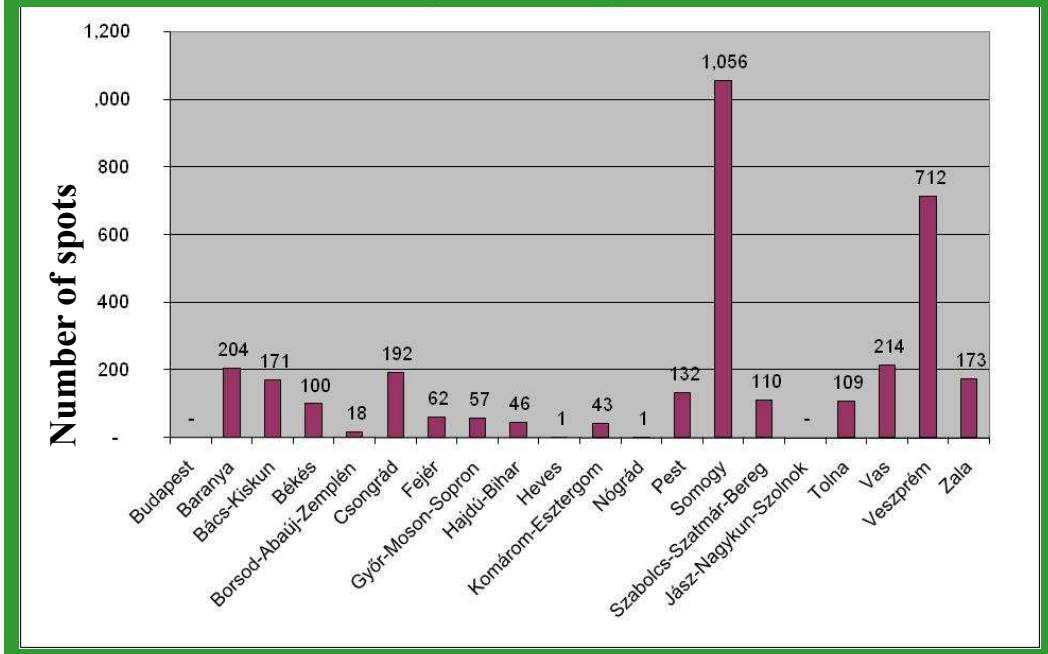
Accuracy assessment, 2011 (before enhancement calibration!)

Result of ground control	#spots	rate (%)
Ragweed dominancy (>50%)	183	19
Ragweed and other weed (50-50%)	71	7
Ragweed and other weed (20-80%)	75	8
Other weed	381	39
Weed-free area	237	24
Ragweed in small spots	34	3
total	**981**	**100**

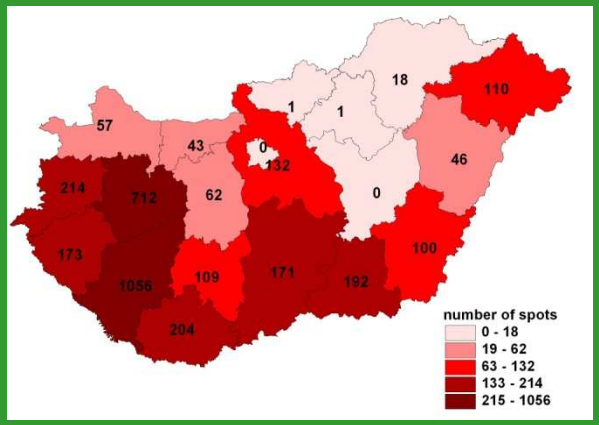
Ragweed occurred in 37% of the spots

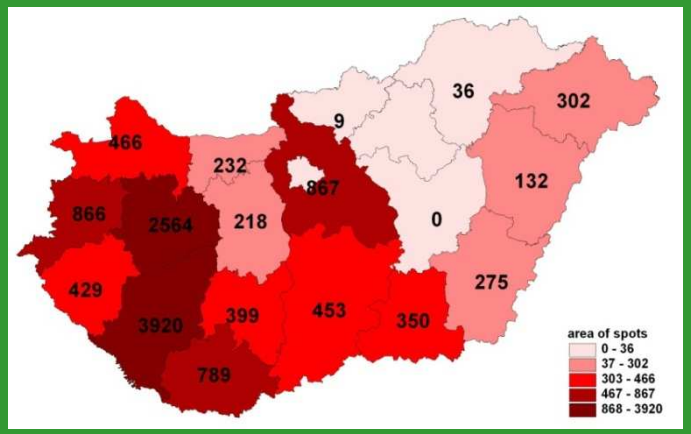


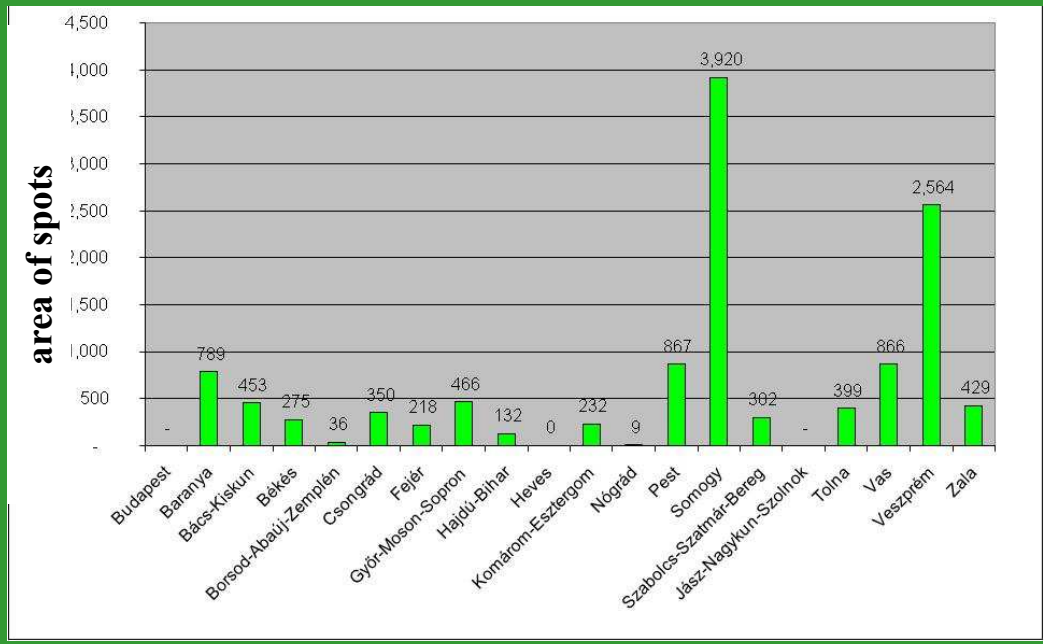
Distribution of registered ragweed spots by counties in 2011



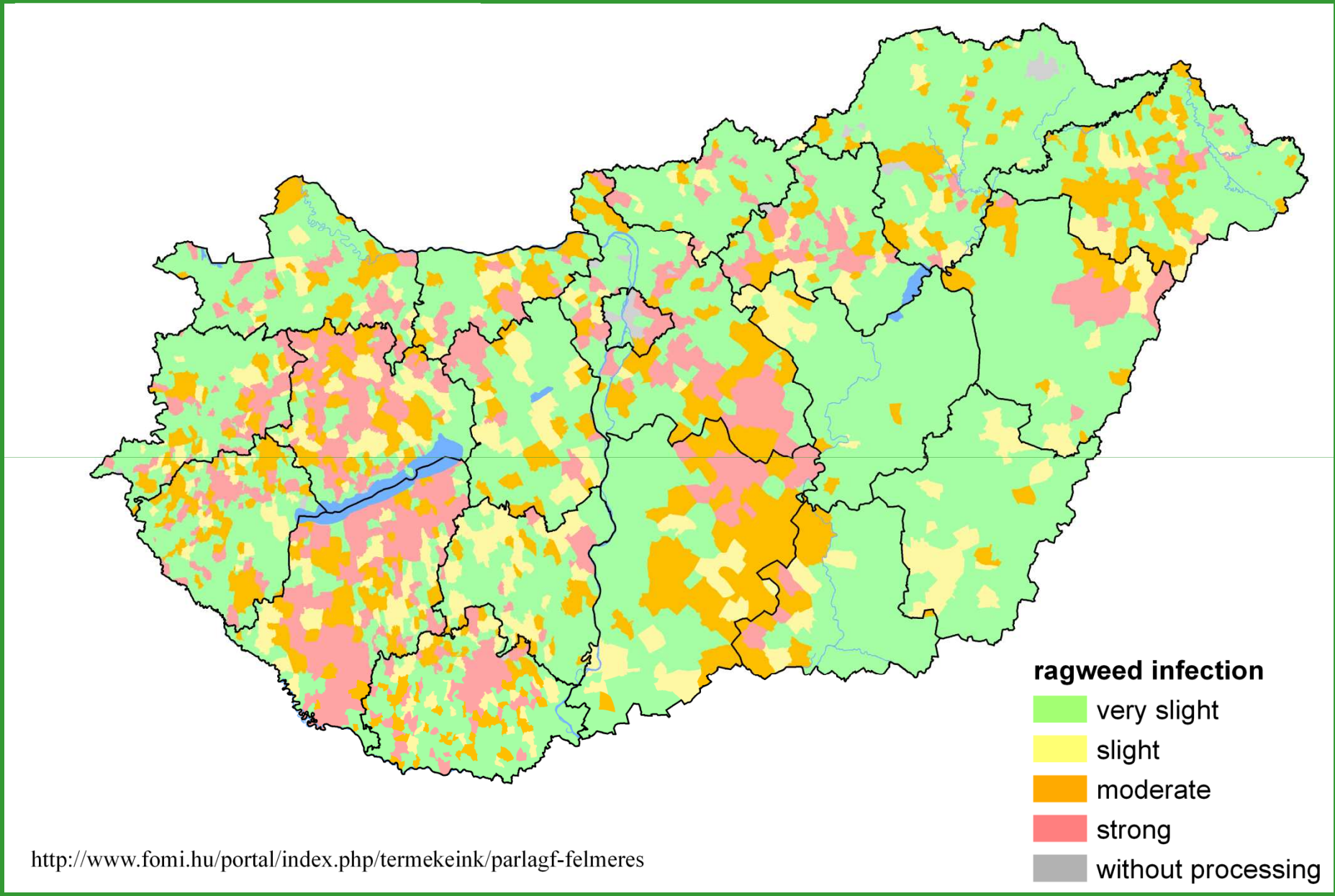
Total: 3559 spots, 12 683 ha





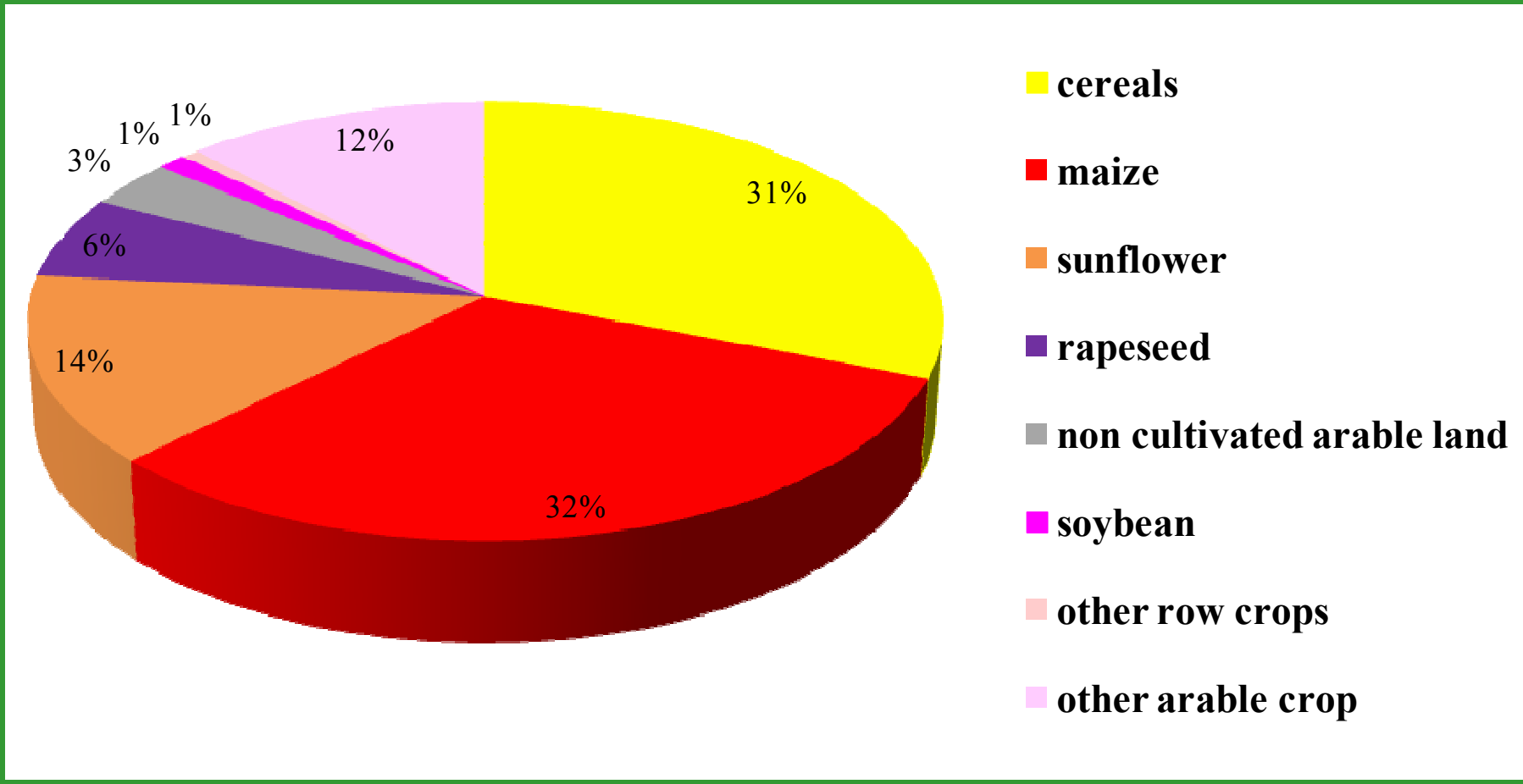


Spatial distribution of registered ragweed spots, 2011

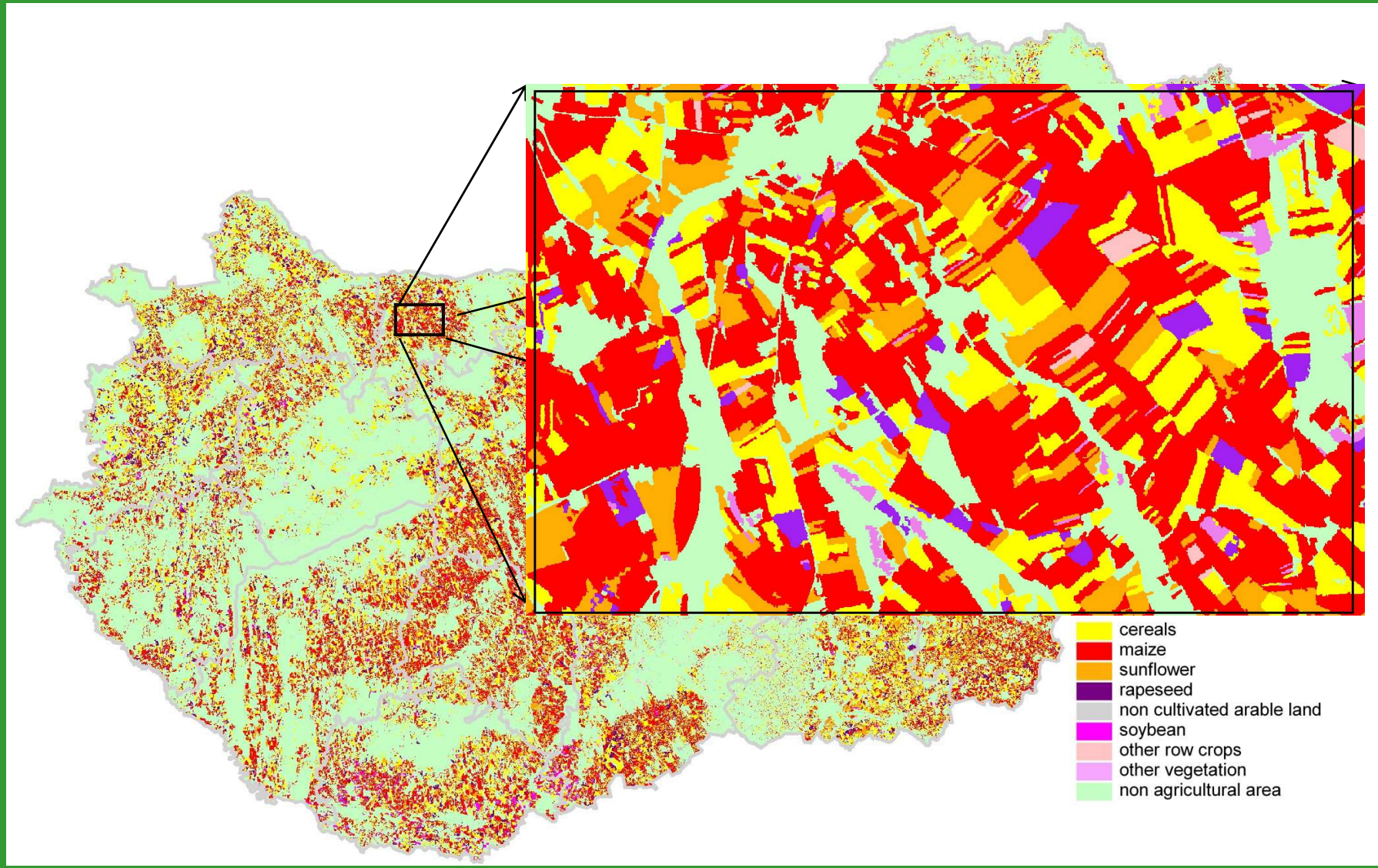


http://www.fomi.hu/portal/index.php/termekeink/parlagf-felmeres

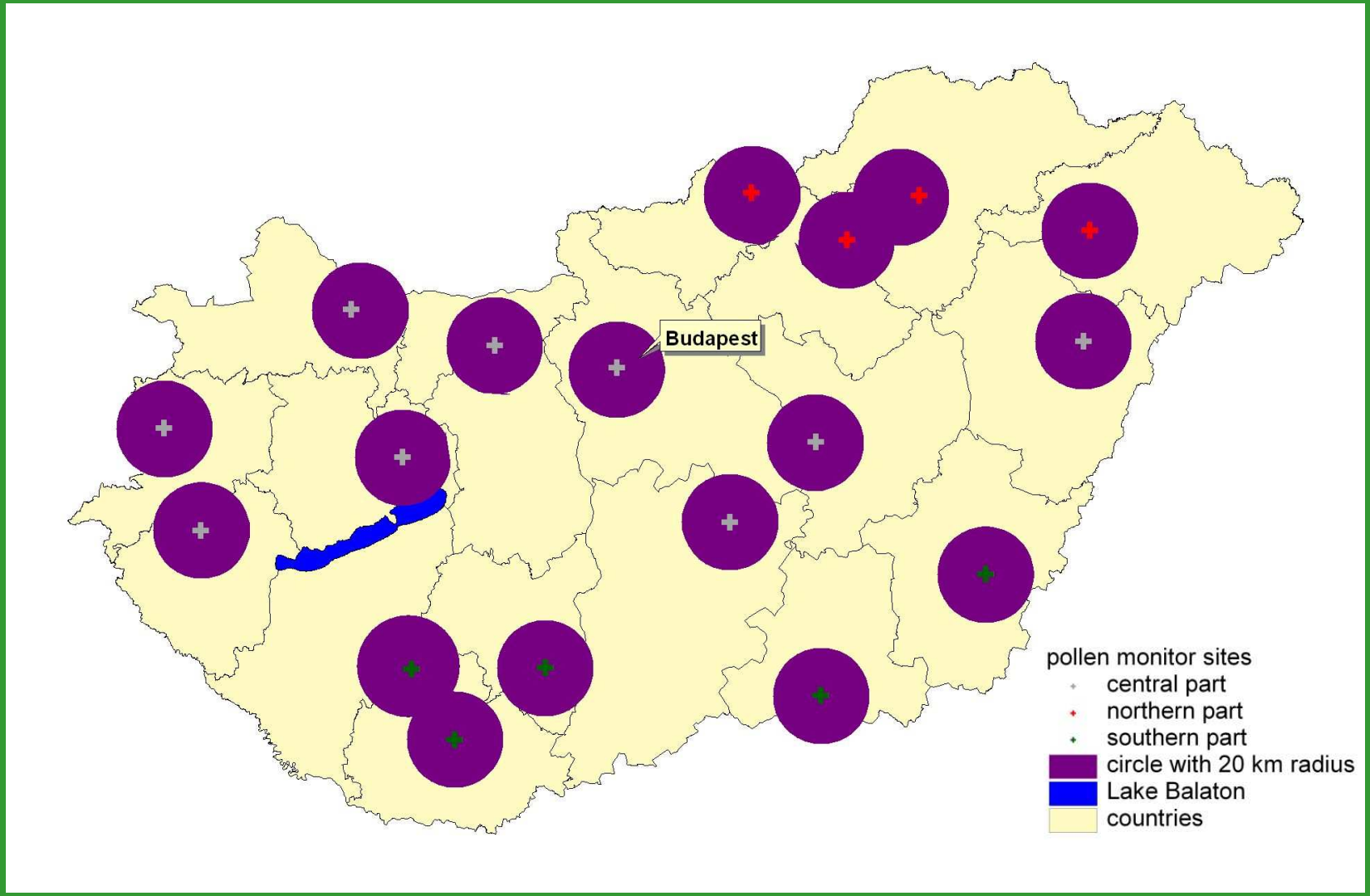
Distribution of agricultural area by most ragweed-risky crop types



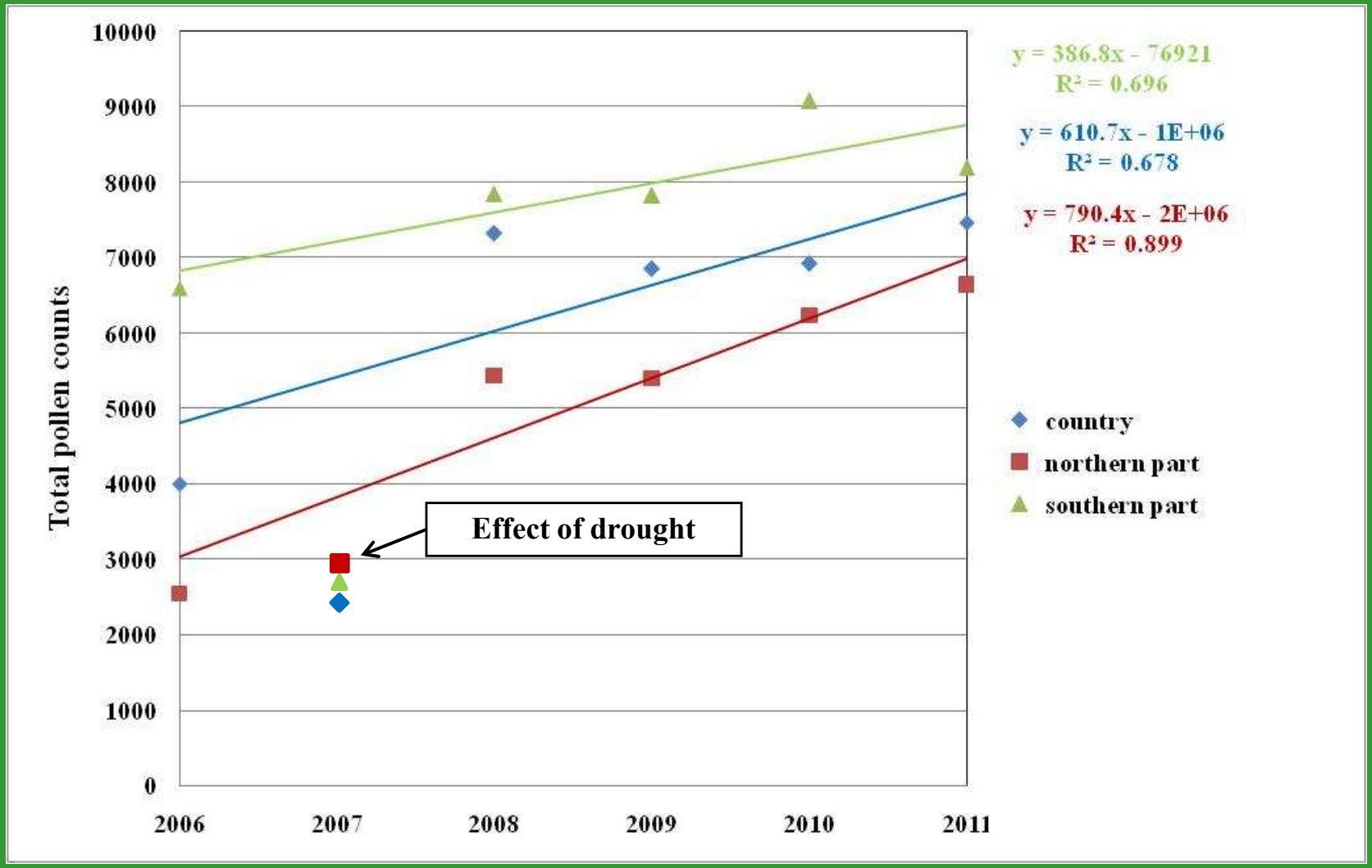
Crop map by Remote Sensing for masking the most ragweed-risky areas



Pollen monitor network in Hungary operated by National Institute of Environmental Health



Total pollen counts between 2006 and 2011



Source of total pollens: National Institute of Environmental Health

Relationship between total pollen counts and different predictor variables by multivariate linear regression model

Predictor variables		description	r: buffer size (km)
Vegetation type	maize	total area of maize within r km radius of pollen monitoring site	20, 30
	cereals	total area of cereales within r km radius of pollen monitoring site	20, 30
	sunflower	total area of sunflower within r km radius of pollen monitoring site	20, 30
	soybean	total area of soybean within r km radius of pollen monitoring site	20, 30
	rapeseed	total area of rapeseed within r km radius of pollen monitoring site	20, 30
Land cover type	forest	total area of forest within r km radius of pollen monitoring site	20
	pasture	total area of pasture within r km radius of pollen monitoring site	20
	vineyard	total area of vineyard within r km radius of pollen monitoring site	20
	orchard	total area of orchard within r km radius of pollen monitoring site	20
Soil type	sandy (good for ragweed)	total area of sandy soil within r km radius of pollen monitoring site	10, 20,30
	saline (bed for ragweed)	total area of saline soil within r km radius of pollen monitoring site	10, 20,30
Validated ragweed spots		total area of ragweed stored in the central ragweed server within r km radius of pollen monitoring site	10,20,30,40

predicted variable	description
Total pollen counts	measured total pollen counts at the pollen monitring site during the pollenation season

Multivariate linear regression model:

Total Pollen Counts vs. (pasture + maize + orchard + sunflower +validated ragweed + vineyard + non cultivated arable land + coordinate of altitude + cereals)

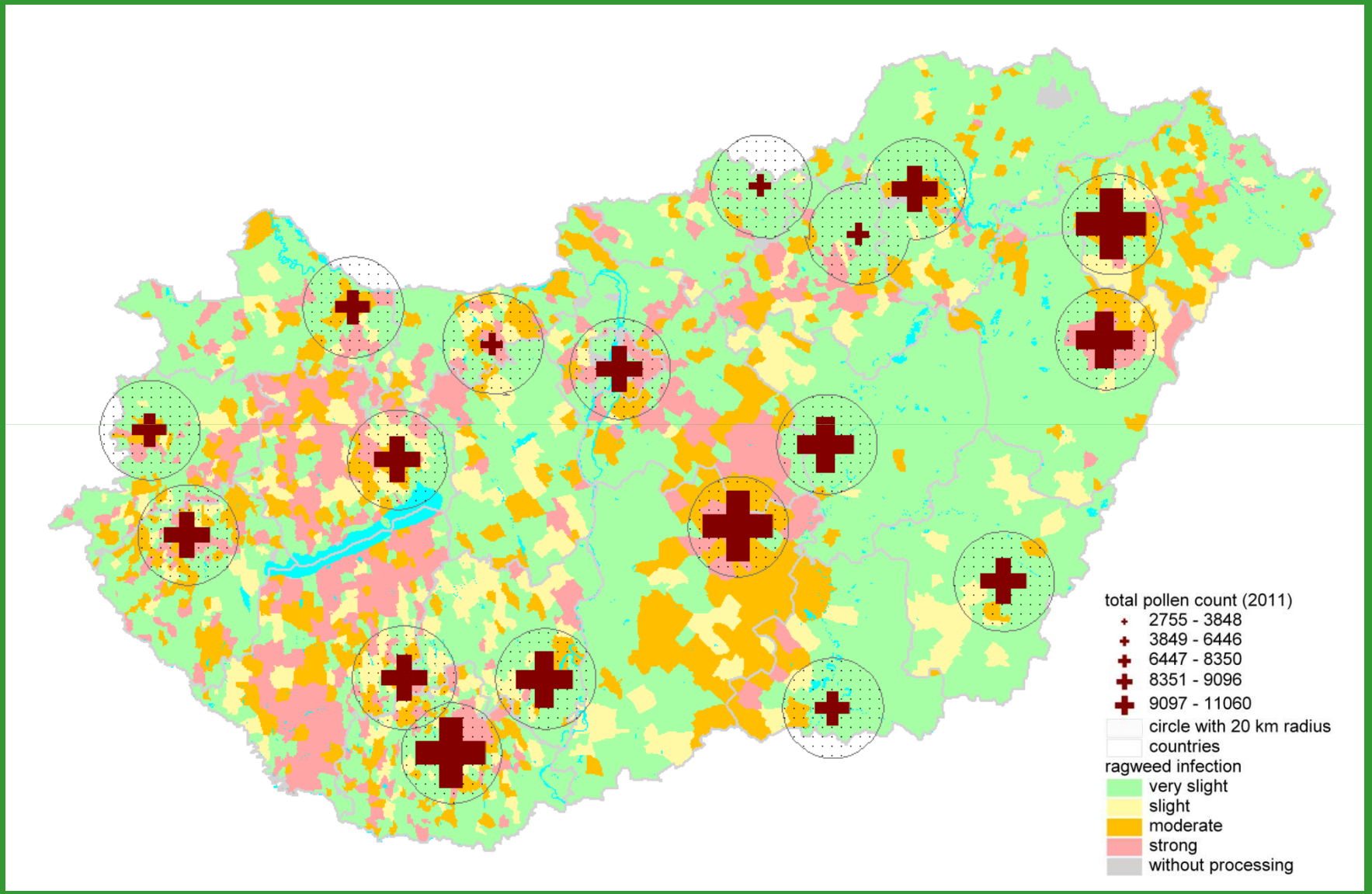
predictor variable	estimate	etd. Error	significance	p-value	code of significance	Effect
pasture_20km	0.61410	0.02915	21.069	0.000000	***	positive
maize on sandy soil_30km	0.17860	0.01044	17.100	0.000001	***	positive
orchard_20km	1.55800	0.09540	16.331	0.000001	***	positive
sunflower_30km	0.07467	0.01431	5.218	0.001228	**	positive
validated ragweed_40km	0.00036	0.00007	5.176	0.001287	**	positive
vineyard_20km	-0.00336	0.00066	-5.093	0.001410	**	negative
non cultivated arable land_20km	0.68440	0.15050	4.548	0.002643	**	positive
coordinate of altitude	-0.00585	0.00133	-4.411	0.003114	**	negative
cereals_20km	0.05889	0.01491	3.950	0.005531	**	positive

code of significance	description
***	p< 0,001
**	0,001 < p < 0,01

Significance of the model:

multiple R^2	Adjusted R^2	significance	p-value
0,9973	0.9938	287,5	0,00000003771

Spatial distribution of registered ragweed spots in 2011 and total pollen count measured in 2011

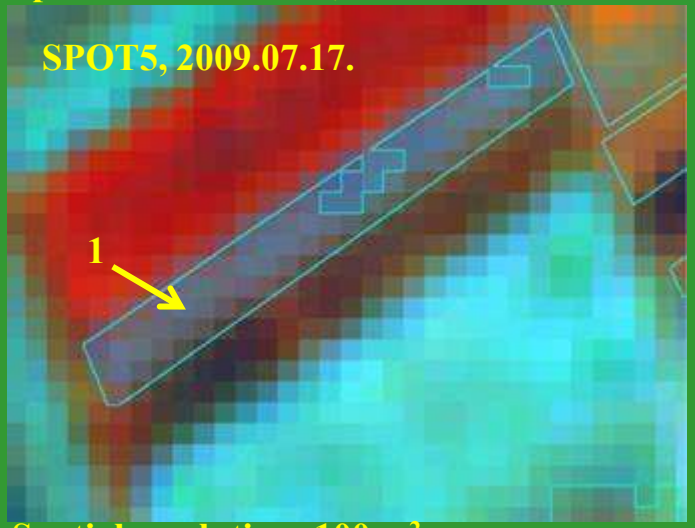


Source of total pollen counts: National Institute of Environmental Health

Ragweed spots in the aerial photography, VHR and HR satellite data

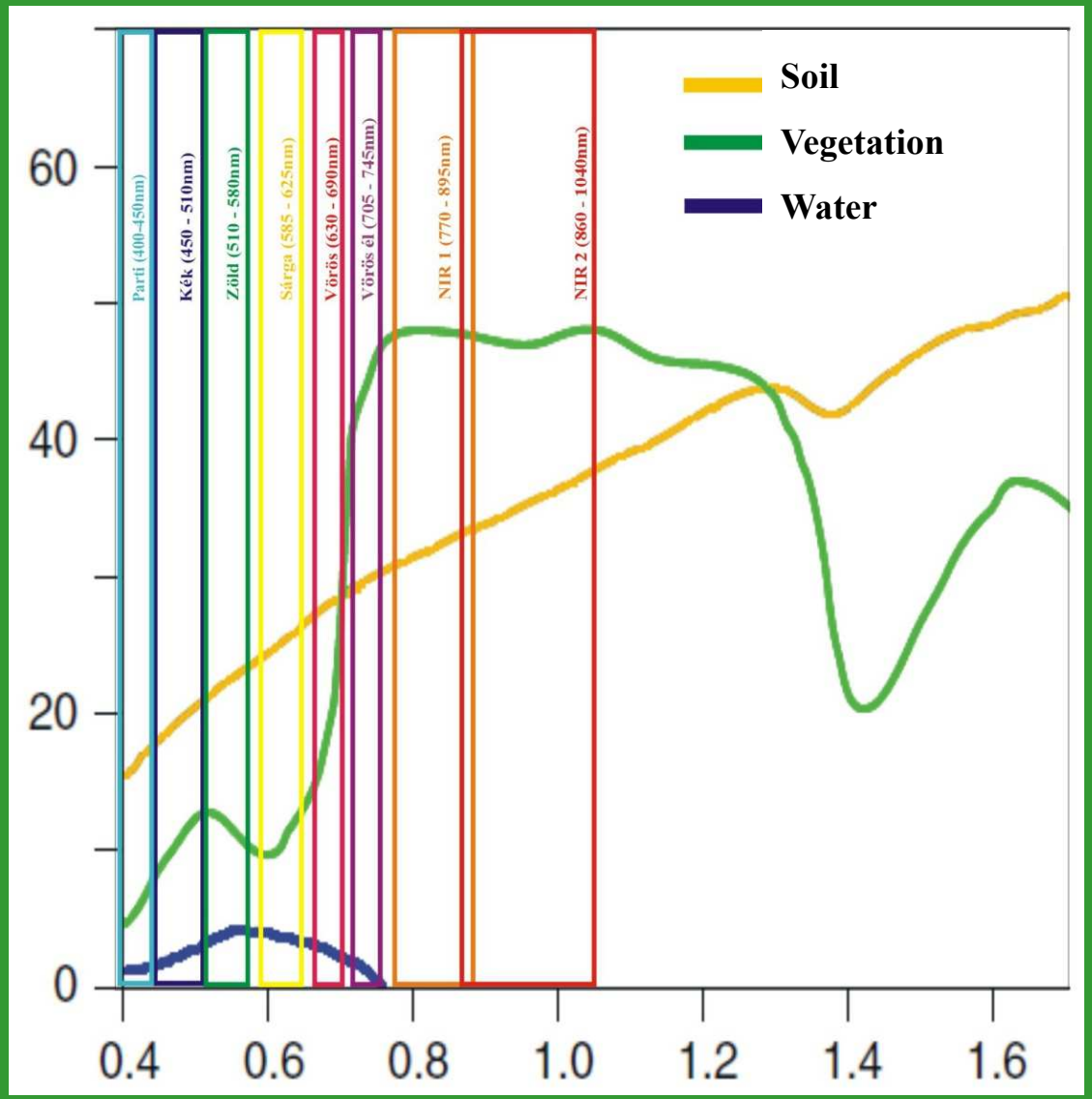
Spatial resolution: 0,16 m^2

Spatial resolution: 16 m^2



Spatial resolution: 100 m^2

WorldView2 characteristics



Excellent spatial and spectral resolution

bands	Wavelength range (nm)
panchromatic	632 – 801
MS 1 (coastal blue)	427 - 453
MS 2 (blue)	478 – 508
MS 3 (green)	546 – 581
MS 4 (yellow)	608 - 627
MS 5 (red)	659 – 689
MS 6 (red edge)	724 – 744
MS7 (NIR 1)	831 – 890
MS 8 (NIR 2)	908 - 954

2 m * 2 m

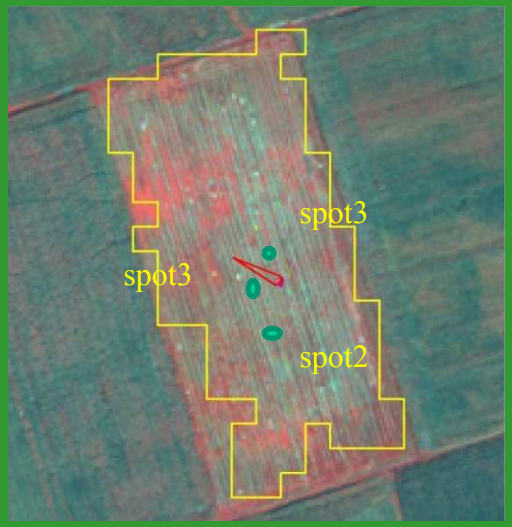
Weed infected cereal stubbles

foxtail

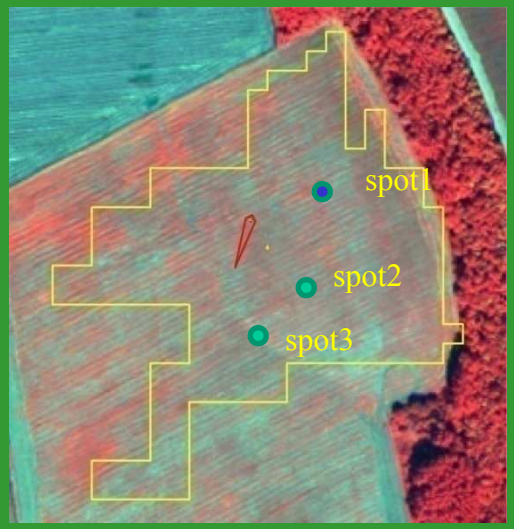
WV2: 22/09/2010

Photo taken on the ground 08/10/2010

Weed infected cereal stubbles



ragweed

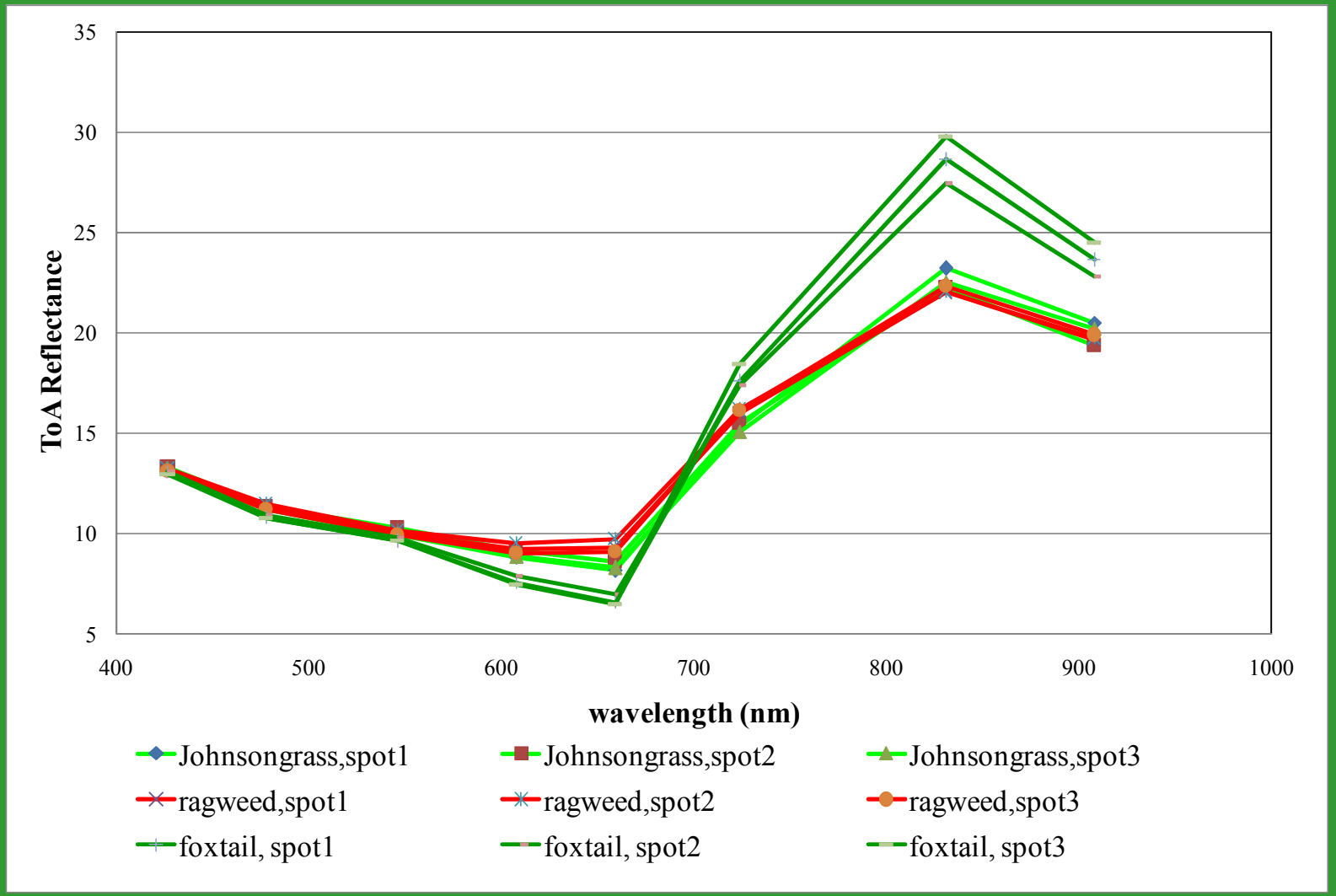


Johnsongrass

WV2: 22/09/2010

Photo taken on the spot (08/10/2010)

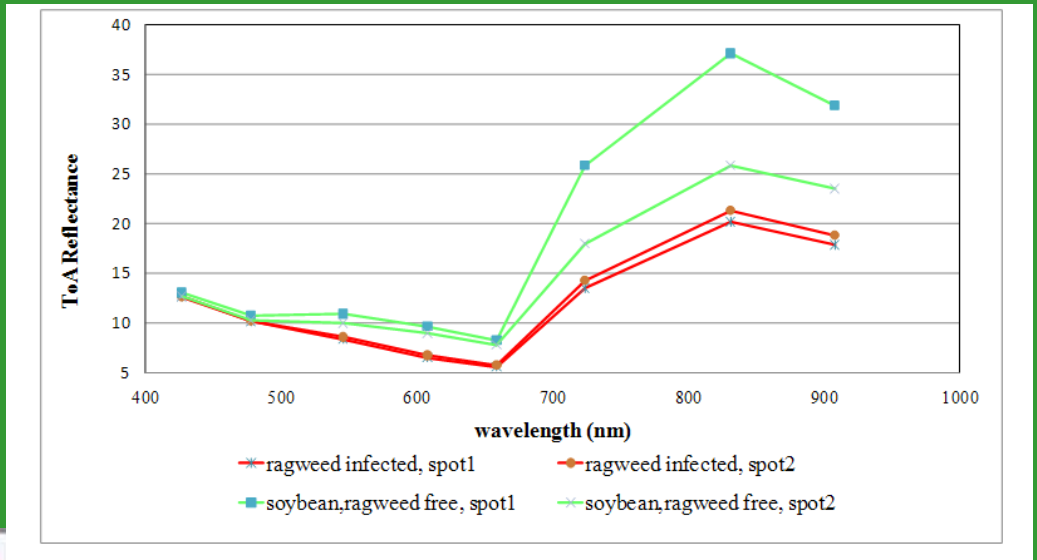
Spectral behaviour of different weed plants measured by WV2 spectral bands



Ragweed infected soybean field

WV2 (22/09/2010)

Photo taken on the spot (07/10/2010)

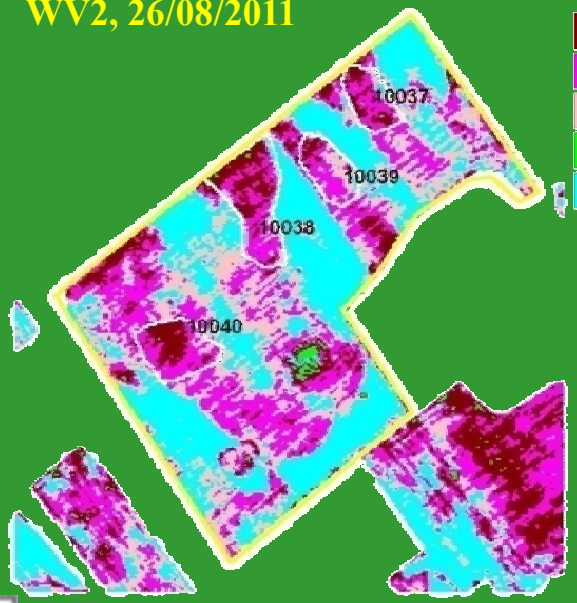


There is a visible difference between ragweed and soybean which reflects in their spectral behaviour

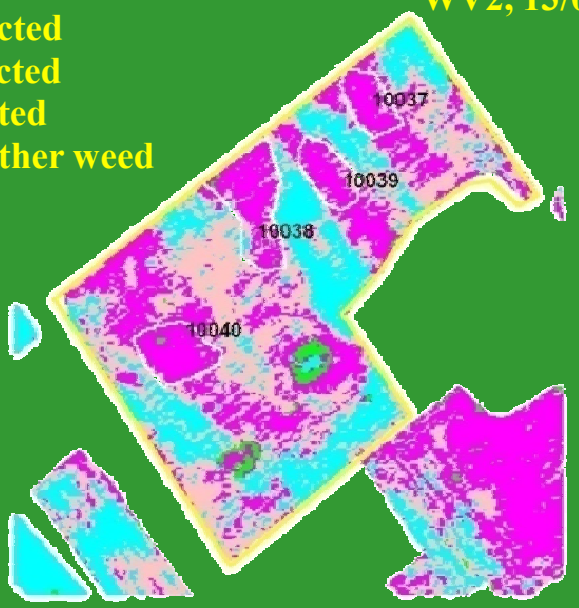
Ragweed infected sunflower fields

WV2, 26/08/2011

WV2, 13/09/2011



- Strongly infected
- Medium infected
- Weakly infected
- Infected by other weed
- Weed-free



Ground assessment of spot „10039” (20/09/2011)

Area type: sunflower stubble
Sunflowers biomass
- **20 plants/m^2**
- **1 m height**

Ragweed biomass
- **40 plants/m^2**
- **1.2 m height**

Coverage:
- **50% ragweed**
- **50% bare soil**

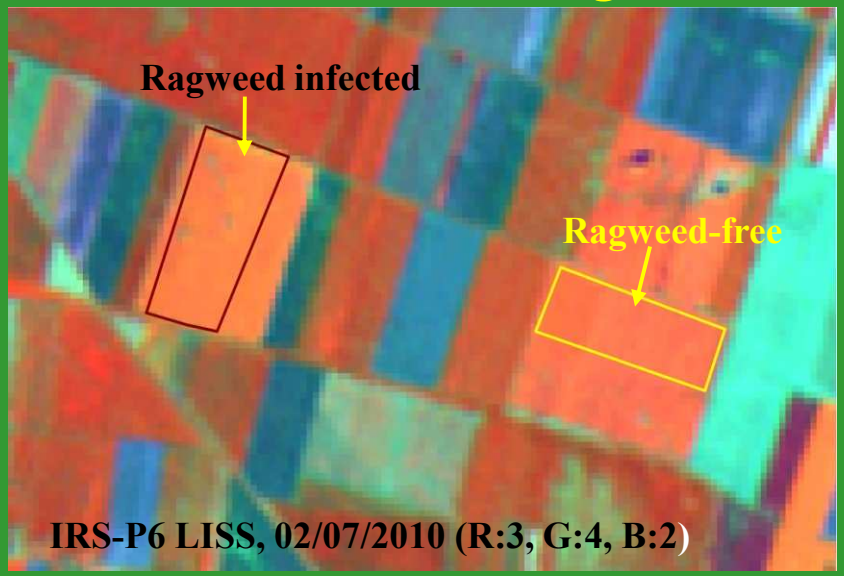
Geometric structure of weed-free and weed infected sunflower fields

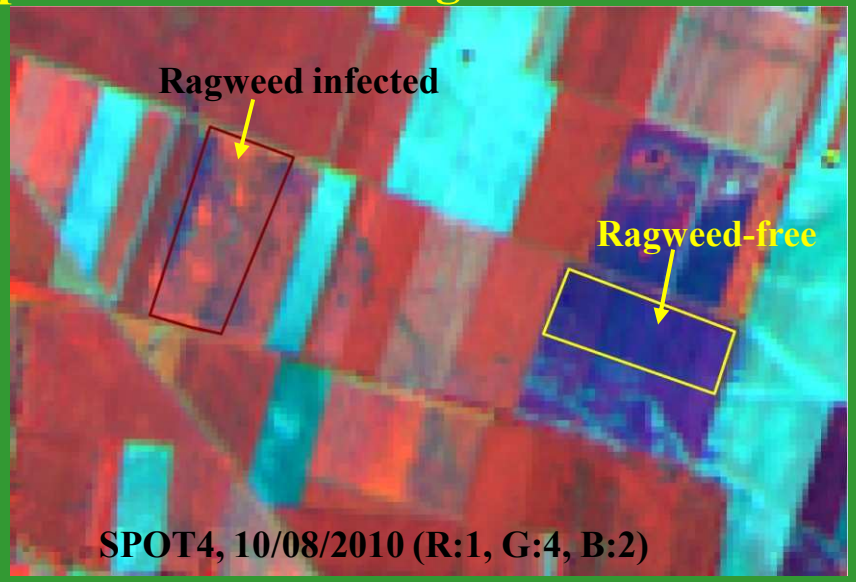
Weed-free

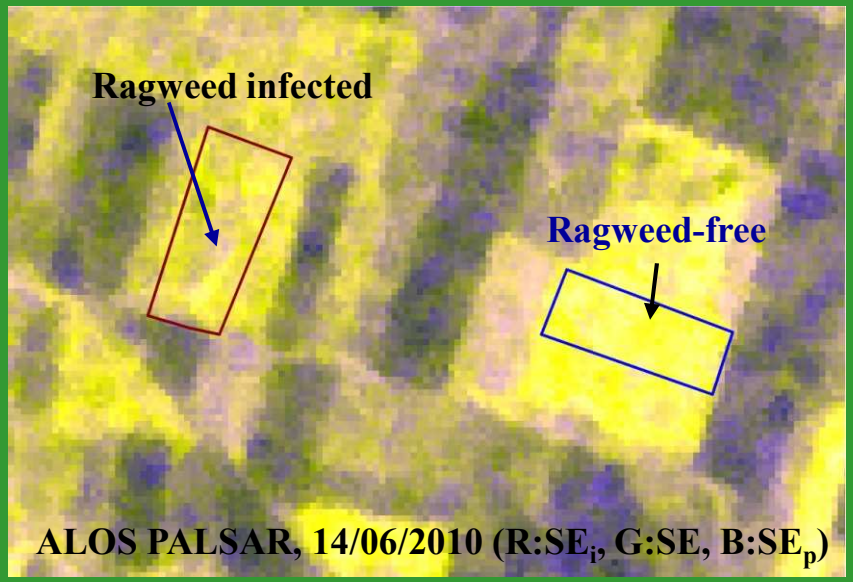
Weed infected

There is a clear difference in geometric structure

Typical ragweed infected and ragweed-free sunflower parcel in optical and radar satellite images and the photo taken on the ground







Shannon entropy* consists of two components:

$$SE = SE_I + SE_P$$

$$SE_I = 2\log\left(\frac{\pi e Tr[C2]}{2}\right) \qquad SE_P = \log\left(4\frac{det[C2]}{Tr[C2]^2}\right)$$

where: SE_I: intrinsic degree of coherence
SE_P: degree of polarization
C2: 2*2 complex covariance matrix of the partially polarised wave

Sketch of the methodology applied

Optical satellite image time series

Generation of vegetation index map

Vegetation index map

Evaluation of vegetation index map

Ragweed-free reference spots

Polarimetric radar data

H-A-Alpha decomposition

Polarimetric descriptors, Shannon entropy

Evaluation of polarimetric descriptors and reference spots

Features characterizing structure of ragweed-free and ragweed infected spots

Efficiency analysis by Welch test

Ranking of polarimetric descriptors

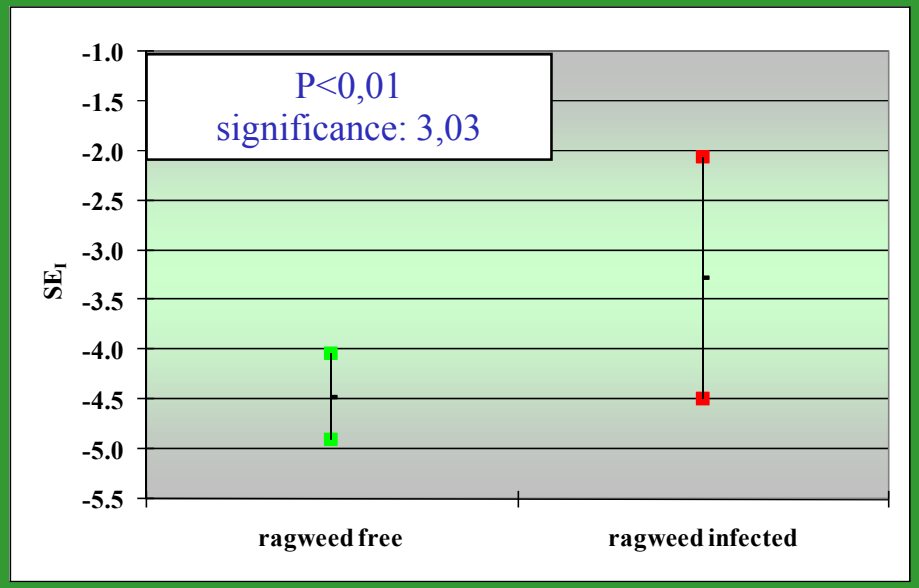
Ragweed infected reference spots

Central Ragweed Server

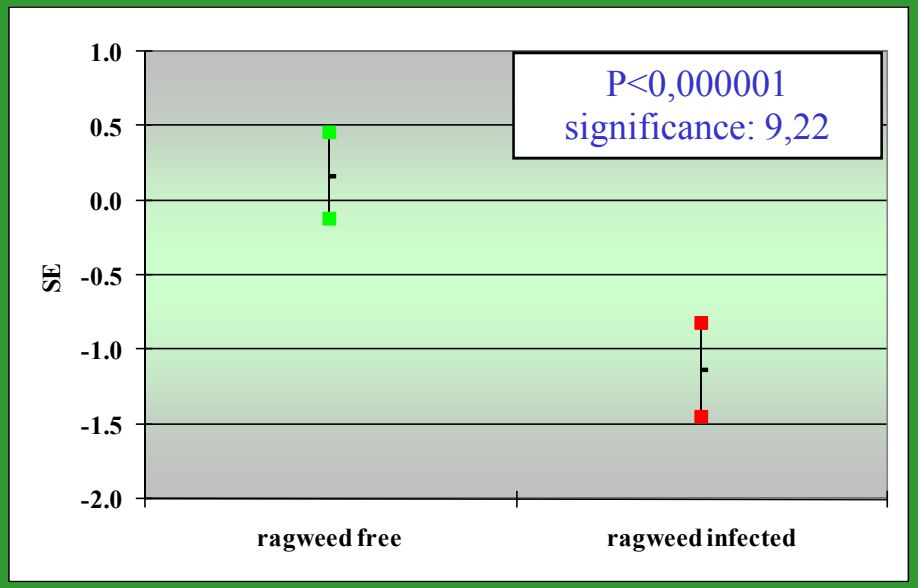
Typical spectral behavior of ragweed infected and ragweed-free reference sunflower plots derived from optical satellite image time series

Efficiency analysis of separation in ragweed-free and ragweed infected sunflower spots

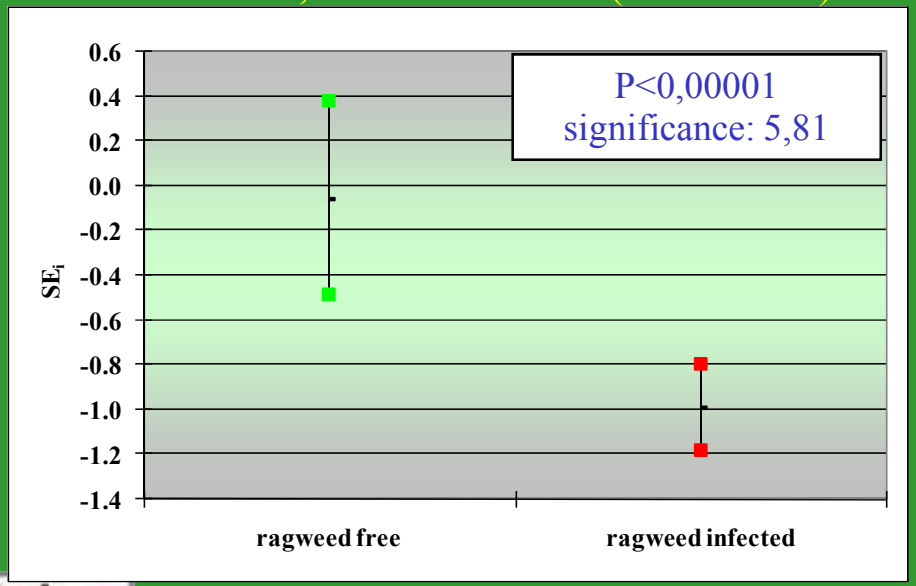
Bács-Kiskun site, ALOS PALSAR (02/06/2010)



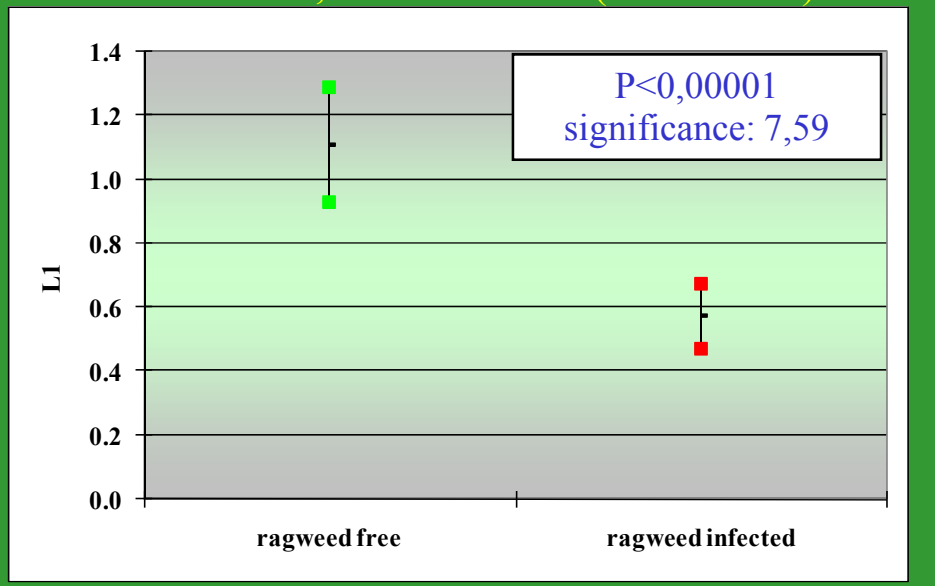
Bács-Kiskun site, RADARSAT2 (19/07/2010)



Békés site, ALOS PALSAR (14/06/2010)



Békés site, RADARSAT2 (13/07/2010)



Summary

- Acquisition of ground reference data is an essential base of the remote sensing analysis.
- The major problems are caused by the fact that ragweed infection shows spot-like structure, covering agricultural fields heterogeneously.
- This fact required searching for satisfying methods for obtaining ground reference data and introduction of new methods in processing remote sensing data.

Conclusion

- Applying optical **Very High Resolution** satellite images to map spottiness, we managed to narrow down notably the number of kinds of weeds which cannot be spectrally separated from ragweed.
- Identification of ragweed infected Row-Crops parcels, which is extremely endangered by ragweed, was carried out successfully by using **Polarimetric Radar** satellite images, because the geometric structure of the crop and the ragweed significantly different.

Thank you for your attention