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### RESEARCH ARTICLE

#### INVASIVE PLANT SPECIES IN SHUMENSKO PLATO NATURAL PARK (NORTHEASTERN BULGARIA).

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#### Abstract

An investigation of the invasive plants distributed on the territory of the Shumensko Plato Natural Park was carried out for the first time. As a result, 19 invasive plant species were identified. The described species originate in different parts of the world, mainly in North America. The number of affected habitats is 14. In most habitats *Ailanthus altissima* and *Robinia pseudoacacia* are invading. Both species also have the highest count: 24,680 individuals of *Ailanthus altissima* and 5,628 individuals of *Robinia pseudoacacia*. In terms of biological type, most species are shrubs and annual herbaceous plants. In terms of life forms, the largest group is the group of phanerophytes that includes 11 tree and shrub species. The majority of invasive plants (12 species) are propagated simultaneously in two ways: by seeds and vegetatively. The main reason for the wide spread of invasive plants in the Park is their introduction as decorative plants or forest crops. Another reason is the transportation of fruits or seeds by vehicles. The authors recommend immediate measures to control the numbers and spread of invasive species in order to completely eradicate them from the Park territory. It is necessary to monitor the affected habitats for several years in order to prevent the invasive species' reoccurrence.

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#### Introduction:-

More than 10,000 foreign species are known in Europe, of which approximately 10-15% are potentially hazardous to biodiversity. In Bulgaria were distributed 734 foreign species of higher plants (17.89% of the high flora of Bulgaria) according to data provided by DAISIE (Delivering Alien Invasive Species Inventories for Europe) [1]. 60 of these species are described as invasive [2], but their number is greater. Once alien species come to natural or semi-natural habitats and ecosystems, they begin interacting with native species and affecting local biodiversity. The invasive alien species threaten human health (some of them cause allergies) or engender serious economic damage (weeds or pests in agricultural and forestry crops).

The Shumensko Plato Natural Park has been an object to diverse research studies, yet the invasive plants at its territory have not yet received attention. The purpose of the present study is to investigate the variety of invasive plants on the territory of the Natural Park. With this study, the authors hope to expose the existing problem with invasive plant species and to contribute to preserving the natural state of the flora and natural habitats in the Park.

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The Shumensko Plato Natural Park is located in the southeastern part of the Danube Plain (Figure 1) and occupies an area of 3,929.9 ha. It is situated in the eponymous and most representative plateau in Northeastern Bulgaria, which is part of the Shumenski Heights. It aims at preserving valuable plant and animal communities as well as preserving the great diversity and beauty of places suitable for recreation and tourism [3, 4].



**Figure 1:-** Geographical position of Shumensko Plato Natural Park, marked with a yellow point in the eastern part of the Balkan Peninsula (map of Europe at the bottom right)

The relief is typically flat. In the central part of the plateau is the highest point, Turnov Dyal Peak (Turnov Tabia) with a height of 501.9 m above sea level. Its average altitude is about 350 m and its area is 73 km<sup>2</sup>. River waters emerge at the periphery of the plateau and flow into several radially oriented small rivers with typical underground karst sustenance. It has a characteristic soil diversity and original soil cover, including 4 types and 13 subtypes of soils [4].

About 90% of the Park's territory is covered by forests. Most prevalent among the forest vegetation are the mesophyte and xeromesophyte forests dominated and co-dominated by *Carpinus betulus* and *Quercus dalechampii*. They belong to root vegetation, although many of them are highly influenced by human activity and have an offspring origin. Besides these, there are thermophilic beech forests on limestone and mixed thermophilic oak forests. Among the bush communities, secondary communities dominated by *Paliurus spina-christi* are the most

common. Grass vegetation is represented by haemophilous communities, mesophytic meadow phytocoenoses and xerophyte grasslands [4].

On the territory of Shumensko Plato Natural Park, 14 habitat types have been identified according to the classification of Directive 92/43/EEC of the Council of the European Community for the Conservation of Natural Habitats and Wild Fauna and Flora. The territory of the Natural Park overlaps with the territory of the Shumensko Plato Protected Area, announced under Directive 92/43/EEC. The protected area aims at preserving the territory and the state of natural habitats and of habitats of species whose population is subject to conservation and, where necessary, recovery, within the protected area. In addition to preserving natural habitats, the protected area is also established in order to conserve the plant species *Himantoglossum caprinum* Spreng (Orchidaceae), as well as a number of fauna species [5].

### Materials and Methods:-

This survey was conducted on the route method in 2016. The marking of the locations where invasive species have been detected was made using GPS receiver Garmin Oregon 450. WGS 84 UTM 35N coordinate system was used. The Google Earth Pro Portable ver. 7.1.5.1557 software was used to map the points.

The determination of species and biological types has been conducted according to the Handbook for Plants in Bulgaria [6]. The Latin names of the species and abbreviations of the authors' names are according to the International Plant Names Index [7]. The Latin names of the families are according to the Angiosperm Phylogeny Group IV [8].

The life forms are according to the Raunkiaer's system [9]. For their determination were used the Flora of the People's Republic of Bulgaria [10, 11] and the Flora of the Republic of Bulgaria [12, 13]. The natural habitats are according to EUNIS habitat types classification [14].

### Results and Discussion:-

As a result of the research, 19 species of invasive plants were found on the territory of Shumensko Plato Natural Park (Appendix).

Most of the invasive species (Table 1) originated in North America (52.6%). The most common species among them are: *Amorpha fruticosa*, *Erigeron annuus*, *Erigeron canadensis*, and *Robinia pseudoacacia*. Second common are Asian species (15.8%). Two of them (*Ailanthus altissima* and *Buddleja davidii*) originate in China and one species (*Elaeagnus angustifolia*) originates in Southwest and Central Asia. The rest of the invasive species originate in Europe, the Mediterranean, Central and South America.

**Table 1:-** Origin of the invasive plant species in Shumensko Plato Natural Park

Origin	Number of species	Percentage of total number
Europe	1	5.3
Mediterranean	1	5.3
Asia	3	15.8
Mediterranean and Asia	1	5.3
North America	10	52.6
Central America	1	5.3
South America	1	5.3
Central and South America	1	5.3

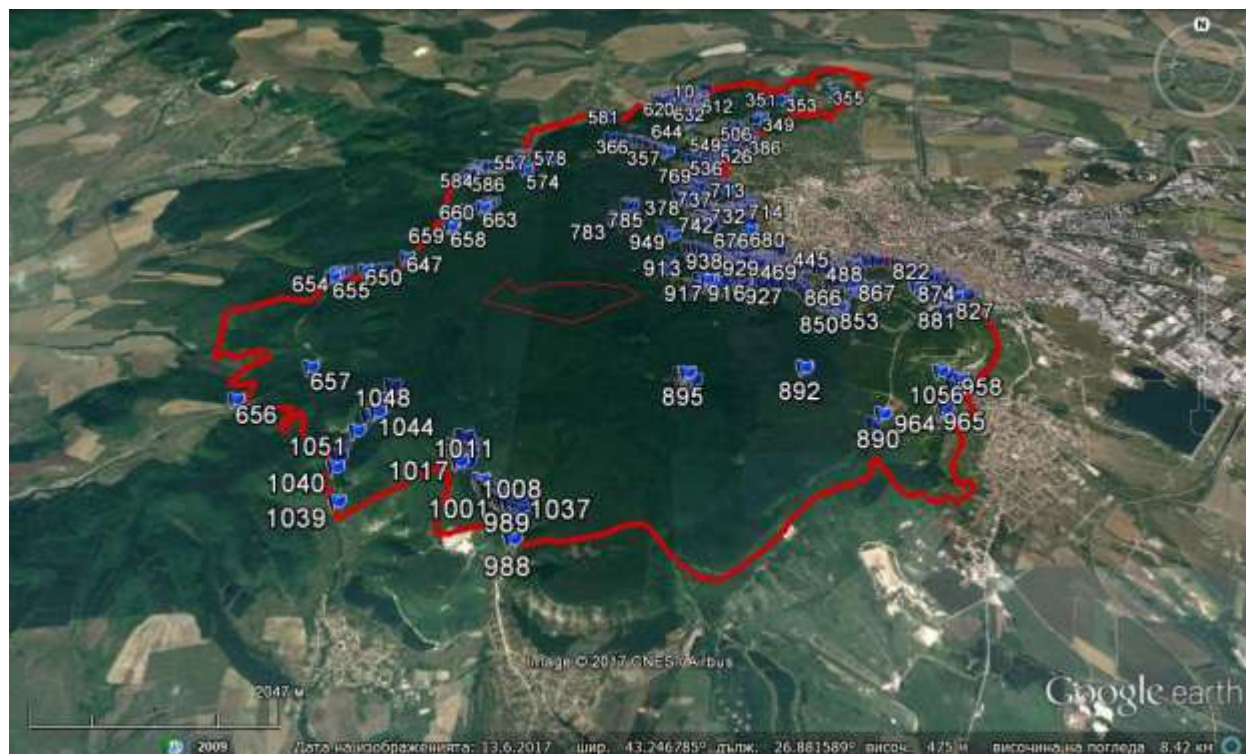
All invasive species originating outside of Europe have first been transferred from their homeland to another European country and afterwards have gradually reached Bulgaria with or without human intervention. Most species have been transported to Bulgaria as decorative plants. Exceptions represent only a few species: *Sorghum halepense*, *Galinsoga parviflora*, *Erigeron canadensis*, *Bidens frondosus*, and *Amaranthus retroflexus*.

According to how long it took the invasive species to enter the Bulgarian flora in wild form, they are divided into 4 groups. Most were found in natural habitats already since the 19th Century (11 species). Three species (*Buddleja*



*davidii*, *Erigeron annuus*, and *Galinsoga parviflora*) were described as spontaneously occurring in the 20th Century, and two species (*Bidens frondosus* and *Parthenocissus quinquefolia*) were discovered and described in the 21st Century. There is no data for the last 3 species found by the authors: *Laburnum anagyroides*, *Sorghum halepense*, and *Spartium junceum*.

The majority of the localities where invasive species were found are located in the peripheral parts of the Natural Park. The concentration of localities with invasive species is greatest in the northeastern part of the Park (Figure 2). The reason for this is the intensive anthropogenic presence in this part of the Park. It is due to the neighboring town of Shumen, which gives the name of the Park. In this part are some of the most visited places for recreation and tourism: Kyoshkovete Forest Park, complex "Founders of the Bulgarian State", Shumen fortress, chalets and holiday homes. Up to the boundaries of the Natural Park in this area is the vast majority of the villa zone of the city. The road network in this part of the Park is highly developed. It includes both asphalt and forest roads and paths. Here is a large area occupied by forest crops.



**Figure 2:-** Distribution of the localities with invasive species in Shumensko Plato Natural Park (the boundaries of the Park are marked with a red line)

Invasive species are found in 14 affected habitats in the Shumensko Plato Natural Park (Appendix). The largest number of habitats were found for *Ailanthus altissima* (12 habitats) and *Robinia pseudoacacia* (11 habitats). This is not accidental, because both are included in the list of the most aggressive invasive alien species endangering the biodiversity in Europe. The reason for this is that these species have high reproductive potential and great ecological plasticity.

Second in their number of habitats are the following species: *Erigeron annuus* (9 habitats), *Erigeron canadensis* (8 habitats), *Amorpha fruticosa*, and *Laburnum anagyroides* (7 habitats).

The remaining species are distributed in a smaller number of habitats. The following species were found in only one habitat: *Buddleja davidii*, *Galinsoga parviflora*, *Bidens frondosus*, *Spartium junceum*, and *Datura stramonium*. The explanation for this is that except for *Spartium junceum* some invasive species are found only in one or two localities and are represented in very low numbers.

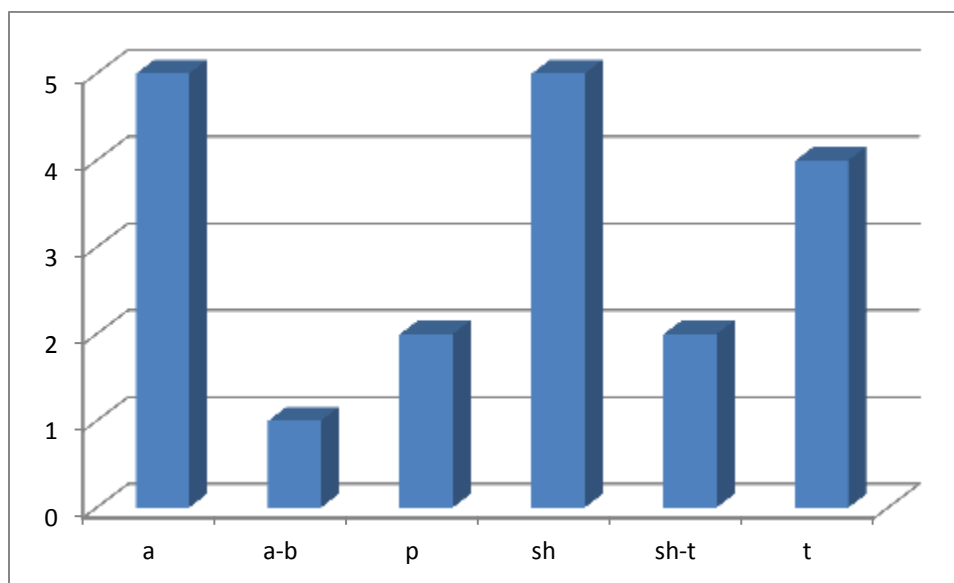
The highest count has *Ailanthus altissima* (24,680 individuals). In second place are species with several thousand individuals (Appendix): *Robinia pseudoacacia* (5,628 individuals), *Amorpha fruticosa* (3,802 individuals), *Erigeron canadensis* (2,439 individuals), *Laburnum anagyroides* (1,130 individuals), and *Erigeron annuus* (1,054 individuals). The third group includes species with several hundred individuals: *Gleditsia triacanthos* (446 individuals), *Spartium junceum* (444 individuals), and *Amaranthus retroflexus* (153 individuals). The remaining 10 species are represented by one to several dozen individuals. It should be noted that this count does not include plant individuals introduced into forestry or as decorative plants by human activity.

Particular attention is paid to the fact that the first three species according to their number in the Shumensko Plato Natural Park are precisely those included in the list of the most dangerous invasive alien species endangering the biodiversity in Europe [2].

The invasive plants in Shumensko Plato Natural Park belong to 4 different biological types: trees, shrubs, perennial herbaceous plants, and annual herbaceous plants. Most species (5 in number) belong to shrubs and annual herbaceous plants (Figure 3). The following species belong to the group of the shrubs: *Amorpha fruticosa*, *Berberis aquifolium*, *Buddleja davidii*, *Parthenocissus quinquefolia*, and *Spartium junceum*. The following species belong to annual herbaceous plants: *Galinsoga parviflora*, *Erigeron annuus*, *Bidens frondosus*, *Amaranthus retroflexus*, and *Datura stramonium*.

The tree species are 4 in number and are represented by the following: *Ailanthus altissima*, *Gleditsia triacanthos*, *Robinia pseudoacacia*, and *Acer negundo*.

Among the perennial herbaceous plants are only two species: *Phytolacca americana* and *Sorghum halepense*. Two species belong to the transition type between shrubs and trees: *Laburnum anagyroides* and *Elaeagnus angustifolia*. *Erigeron canadensis* belongs to the transitional type between annual herbaceous plants and biannual herbaceous plants.

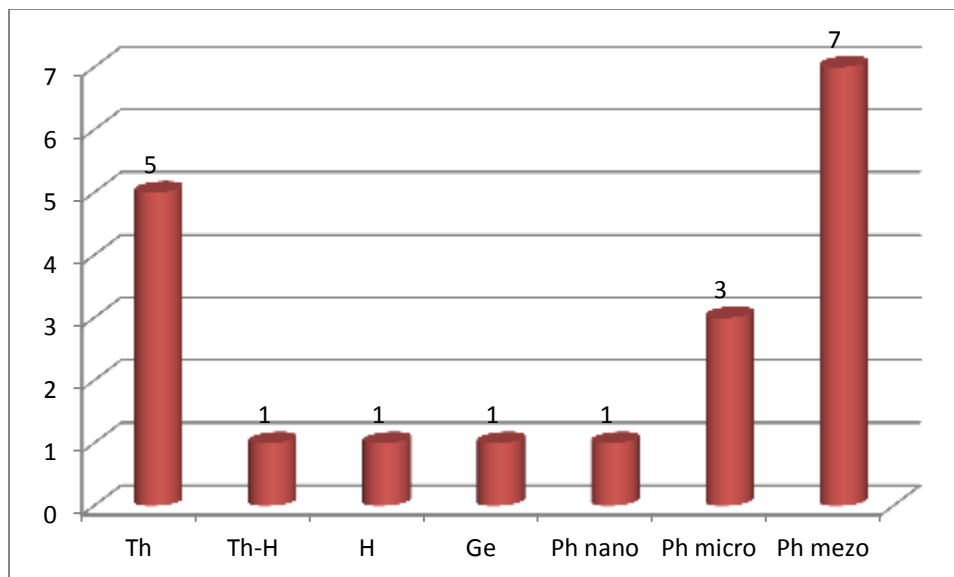


**Figure 3:-** Allocation by biological type of the invasive plant species in Shumensko Plato Natural Park. Legend: a - annual herbaceous plants, a-b - from annual to biannual herbaceous plants, p - perennial herbaceous plants, sh - shrubs, sh-t - from shrubs to trees, t - trees

Among the invasive plants, the largest group form are the phanerophytes (Figure 4). This group includes species from three subgroups: nanophanerophytes, microphanerophytes, and mesophanerophytes. Of these, most species are found in the subgroup of mesophanerophytes (7 species). This group includes the following species: *Ailanthus altissima*, *Gleditsia triacanthos*, *Laburnum anagyroides*, *Elaeagnus angustifolia*, *Parthenocissus quinquefolia*, *Robinia pseudoacacia*, and *Acer negundo*. The microphanerophytes are 3 species: *Amorpha fruticosa*, *Buddleja davidii*, and *Spartium junceum*. Nanophanerophytes are represented with only one species (*Berberis aquifolium*).

The second-highest count has the group of therophytes. This group includes the following 5 species: *Galinsoga parviflora*, *Erigeron annuus*, *Bidens frondosus*, *Amaranthus retroflexus*, and *Datura stramonium*.

Represented by one species are the following groups: hemicryptophytes (*Phytolacca americana*), geophytes (*Sorghum halepense*), and the transition group between therophytes and hemicryptophytes (*Erigeron canadensis*).



**Figure 4:-** Allocation by life form of the invasive plant species in Shumensko Plato Natural Park. Legend: Th - Therophytes, Th - H - from Therophytes to Hemycryptophytes, H - Hemycryptophytes, Ge - Geophytes, Ph - Phanerophytes

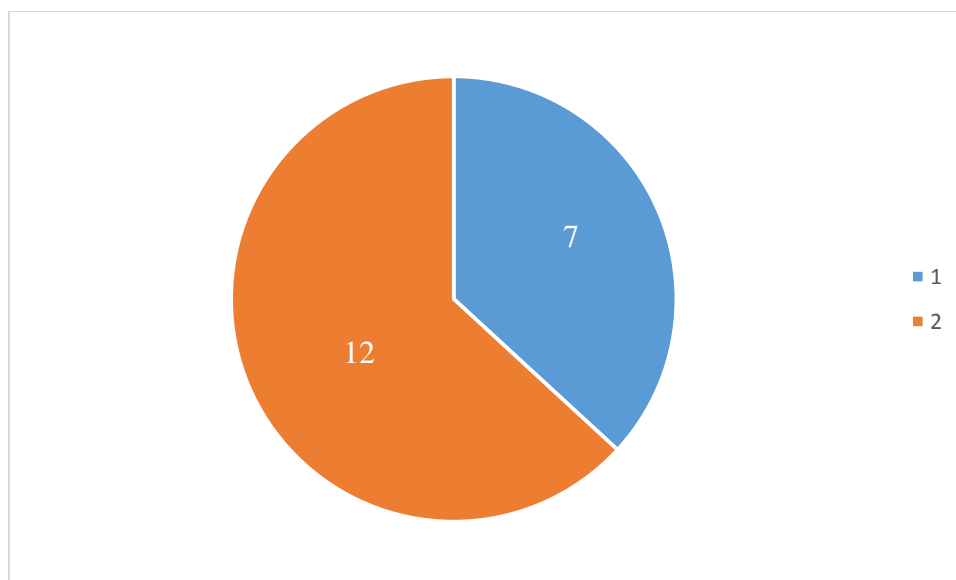
High reproductive potential is one characteristic that allows alien plant species to become invasive in a new territory. Most of the invasive plants in the Shumensko Plato Natural Park (12 species) are propagated simultaneously in two ways: by seeds and vegetatively (Figure 5). In this way spread invasive trees, shrubs, and perennial herbaceous plants. Exceptions are *Laburnum anagyroides* and *Spartium junceum* that propagate only by seeds. The annual herbaceous plants propagate also by seeds only. Particular attention deserves *Galinsoga parviflora*. Although it is an annual plant, it can, similar to perennial herbaceous plants, propagate also in a vegetative way. This is done by rooting the stems, even when cut off or uprooted.

Remarkable high seed yields have the following species: *Buddleja davidii* - up to 3,000,000 seeds for one individual per year, *Ailanthus altissima* - up to 325,000 seeds, *Erigeron canadensis* - up to 230,000 seeds, *Amaranthus retroflexus* - up to 100,000 seeds [2].

The invasive species can be divided into 3 groups according to reasons for their presence in the Park. Most were introduced as decorative plants. 11 species (57.9%) belong to this group. According to Zahariev and Radoslavova [15], decorative plants were introduced into the territory of the Park in three stages.

The first species were imported for the creation of Kyoshkovete Forest Park in the 1800s. One example is *Acer negundo* with several old trees preserved on the shores of Poroyna River in the Forest Park. Over the years, new species such as *Gleditsia triacanthos* and *Robinia pseudoacacia* have been added to the Park's decorative flora.

The second stage of introduction of decorative plants to the Natural Park was during the opening and reconstruction of the Shumen Fortress between 1974 and 1981. Along the asphalt road to the fortress *Amorpha fruticosa* was cultivated as a decorative plant, and probably to strengthen the slope to the road. A composition of shrubs including *Buddleja davidii* was established at the fortress' entrance.



**Figure 5:-** Allocation by the method of propagation of invasive plant species in Shumensko Plato Natural Park.  
Legend: 1 - by seeds, 2 - by seeds and vegetatively

The third stage of introducing decorative plantations occurred during the construction of complex “Founders of the Bulgarian State” to commemorate the 1300th anniversary of Bulgaria’s foundation. During this period (1977-1980), multiple new decorative plants were planted around stairs and alleys of the complex and in its vicinity the roads leading to nearby villages Lozevo and Kotchovo. Invasive species are represented by the following: *Amorpha fruticosa*, *Laburnum anagyroides*, *Elaeagnus angustifolia*, *Parthenocissus quinquefolia*, *Robinia pseudoacacia*, and *Spartium junceum*.

Two of the invasive species (10.5%) were introduced into the Park both as decorative plants and as forest crops. These are *Gleditsia triacanthos* and *Robinia pseudoacacia*.

Special attention deserves the group of inadvertently spread invasive species in the Park. There are 8 species (42.1%) in this group. Unlike decorative plants and forest crops, it is difficult to determine when and how these species came to the Natural Park. One can deduce possible ways for these species’ penetration from the locations in which they occur today. Consequently, several ways of penetrating will be identified:

1. Animal transport. Examples for this spread mechanism are *Phytolacca americana* and *Parthenocissus quinquefolia*. Their fruits are used for poultry feed and the animals successfully spread the seeds.
2. Transport of goods and cargo. Examples for this mechanism is the mass distribution of *Sorghum halepense*, *Erigeron annuus*, and *Erigeron canadensis* around the road infrastructure. Another species, *Bidens frondosus* is found only nearby forest roads. *Galinsoga parviflora* is found only on one of the alleys in the Kyoshkovete Forest Park, accessible by cars. Scholarly sources describe several ways for fruits and seeds to be spread by mean of transportation, for instance during the movement or cleaning of motorized vehicles.
3. Waste disposal. An unregulated waste deposit on the edge of a landslide near the asphalt road from the village of Lozevo to the village of Kochovo has become the habitat for three species: *Phytolacca americana*, *Amaranthus retroflexus*, and *Datura stramonium*.

Among the measures recommended for control of invasive species the mechanical can be applied most efficiently. For instance, appropriate is the manual removal of plants by eradication or felling. For species that regenerate quickly from root or stem buds, the authors recommend systematic application of this measure (several times annually) for several years until the underground parts of the plants are exhausted and the formation and growth of seedlings stop.

If there is an existing road network of asphalt or forest roads in the immediate vicinity, machines can also be used for the eradication of tree and shrub species and the removal of residues from their root system. This is suitable for species that can regenerate from preserved small parts of their root system, such as *Ailanthus altissima*.

Chemical control by using herbicides for destruction is not applicable to the Natural Park. According to the recommendations for the protection of the wolf's habitats in the application of NATURA 2000 measures the use of chemicals for protection in agriculture and forestry is not recommended. Alternatively, this recommendation may be discussed and the possibility of chemical control on certain territories can be explored where chemicals are not prohibited by the Protected Areas Act of Republic of Bulgaria (i.e. other than national parks) [16].

Biological control through deliberate use of populations of the invasive species' natural enemies poses the risk for self-propagation of the biological agent and turning it into a threat to other species. Typically, invasive species do not have enemies and pathogens among the native species. Consequently, it would require the use of non-native species to eradicate invasive species, which is also not appropriate for a protected area. According to Article 31, item 2 of the Protected Areas Act of Republic of Bulgaria [16] in the natural parks, it is prohibited to import plant and animal species outside the region.

The last set of measures (habitat management) includes burning, grazing, etc. The authors of this study consider using these methods to be impracticable in the specific case. On the one hand, there are prohibitions in the Protected Areas Act: Article 31, item 3 – prohibition of goat grazing except in certain places and Article 31, item 6 – camping and instigating fire outside of the designated places [16]. On the other hand, the practice shows that the burning of plant parts above the ground does not solve the problem but exacerbate it. For example, destruction of aerial parts for *Robinia pseudoacacia* causes rapid growth of root shoots. It should also be noted that the fire stimulates germination of seeds present in the soil and creates conditions for the mass growth of seedlings [1]. The grazing is also not a solution because none of the established invasive species is used for feed by grazing animals.

After destroying tree and shrub invasive species, it is very important to take measures to restore habitats by afforestation with indigenous species. Otherwise, their destruction might lead to harming of existing habitats, which in its own right is a precondition for re-invasion by invasive species. After the invasive species' complete destruction on the territory of Shumensko Plato Natural Park, the authors recommend monitoring of the affected habitats for several years in order to prevent re-invasion.

### Conclusion:-

The proposed measures for control of invasive plants distributed on the territory of Shumensko Plato Natural Park should be implemented as soon as possible. While this will be a long and costly process, it is necessary to preserve the natural habitats that are subject to conservation in the Natural Park and the Protected Area.

The obtained results can be used as a basis for comparison with results from similar research in other natural parks, as well as in other protected areas in Bulgaria.

### Appendix:-

#### Invasive plant species found in Shumensko Plato Natural Park

#### Legend:-

**Biological types:** a - annual herbaceous plants, b - biannual herbaceous plants, p - perennial herbaceous plants, sh - shrub, t - tree.

**Life forms:** Ge - Geophyte, H - Hemycryptophytes, Th - Therophytes, Ph - Phanerophytes.

**Affected habitats:** E1 - Dry grasslands, E2 - Mesic grasslands, F3 - Temperate and mediterranean-montane scrub, G1 - Broadleaved deciduous woodland, G3 - Coniferous woodland, G4 - Mixed deciduous and coniferous woodland, G5 - Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice, H2 - Scree, H3 - Inland cliffs, rock pavements and outcrops, H5 - Miscellaneous inland habitats with very



sparse or no vegetation, I2 - Cultivated areas of gardens and parks, J1 Buildings of cities, towns and villages, J4 - Transport networks and other constructed hard-surfaced areas, J6 - Waste deposits.

Species	Family	Biological type	Life form	Number	Affected habitats
<i>Acer negundo</i> L.	Sapindaceae	t	Ph	11	G1, J4
<i>Ailanthus altissima</i> (Mill.) Swingle	Simaroubaceae	t	Ph	24,680	E1, E2, F3, G1, G3, G4, G5, H3, I2, J1, J4, J6
<i>Amaranthus retroflexus</i> L.	Amaranthaceae	a	Th	153	E1, H5, J1, J4, J6
<i>Amorpha fruticosa</i> L.	Fabaceae	sh	Ph	3,802	E1, G1, G3, G4, G5, H3, J4
<i>Berberis aquifolium</i> Pursh	Berberidaceae	sh	Ph	5	G3, J4
<i>Bidens frondosus</i> L.	Asteraceae	a	Th	54	H5
<i>Buddleja davidii</i> Franch.	Buddlejaceae	sh	Ph	1	G3
<i>Datura stramonium</i> L.	Solanaceae	a	Th	2	J6
<i>Elaeagnus angustifolia</i> L.	Elaeagnaceae	sh-t	Ph	87	E1, G1, J4
<i>Erigeron annuus</i> (L.) Pers.	Asteraceae	a	Th	1,054	E1, E2, H5, F3, G1, G3, G5, J1, J4
<i>Erigeron canadensis</i> L.	Asteraceae	a-b	Th-H	2,439	E1, F3, G1, G3, G5, H5, J1, J4
<i>Galinsoga parviflora</i> Cav.	Asteraceae	a	Th	2	I2
<i>Gleditsia triacanthos</i> L.	Fabaceae	t	Ph	446	E1, G1, G3, G5, I2, J4
<i>Laburnum anagyroides</i> Medik.	Fabaceae	sh-t	Ph	1,130	E1, G1, G3, G5, H2, H5, J4
<i>Parthenocissus quinquefolia</i> (L.) Planch	Vitaceae	sh	Ph	80	F3, G1, H2, J4
<i>Phytolacca americana</i> L.	Phytolacaceae	p	H	67	G1, J6
<i>Robinia pseudoacacia</i> L.	Fabaceae	t	Ph	5,628	E1, E2, F3, G1, G3, G4, G5, H2, I2, J1, J4
<i>Sorghum halepense</i> (L.) Pers.	Poaceae	p	H	41	E1, E2, G1, H5, J4
<i>Spartium junceum</i> L.	Fabaceae	sh	Ph	444	J4

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