REGULATION OF VEGETATION ON LANDS WITH PHOTOVOLTAIC POWER PLANTS

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Abstract: This paper deals with the evaluation of weed species diversity on chosen land with photovoltaic power plant. At the same time, the impact of different regulatory interventions on the species diversity is observed. The area is located in South Moravia, Brno-country district in the village Unin. Evaluation of vegetation was carried out by method of phytocoenology relevé. Three different types of maintenance was performed on selected frames, without any intervention for the first one, second one with herbicide application and third one prepared by string trimmer. The obtained data were processed by multivariate analysis of ecological data segment analysis DCA (Detrended Correspondence Analysis) and canonical correspondence analysis CCA (Canonical Correspondence Analysis). We consider species *Cirsium arvense*, *Tanacetum vulgare*, *Salix triandra*, *Salix alba*, *Anthriscus sylvestris* as problematic for the operation of photovoltaic power plant. These species may be difficult for operation of the power plant if the maintenance is not regular.

Key Words: weeds, photovoltaic power plant, phytocoenology relevé

INTRODUCTION

Photovoltaics originates from two words, one from Greek phos (light) and the name of the Italian physicist Alessandro Volt. The photovoltaic effect was first described by Edmond Becquerel. First selenium solar cell with a thin layer of gold, which efficiency was below 1%, was constructed (Charles Fritts) in 1883. Albert Einstein described this phenomenon physically in 1904 and was awarded with the Nobel Prize in 1921 (Ministry of Regional Development 2014). The gradual development of photovoltaics has been observed since 1980, when the US installed power around 3MW. The number of installed power increased to 25 MW within five years (Lodhi 1995). According to figures of the Energy Regulatory Authority (2014), there has been a significant increase in installed photovoltaic power in in Czech Republic in 2010.

The reason for the massive expansion of renewable energy is to reduce emissions particularly CO_2. The boom of photovoltaics is still awaited. One kWh produced from solar sources will save 0.6–1 kg of CO_2. The solar industry supports the environment and also provides work for several thousands of people (Tsoutsos 2005).

The photovoltaic panel is very sensitive to a number of factors. An essential factor is shading. Just a single weak solar cell in the entire panel and power will be limited to the performance of the weakest cell. The only overshadowed panel can reduce the performance of the whole loop (MLAB 2012). Shading may be caused by the small distance of the module from the fence, surrounding trees or too tall plants. Therefore, it is necessary that the operator keep the maintenance of the area. Otherwise, it runs the risk of financial loss (Rehak et al. 1998).

The options of weed regulations are several. Mulching is the process of covering the soil surface with the organic material to a height of at least 3 centimeters. Chopped grass can be an organic material. We use mulch as soon as possible during the vegetation period until the weeds are too small. Coverage of the soil layer with organic material makes impossible the supply of solar radiation and thereby reduces their further growth (Urban, Šarapatka 2003).

Biological weed control is the most natural and least intrusive at all. The advantage here is the process of self-regulation. This means, more weeds occur, than more their pests we can observe. Some insects and fungal parasites can destroy certain weed species under certain conditions (Deyl 1964).

An important regulator of weeds, outside of arable land, are sheeps. More and more operators of solar power plants use their quality grazing (Respol 2014).

Herbicides are substances with phytotoxic effects. The effect consists in tissue damage or block the vital processes in the plant. Herbicides contain besides active substance (phytotoxic compound) as well as various fillers, emulsifiers, solvents and colorants for better storability and dilutability. To improve the effect of the use of so-called. Adjuvants are used to improve the effect of use (Dvořák, Smutný 2008).

This paper deals with the evaluation of weed species diversity on chosen land with photovoltaic power plant. At the same time, the impact of different regulatory interventions on the species diversity is observed. Evaluation of the impact of regulatory interventions on the species diversity and determination of difficult controllable weed species will be the result of this research.

MATERIAL AND METHODS

Characteristics of the area

The monitored area is located in the South Region, Brno-country district, in the village Unin, which is located northwest from Brno city. Climate region is moderately warm and humid. With an average annual temperature of 6–7°C and an annual precipitation with 650–750 mm.

The entire plant is located on a total land area of 18.147 m^2, of which 2.593 m^2 consisted of arable land and 2.373 m^2 were permanent grassland. The rest consists of other areas. Unin photovoltaic power plant was put into operation in 2010. Installed capacity is 0.627 MW.

Evaluation of vegetation and statistical processing

Evaluation of vegetation was performed by method of phytocoenology relevé in three periods of observation. The size of each relevé was 20 m^2. Each image was first performed for determination of the plant species and subsequently was assessed their coverage.

Places of individual relevé were selected in different conditions within the monitored land. Three different types of maintenance were carried out, the first one without intervention, a second one with application of herbicide and third one prepared by string trimmer. Czech and Latin names of each weed species were used according to Kubát (2002).

The obtained data were processed by multivariate analysis of ecological data segment analysis DCA (Detrended Correspondence Analysis) and canonical correspondence analysis CCA (Canonical Correspondence Analysis). A total number of 499 permutations were calculated in Monte-Carlo test. Collected data were processed by a computer program called Canoco 4.0 (Ter Braak 1998).

RESULTS AND DISCUSSION

A total of 57 weed species of has been identified, this indicates species community strongly varied. The average coverage of weed species is shown in Table 1.

The obtained data about frequency and coverage were initially processed by the DCA analysis which determined the length of the gradient, and it was 3.528. Based on this calculation was for further processing selected canonical correspondence analysis CCA. Analysis CCA defines the spatial arrangement of plant species and selected environmental factors. This is subsequently graphically expressed by the ordination diagram. Weed species and different habitats are shown by points of different shape and color.

Table 1 The average weed coverage under different variants of maintenance

Species	Abbreviations	Type of maintenance		
		Without intervention	Herbicide applications	Mowing
Acer campestre	*Ace camp*			0.13
Achillea millefolium	*Ach mill*	3.13	13.33	0.75
Alopecurus pratensis	*Alo prat*		1.67	
Anthemis arvensis	*Ant arve*	0.81		
Anthoxanthum odoratum	*Ant odor*		0.67	3.75
Anthriscus sylvestris	*Ant sylv*		0.33	
Apera spica-venti	*Ape spic*	33.75	1.33	
Armoracia rusticana	*Arm rust*	1.13	0.33	
Calamagrostis epigejos	*Cal epig*		3.33	20.00
Capsella bursa-pastoris	*Cap burs*		7.00	
Cirsium arvense	*Cir arve*	1.00	30.00	22.63
Crepis biennis	*Cre bien*		0.67	0.13
Dactylis glomerata	*Dac glom*	11.88	28.33	55.00
Digitaria sanguinalis	*Dig sang*	31.88		
Epilobium ciliatum	*Epi cili*	3.13		
Equisetum arvense	*Equ arve*	0.63		0.75
Erigeron annuus	*Eri annu*		1.67	
Fallopia convolvulus	*Fal conv*	0.63		
Festuca rubra	*Fes rubr*	3.75		42.50
Fragaria vesca	*Fra vesc*	1.88	6.67	
Galium aparine	*Gal apar*	0.63	38.33	10.00
Geranium pusillum	*Ger pusi*	6.25		
Chelidonium majus	*Che maju*		0.67	
Chenopodium album	*Che albu*	3.13		
Impatiens parviflora	*Imp parvi*		1.67	1.25
Lamium album	*Lam albu*			17.50
Lamium purpureum	*Lam purp*	5.00	1.67	
Lathyrus pratensis	*Lat prat*	0.13		
Leucanthemum vulgare	*Leu vulg*	0.38		
Lolium perenne	*Lol pere*			2.50
Medicago lupulina	*Med lupu*		5.00	30.00
Phleum pratense	*Phl prat*			3.00
Plantago major	*Pla majo*		1.67	
Plantago media	*Pla medi*	0.63	1.67	0.25
Prunus domestica	*Pru dome*		0.17	
Ranunculus acris	*Ran acri*		0.67	
Rosa canina	*Ros cani*		2.00	1.25
Rubus idaeus	*Rub idae*	1.88	3.33	1.25
Rumex crispus	*Rum cris*		1.00	2.50
Salix alba	*Sal alba*	0.25	0.50	
Salix cinerea	*Sal cine*	0.75		
Salix triandra	*Sal tria*		0.67	
Sambucus nigra	*Sam nigr*	0.06	10.00	2.50
Senecio vulgaris	*Sen vulg*		26.67	0.75
Solanum nigrum	*Sol nigr*		0.33	
Sonchus oleraceus	*Son oler*	0.63		1.25
Tanacetum vulgare	*Tan vulga*	5.00	27.00	11.50
Taraxacum officinale	*Tar offi*	34.38	25.00	36.50
Trifolium hybridum	*Tri hybr*	20.00		
Trifolium pratense	*Tri prat*	1.88		
Trifolium repens	*Tri repe*	23.13	16.67	
Tussilago farfara	*Tus farf*	0.63	0.33	
Urtica dioica	*Urt dioi*	1.25	33.33	10.00
Urtica urens	*Urt uren*	1.38	10.67	35.00
Vicia cracca	*Vic crac*		3.33	1.25
Vicia sepium	*Vic sepi*	11.38		
Viola arvensis	*Vio arve*		3.33	

Influence of the control method on the frequency of occurrence and species abundance was according to the CCA analysis significant at the significance level α = 0.002 for all canonical axes. The results are statistically highly significant. According to the ordination diagram (Figure 1) plant species can be divided into several groups. The first group of species have more and frequently occurred on a variant without treatment with stable panels, where originally was arable land: *Trifolium repens, Tussilago farfara*, *Lamium purpureum L., Armoracia rusticana, Apera spica-venti, Trifolium pratense, Leucanthemum vulgare Lam., Trifolium hybridum, Chenopodium album, Digitaria sanguinalis, Epilobium ciliatum, Vicia sepium, Fallopia convolvulus, Salix cinerea, Geranium pusillum, Lathyrus pratensis, Anthemis arvensis.*

The second group of species have occurred on a variant with herbicide application and it were species: *Tanacetum vulgare, Urtica dioica, Galium aparine, Vicia cracca, Sambucus nigra, Crepis biennis, Senecio vulgaris, Plantago major, Salix triandra, Chelidonium majus, Anthriscus sylvestris, Ranunculus acris, Capsella bursa-pastoris, Solanum nigrum, Prunus domestica, Alopecurus pratensis, Erigeron annuus, Viola arvensis.*

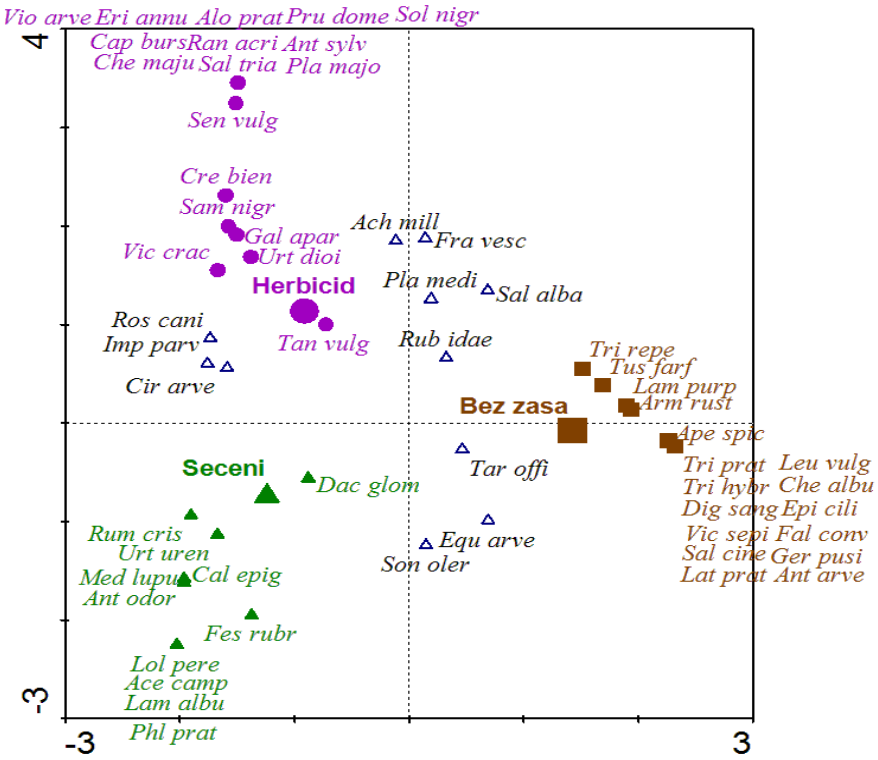
The third group of weed species was more often identified on the variant of mowing: Dactylis glomerata*, Rumex crispus, Urtica urens, Medicago lupulina, Calamagrostis epigejos, Anthoxanthum odoratum, Festuca rubra, Lolium perenne, Acer campestre, Lamium album, Phleum pratense.*

Effect of selected type of weed control had a very significant impact. Species as shepherd's-purse and common groundsel and others were recorded on a variant with herbicide application. Conversely species as common dandelion, common horsetail and common sow thistle are strictly occurred outside the area exposed to the herbicide.

Species as cock's-foot, perennial rye-grass, annual nettle and others were present on relevé exhibited to the influence of mowing.

Species as ox-eye daisy, Dutch clover, hairy crabgrass, windgrass and others were found on relevé without any treatment.

Figure 1 Ordination diagram expressing the effect of regulation methods on the occurrence and coverage of found plant species



Legend: Variant of maintenance: Herbicid means the control with herbicide applications. Seceni is the control by mowing – mulching or with string trimmer. Bez zasa means without intervention, plants were left without control.

CONCLUSION

Based on the observations we can classified as this species as heavily regulated: creeping thistle, which is heavily regulated herbicide in case of excessive growth. It must be applied herbicide of a greater concentration. At the same time, if we regulate the incidence by mowing, then the vegetation of thistle causes extreme burden on mulching machines.

Common tansy is another problematic species. Here again, if we let overgrow plants above one meter, it is a strong burden on mowing equipment.

As problematic plants for operation of photovoltaic plants we consider these species: *Cirsium arvense*, *Tanacetum vulgare*, *Salix triandra*, *Salix alba*, *Anthriscus sylvestris*. Weeds may be difficult for operation of the power plant in case of irregular maintenance. If weeds overgrow over one meter, they can cause shading of photovoltaic panels. This creates a place called hotspot, a part of the panel, which is excessively hot and will reduce the production of electricity. As a result, not only the investor loses profits, but if the problem persists for some time, it can lead to permanent damage of the photovoltaic panel.

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