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*Article*

# Changes in the frequency and degree of dominance of native and alien species in the synanthropic vegetation of the vicinity of Maykop (Republic of Adygea) over a three-year period (2021–2024)

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**Abstract.** This paper discusses the potential of a new approach to monitoring dominant species in plant communities. Instead of focusing on single dominant species, the study analyzes complexes of these dominants, i.e., multiple species that share dominance across relatively large areas of vegetation cover (in a series of compactly located sample plots of 0.15–0.2 hectares). The participation of species in communities is assessed by the frequency of their dominance in accounting plots (1 m$^2$), as well as by the frequency of their reaching a certain projective cover. The study is based on material collected in 2021 and 2024 at five sites of synanthropic vegetation in the vicinity of the city of Maykop (Northwestern Caucasus). Within their boundaries, 34 sample plots were established, including 4167 accounting plots in 2021 and 4262 in 2024. The results showed that changes in the frequency of dominance of individual species from 2021 to 2024 across different vegetation areas were predominantly synchronous and therefore not random. The direction of these changes was largely determined by the requirements of species for their growing conditions. A decrease in the overall dominance of synanthropic species was observed across all areas. In some cases, an increase in this characteristic was observed for forest or steppe species. The data obtained may indicate both a decline in specific human activities and the onset of recovery processes, as well as the possible impact of climate change. This research method is applicable and effective for monitoring vegetation cover and indicating biotopic conditions across large areas.

**Keywords:** anthropogenic habitats, synanthropic communities, dominant species, projective cover, florocenotic element, Western Caucasus

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*Научная статья*

# Изменение частоты и степени доминирования аборигенных и чужеродных видов в синантропной растительности окрестностей г. Майкопа (Республика Адыгея) за трехлетний период (2021–2024 гг)

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**Аннотация**. В работе показаны возможности нового подхода к наблюдению за доминирующими видами растительных сообществ. В качестве объектов исследования используются не отдельные доминанты, а их комплексы, то есть группы видов, доминирующих на относительно крупных участках растительного покрова (в серии компактно расположенных пробных площадей по 0.15–0.2 га). Участие видов в сообществах оценивается по частоте их доминирования на учетных площадках (1 м$^2$), а также по частоте достижения ими определенного проективного покрытия. Материал для исследования был собран в 2021 и 2024 гг. на пяти участках синантропной растительности окрестностей г. Майкопа (Северо-Западный Кавказ). В их пределах были заложены 34 пробные площади, включающие 4167 учетных площадок в 2021 г. и 4262 – в 2024 г. Результаты показали, что на разных участках растительного покрова изменения частоты доминирования отдельных видов с 2021 по 2024 год имели преимущественно синхронный по направлению, следовательно, не случайный характер. Направление этих изменений в значительной степени определялось требованиями видов к условиям их произрастания. На всех участках отмечено снижение суммарной частоты доминирования синантропных видов. В некоторых случаях выявлен рост значений данной характеристики для лесных или степных видов. Полученные данные могут свидетельствовать как о снижении антропогенного пресса и начале восстановительных процессов, так и о возможном влиянии климатических изменений. Сделан вывод о применимости описанного метода исследований при мониторинге растительного покрова и индикации биотопических условий в относительно крупном пространственном масштабе.

**Ключевые слова:** антропогенные местообитания, синантропные сообщества, доминирующие виды, проективное покрытие, флороценоэлементы, Западный Кавказ

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## Introduction

Observations of species dominant in plant communities, as well as their changes in time and space, are an important component of phytomonitoring (Houlahan and Findlay, 2004; Prach and Wade, 1992; Rejmánek et al., 2013; etc.). The following reasons show the importance of these observations:

(1) The increasing prevalence of alien dominants in plant communities may have negative consequences for their species diversity, at least at the local scale (Akatov et al., 2021; Gaertner et al., 2009; Powell et al., 2011). In addition, some of them can dramatically alter the habitats (Levine et al., 2003; Rejmánek et al., 2013; Vinogradova et al., 2010). Moreover, the number and distribution area of invasive plant species capable of dominance have been continuously increasing in recent decades (Neronov and Lushchekina, 2001; Hejda et al., 2009; Rejmánek et al., 2013; Vinogradova et al., 2010).

(2) Some native species also expand their distribution, colonize new habitats, and increase their frequency and degree of dominance in communities (expansive species, according to Prach and Wade, 1992). For example, some publications indicate *Brachypodium pinnatum* (L.) P. Beauv., *Molinia caerulea* (L.) Moench, *Calamagrostis villosa* (Chaix) J.F. Gmel., *Calamagrostis epigeios* (L.) Roth, and *Stipa pulcherrima* C. Koch (Czarniecka-Wiera et al., 2019; Hejda et al., 2021) as problematic native species for Europe. It is emphasized that indigenous (native) species that become dominant and increase their range can threaten local biodiversity to a similar extent to alien species and, accordingly, require the same monitoring (Czarniecka-Wiera et al., 2019; Hejda et al., 2021; Houlahan and Findlay, 2004; Pyšek et al., 2004; etc.).

(3) Global environmental change and other anthropogenic impacts, including habitat eutrophication and physical and biological disturbances, may favor some dominant species, increasing their impact on plant communities, but be detrimental to others. The decline in abundance and even the extinction of previously dominant species can also have negative consequences for vegetation and ecosystems, and these consequences are far more serious than the loss of rare species (Ellison et al., 2005; Hillebrand et al., 2008; Winfree et al., 2015).

(4) The composition of dominant complexes often responds more quickly to anthropogenic impacts than species diversity, functional composition of communities, and other biodiversity indicators, and therefore they can be used as indicators of changes in the natural environment (Alves et al., 2023; Avolio et al., 2019; Gaston, 2011). This approach allows the organization of vegetation observations and forecasting at a larger spatial scale than when monitoring and quantifying the species composition of entire communities (Avolio et al., 2019; Lindenmayer et al., 2015).

Data on the distribution and population status of individual (mostly alien) dominant species are widely presented in the scientific literature (Abramova et al., 2021; Borisova and Shilov, 2017; Chadayeva et al., 2018; Kravtsova et al., 2010; Silliman and Bertness, 2004; and many others), but in most cases they were collected or recorded only once. This situation is typical not only for Russian, but also for foreign geobotany (Pyšek et al., 2024). Long-term observational data on common species are underrepresented in the literature (Gasymova et al., 2021; Gusev, 2016, 2018; Gusev and Sokolov, 2021; Hunter, 1991; Kravtsova et al., 2010; Nuzzo, 1993; Pyšek et al., 2024; Wulf et al., 1997). They are obtained mainly on permanent sample plots. This method is one of the most effective for solving monitoring problems, but since such plots are usually small in size (mainly up to 100 $m^2$, rarely 1000–2500 $m^2$) and are laid out in limited quantities, the results of such studies are difficult to extrapolate to a larger area. Other approaches are needed to assess changes in the role of dominant species in vegetation across large areas. For example, some information on this can be obtained as a result of repeated or continuous standardized records of plant species composition in syntaxonomic studies. Unfortunately, such publications are rare (Lysenko and Korotchenko, 2006; Mirkin et al., 2004; Starodubtseva et al., 2013; etc.). Moreover, a disadvantage of this method is the obtained results are biased by the location of the sample plots, since organizing a true randomized collection of descriptions within the study area is often very difficult (Golub, 2011).

We propose a new approach to solving this problem. Instead of using individual dominant species, we use their complexes as monitoring objects, i.e., groups of species that dominate relatively large areas of vegetation cover (in a series of compactly located sample plots of 0.15–0.2 hectares) (Akatov et al., 2022, 2024). Species participation in communities is assessed based on their frequency and dominance, as well as the frequency with which they reach a certain projective cover. In 2021, we used this method to compare the frequency and degree of dominance of alien and native species in synanthropic vegetation communities in several regions of southern Russia (Akatov et al., 2022), as well as in natural (semi-natural) and anthropogenic habitats of various types (Akatov et al., 2024).

In 2024, the study was repeated at five sites in one of these areas (the vicinity of Maykop). It aimed at assessing the potential of this method for long-term observations of the distribution and coverage of dominant species. We focused on issues of interest to the monitoring studies: the nature and scale of changes in the frequency and degree of dominance of species in the study area over a three-year period (2021 to 2024). Specifically, our objectives were to establish the following:

(1) how synchronous in direction are such changes in different areas of vegetation in individual species;

(2) to what extent do species of different origins differ in this respect, with different resistance to the impact of anthropogenic factors and different attitudes to abiotic environmental conditions;

(3) what are the possible reasons for the changes identified.

## Materials and methods

The study was conducted in the vicinity of Maykop: Northwestern Caucasus, Belaya River valley, 180–260 m a.s.l. According to natural and climatic conditions, this is a border area between the zones of meadow steppes and broad-leaved forests with dominance and codominance of *Quercus robur* L., *Q. petraea* (Matt.) Liebl., *Fagus orientalis* Lipsky, *Carpinus betulus* L., *Alnus incana* (L.) Moench and *A. glutinosa* (L.) Gaertn., etc. The average annual air temperature is +11.8 °C, the average July temperature is +22.8 °C, and January temperature is −1.6 °C; the annual precipitation is 700–800 mm. Summer is moderately hot and moderately humid. The precipitation range during the warm period (April–October) is 370–450 mm. The frequent recurrence of dry periods, such as summer drought, is a characteristic feature of summer months (Buzarov et al., 1995; Kostianoy et al., 2021a).

The material was collected in 2021 and 2024 at the same time (late May–June) in five areas of herbaceous (synanthropic) vegetation located mainly on the terraces of the Belaya and Kurdzhips rivers in the altitude range from 180 to 260 m a.s.l. (Fig. 1). Two of them are located in the western (WM) and southwestern (SWM) outskirts of Maykop (N 44°36'31'' E 40°03'10''), one is in the forest park zone on its southern vicinity (FP) (N 44°35'27'' E 40°06'28''), and two more are at some distance from the city limits: in the riverside zones of the Belaya River (BR) and its right tributary, the Kurdzhips River (KR) (N 44°34'01''–44°36'08'' E 40°02'36''–40°05'21''). The vegetation areas of the Western and South-Western regions are limited by roads and buildings, the rest (FP, BR and KR) are disturbed forest communities dominated or with significant participation of *Populus alba* L., *P. nigra* L., *Salix alba* L., *Fraxinus excelsior* L., as well as *Quercus petraea* (KR), *Robinia pseudoacacia* L. (FP and BR), *Populus tremula* L. and *Acer negundo* L. (BR). The vegetation cover of the surveyed areas includes communities of forest clearings, forest edges, wastelands, fallow lands, soil outcrops, and others. In all cases, wastelands and fallow lands are the most common; forest clearings of anthropogenic origin are also present in the FP, BR, and KR. The natural vegetation cover of all these areas (presumably riverside broadleaf forests) was significantly disturbed in the past. During their survey in 2021 and 2024, we found no obvious evidence of significant new disturbances, except for occasional grazing by domestic animals, haymaking, or soil trampling in places.

Each of the plots was divided into several (4–9) relatively uniform sample plots of 0.15–0.2 ha, adjacent to or located close to each other. Within each plot, 100–150 accounting plots of 1 m2 were laid out in a regular manner. In each accounting plot, the role of the dominant species in the formation of the herbage was assessed using a five-point scale: 1 – no species is observed to be dominant; 2 – the dominant species has a visually clearly observed higher projective cover than any other species, but less than 40%; 3 – 40–60%; 4 – 60–80%; 5 – more than 80%. For species of the genus *Rubus* (*R. ibericus* Juz., *R. canescens* DC, *R. caesius* L.), their total cover was assessed, since when these species grow together, it is difficult to assess the projective cover of each of them, especially if the thickets occupy a large area.


**Fig. 1.** Map of the study area (Maykop, Republic of Adygea). Numbers indicate the studied vegetation zones: 1 and 2 are located in the western (WM) and southwestern (SWM) outskirts of Maykop, 3 – riverside of the Belaya River (BR); 4 – in the forest park zone (FP); 5 – riverside of the Kurdzhips River (KR).

The total number of established sample plots was 34, and the number of accounting plots was 4167 in 2021 and 4262 in 2024. Based on these, the values of several indicators were calculated and compared:

- the percentage of accounting plots dominated by certain species (frequency of dominance), as well as with their coverage of less than 40%, 40–60%, 60–80%, more than 80%;
- total frequency of dominance of species of different florocenotic elements;
- the number of dominant species, including native and alien species, as well as those with different dynamic trends.

The characteristics of the dominant plant species' relationship to environmental conditions were determined in accordance with the work of A.L. Ivanov (2019) based on their affiliation with specific florocenotic elements: forest, meadow, steppe, semi-desert, desert, aquatic, and weed. By weed (synanthropic), we meant species classified by Ivanov (2019) as obligate ruderal and segetal plants (both alien and apophytes). According to P.L. Gorchakovsky's (1984) concept, the degree of participation of weed (synanthropic) species in the formation of the vegetation cover reflects the degree of its anthropogenic transformation. Taxa names are given according to Plants of the World Online[1].

The reliability of the difference between the frequency of species dominance in 2021 and 2024 was assessed using the Student's t-test; between the ratios of the frequency of achieving different projective cover by species – using the $\chi^2$ test.

## Results

In 2021, the total number of species identified as dominant in at least one of the survey plots across all five sites was 79. In the sample plots established within the forest park zone, 45 species were noted, while in the remaining four sites their number varied from 23 to 27. Of the 79 dominants, eight (10.1%) are alien: *Ambrosia artemisiifolia*, *Asclepias syriaca*, *Bidens frondosa*, *Erigeron canadensis*, *Parthenocissus quinquefolia*, *Erigeron annuus*, *Solidago canadensis*, *Xanthium orientale* (Table 1).

The highest average frequency of dominance in synanthropic communities of the study area (that is, in all five sites) in 2021 was observed for *Elymus repens* (dominated in 385 out of 4167 survey sites – 9.2%). *Medicago falcata* occupies the second position (8.6%), *Solidago Canadensis* – third (7.4%). Species of the genus *Rubus* (5.8%) and *Melilotus officinalis* (4.7%) were also characterized by a high total frequency of dominance. One alien dominant, *Ambrosia artemisiifolia* (2.8%), and several native species, *Calamagrostis epigejos* (1.6%), *Trifolium hybridum* (1.6%), *Eryngium campestre* (1.4%), and *Achillea millefolium* (1.3%), were among the top ten. If we consider individual sites, *Elymus repens* had the highest degree of dominance in three of them (WM, SWM, FP). In the deforested areas of the riverside zone of the Belaya and Kurdzhips rivers (BR and KR), the leading positions were occupied by *Solidago canadensis* and *Medicago falcata*, respectively. Species of the genus *Rubus* together had a relatively high frequency of dominance in the FP and BR; *Melilotus officinalis* – in all areas except the WM; *Eryngium campestre* – in the WM and SWM; *Trifolium hybridum* – in the SWM and FP; *Ambrosia artemisiifolia* and *Erigeron annuus* – in the BR and KR, respectively; *Calamagrostis epigejos* – in the FP. The total frequency of dominance of alien species as a whole varied between 1.6 and 31.6% across the sites. Its minimum values were in the SWM and FP (1.6 and 2.95), and the highest were in the BR and KR zones (20.9 and 31.6%); in the WM it was 8.8%.

In 2024, the surveyed sites showed approximately the same number of dominant species as in 2021: 83 species overall, 45 species in the FP sample plots, and 22 to 34 species in the remaining sites. Six dominant species were alien. No dominance by *Erigeron canadensis* or *Xanthium orientale* was

[1] Plants of the World Online. Web page.https://powo.science.kew.org/ (accessed: 12.01.2026).

**Table 1.** Frequency of species dominance in areas of post-forest synanthropic vegetation in the vicinity of Maykop in 2021 and 2024 (%). Values in bold are statistically significantly higher than those in other plots during one of the observation periods (t-test, $p < 0.05$). Vegetation areas: WM and SWM are the western and southwestern outskirts of the city of Maykop, FP is the forest park zone, KR and BR are the riverside zones of the Kurdzhips and Belaya rivers, respectively. Florocenotic elements: A – aquatic, P – meadow, R – weedy (Re – alien), S – forest, ST – steppe, SD – semi-desert, D – desert.

| Year of observation | 2021 | | | | | 2024 | | | | | Florocenotic element |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Vegetation area | SWM | WM | FP | KR | BR | SWM | WM | FP | KR | BR | |
| Number of accounting plots | 916 | 556 | 1016 | 1109 | 570 | 810 | 533 | 1191 | 1069 | 659 | |
| Number of dominants (S) | 27 | 25 | 45 | 27 | 23 | 22 | 34 | 45 | 24 | 26 | |
| Group 1. Species with a relatively high frequency of dominance in 2021 and 2024 | | | | | | | | | | | |
| *Poa angustifolia* L. | 1.9 | 0.5 | 1.5 | . | 0.2 | 0.6 | 0.4 | 0.9 | . | . | P |
| *Solidago canadensis* L. | **0.4** | 1.1 | 1.5 | 11.5 | 27.4 | . | 0.2 | 1.3 | **17.2** | 29.4 | Re |
| *Erigeron annuus* (L.) Desf. | 0.3 | 0.2 | 0.6 | 1.0 | 2.6 | . | 0.2 | 1.2 | **2.2** | 1.4 | Re |
| *Asclepias syriaca* L. | 0.4 | 0.2 | 0.2 | 0.7 | 1.2 | 1.0 | 0.6 | 0.5 | 0.5 | 1.8 | Re |
| *Medicago falcata* L. | 7.4 | 0.5 | . | 21.8 | **8.0** | **10.6** | 0.6 | . | 22.3 | . | ST |
| Group 2. Species with higher frequency of dominance in 2021 | | | | | | | | | | | |
| *Vicia cracca* L. | **2.0** | **0.7** | 0.1 | . | . | . | . | . | . | . | P |
| *Trifolium hybridum* L. | **3.9** | 0.4 | **3.0** | . | . | . | . | 1.0 | . | . | P |
| *Trifolium ambiguum* M. Bieb. | 0.2 | 0.2 | 0.1 | . | . | . | 0.2 | . | . | . | P |
| *Thymus pannonicus* All. | 1.5 | 0.4 | 0.1 | 0.1 | . | 1.5 | . | . | **1.0** | . | P |
| *Trifolium repens* L. | . | 0.2 | 0.9 | 0.5 | 0.9 | . | . | 0.5 | 0.3 | 0.2 | P |
| *Ambrosia artemisiifolia* L. | **0.4** | 7.2 | . | **6.5** | 0.2 | 0.0 | 8.3 | 0.1 | 0.6 | . | Re |
| *Cirsium arvense* (L.) Scop. | **0.4** | 0.2 | **1.4** | . | 0.4 | 0.0 | 0.4 | 0.2 | . | . | R |
| *Melilotus officinalis* (L.) Lam. | 0.2 | **6.7** | **2.8** | **5.9** | **10.9** | . | 0.2 | 1.2 | 0.5 | 0.6 | R |
| *Polygonum aviculare* L. | 0.2 | 0.5 | **0.7** | . | . | . | . | 0.1 | . | . | R |
| *Achillea millefolium* L. | **4.0** | 0.2 | 1.8 | . | . | . | 0.2 | 1.7 | . | . | ST |

| Year of observation | 2021 | | | | | 2024 | | | | | Florocenotic element |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Vegetation area | SWM | WM | FP | KR | BR | SWM | WM | FP | KR | BR | |
| Number of accounting plots | 916 | 556 | 1016 | 1109 | 570 | 810 | 533 | 1191 | 1069 | 659 | |
| Number of dominants (S) | 27 | 25 | 45 | 27 | 23 | 22 | 34 | 45 | 24 | 26 | |
| Group 3. Species with higher frequency of dominance in 2024 | | | | | | | | | | | |
| *Elymus repens* (L.) Gould | 15.3 | 20.9 | 11.5 | 0.6 | 0.9 | **22.2** | 22.0 | **15.4** | **4.1** | 2.0 | P |
| *Bromus commutatus* Schrad. | . | . | 0.3 | . | . | **2.0** | 0.2 | 0.2 | . | . | P |
| *Verbascum lychnitis* L. | . | . | . | . | . | 0.1 | **0.9** | 0.2 | . | . | P |
| *Agrimonia eupatoria* L. | . | . | 0.1 | . | . | **0.5** | . | 0.2 | 0.3 | . | P |
| *Geranium columbinum* L. | 0.1 | . | . | . | . | **3.1** | **1.5** | 0.3 | . | . | P |
| *Calamagrostis epigejos* (L.) Roth | . | . | 4.6 | 1.4 | 0.9 | **1.1** | 0.6 | **7.8** | 2.3 | 2.7 | P |
| *Rubus spp.* | . | 0.5 | 7.1 | 1.9 | 25.8 | . | **8.6** | **14.9** | 2.7 | **33.2** | S |
| *Clematis vitalba* L. | . | . | 0.5 | . | . | **0.5** | . | 1.1 | 0.2 | . | S |
| *Bromus sterilis* L. | . | . | 0.3 | . | . | **4.6** | **13.1** | **7.2** | **0.8** | **2.7** | ST |
| *Galium humifusum* M. Bieb. | 1.1 | . | . | . | . | 1.1 | **1.1** | **0.4** | **0.4** | 0.5 | ST |
| *Eryngium campestre* L. | 4.9 | 2.0 | 0.2 | . | . | **13.6** | 1.3 | 0.3 | **0.4** | . | ST |
| *Festuca valesiaca* Schleich. ex Gaudin | 0.7 | 0.7 | 0.4 | 0.1 | . | **5.4** | 0.6 | **1.6** | **2.2** | . | ST |
| *Convolvulus cantabrica* L. | . | . | . | . | . | **0.6** | 0.2 | . | **0.6** | . | D |

**Supplement to Table 1.**

*Carex hirta* L. (A), *Trifolium bonannii* C. Presl. (A), *Fragaria viridis* Weston. (P), *Coronilla varia* L. (P), *Lamium purpureum* L. (P), *Origanum vulgare* L. (P), *Inula salicina* subsp. *aspera* (Poir.) Jáv. (P), *Vicia grandiflora* Scop. (P), *Lolium arundinaceum* subsp. *orientale* (Hack.) G.H.Loos (P), *Aegilops cylindrica* Host (P), *Chenopodium album* L. (R), *Bidens frondosa* L. (Re), *Parthenocissus quinquefolia* (L.) Planch. (Re), *Lepidium draba* L. (R), *Equisetum telmateia* Ehrh. (S), *Galega orientalis* Lam. (S), *Humulus lupulus* L. (S), *Sambucus ebulus* L. (S), *Botriochloa ischaemum* (L.) Keng (ST), *Plantago lanceolata* L. (ST), *Potentilla argentea* L. (ST), *Cynodon dactylon* (L.) Pers. (ST), *Convolvulus arvensis* L. (ST), *Euphorbia stepposa* Zoz ex Prokh. (ST), *Sedum pallidum* M.Bieb. (ST).

Group 5. Species that rarely dominated in areas, and only in 2021.
*Lythrum salicaria* L. (A), *Solanum dulcamara* L. (A), *Rorippa austriaca* (Crantz) Besser (A), *Thypha laxmannii* Lepech. (A), *Linaria vulgaris* Mill. (P), *Vicia hirsuta* (L.) Gray (P), *Medicago lupulina* L. (P), *Trifolium pretense* L. (P), *Hypericum perforatum* L. (P), *Trifolium campestre* Schreb. (P), *Lathyrus hirsutus* L. (P), *Erigeron canadensis* L. (Re), *Setaria viridis* (L.) P.Beauv. (R), *Urtica dioica* L. (R), *Sisymbrium loeselii* L. (R), *Xanthium orientale* L. (Re), *Ranunculus constantinopolitanus* (DC) d'Urv. (S), *Geum urbanum* L. (S), *Calystegia silvatica* (Kit.) Griseb. (S), *Chaerophyllum nodosum* (L.) Crantz (S), *Arthemisia scoparia* Waldst. et Kit. (ST), *Centaurea biebersteinii* DC (ST), *Alcea rugosa* Alef. (ST), *Medicago minima* (L.) Bartal. (ST), *Sedum spurium* M. Bieb. (D).

Group 6. Species that rarely dominated in areas, and only in 2024.
*Epilobium hirsutum* L. (A), *Juncus effusus* L. (A), *Phragmites australis* (Cav.) Trin. ex Steud. (A), *Lotus corniculatus* L. (P), *Inula helenium* L. (P), *Salvia verticillata* L. (P), *Echium vulgare* L. (P), *Potentilla recta* L. (P), *Seseli tortuosum* L. (P), *Theucrium chamaedrys* L. (P), *Vicia sepium* L. (P), *Poa compressa* L. (P), *Lolium perenne* L. (P), *Tanacetum vulgare* L. (P), *Geranium dissectum* L. (P), *Sanguisorba minor* Scop. (P), *Trifolium arvense* L. (P), *Carthamus lanatus* L. (R), *Senecio vulgaris* L. (R), *Carex pendula* Huds. (S), *Hedera helix* L. (S), *Brachypodium rupestre* (Host) Roem. et Schult. (S), *Stellaria holostea* L. (S), *Torilis arvensis* (Huds.) Link (S), *Dipsacus laciniathus* L. (S), *Berteroa incana* (L.) DC. (ST), *Festuca myuros* L. (SD), *Vicia villosa* Roth (D).

detected during the second observation period. The proportion of alien species among the total number of dominant species in 2024 was 7.2%, slightly lower than in 2021 (10.1%).

The total number of species dominant in the sites in 2021 and 2024 was 106. According to the frequency of dominance in different observation periods, they were combined into six groups (Table 1). Group 1 (4.7% of the total number of species) includes species that were present in most sites and had a relatively high degree of dominance in at least some of them in both years of observation. Species in group 2 (9.4%) showed a predominantly higher degree of dominance in 2021 compared to 2024, while species in group 3 (12.3%) showed the opposite. Group 4 (23.6%) includes species with a relatively low frequency of dominance in the sites in both observation periods. Species of group 5 (23.6%) rarely dominated in the sites, and only in the first observation period, and group 6 (26.4%) – only in the second. Species of groups 1-3 can be conditionally considered key dominants, groups 4–6 – as accidental (they rarely achieve dominant positions, making maximum use of favorable conditions developing at a specific time and in a specific site) (Gorbulin, 2012). If we consider only key dominants, then among them in both observation periods, 17.3% of species had a similar frequency of dominance, higher in 2021 – 35.7%, in 2024 – 46.4%.

The first group includes five species. Three of these are alien (*Solidago canadensis*, *Erigeron annuus*, and *Asclepias syriaca*). In addition, three species were among the most frequently dominant in 2021 at various sites in the study area (*Solidago canadensis*, *Medicago falcata*, and *Erigeron annuus*).

The second group comprises 10 species. Among them are four synanthropic (weedy) species (*Ambrosia artemisiifolia*, *Melilotus officinalis*, *Cirsium arvense*, and *Polygonum aviculare*). The remaining species belong primarily to the meadow florocoenotype. Four species from this group frequently dominated in 2021 at various sites in the study area: *Melilotus officinalis*, *Ambrosia artemisiifolia*, *Trifolium hybridum*, and *Achillea millefolium*.

The third group includes 13 species, five of which belong to the steppe and desert florocenotic elements (*Bromus sterilis*, *Galium humifusum*, *Eryngium campestre*, *Convolvulus cantabrica*, and *Festuca valesiaca*), six to the meadow florocenotic element (*Elymus repens*, *Bromus commutatus*, *Geranium columbinum*, *Calamagrostis epigejos*, *Verbascum lychnitis*, and *Agrimonia eupatoria*), and several to the forest florocenotic element (*Clematis vitalba* and *Rubus* species). Synanthropic species, including alien ones, are absent from this group. *Rubus* species, as well as *Calamagrostis epigejos* and *Eryngium campestre*, were among the most frequently dominant plants at each site in 2021.

Groups 4, 5, and 6 contain similar numbers of species (25, 25, and 28, respectively), which belong to different florocenotic elements. It can be assumed that their absence from the dominant species in the first or second observation periods is for stochastic reasons.

According to our data, in 2021, in the SWM area, meadow and steppe florocenotic elements were more often dominant; in the WM, meadow and synanthropic species; in the FP, meadow species, as well as forest and synanthropic species (to a lesser extent); in the KR, steppe and synanthropic species; and in the BR, synanthropic and forest species (Table 2). This characteristic may reflect the characteristics of environments and the state of vegetation. For example, a clearly expressed predominance of meadow species in the sample plots may indicate the distribution of predominantly moderately humid habitats (WM and FP) in them; meadow and steppe species – moderately and slightly humid (SWM); steppe species – slightly humid (KR), forest species – post-forest or forest edge (BR); weed species – about the degree of disturbance of the communities (higher in WM, KR and BR areas, less in SWM and FP). In addition, Table 2 shows that in all the studied vegetation areas over a three-year period, the total frequency of dominance of synanthropic species decreased to varying degrees: in SWM from 2.7 to 1.0, in WM from 16.4 to 11.4, in FP from 8.8 to 5.2, in KR from 26.8 to 21.0, in BR from 42.8 to 33.5. At the same time, in some areas, a significant increase in the values of this characteristic was revealed for forest (WM – from 0.7 to 8.6, FP – from 8.3 to 19.9) and steppe species (SWM – from 19.1 to 35.4, WM – from 5.6 to 18.8 and FP – from 3.2 to 11.9).

Table 3 and Fig. 2 show the ratios of the frequency of achieving different projective covers by species with a relatively high frequency of dominance in the studied vegetation plots during both observation periods. In 2024, *Solidago canadensis* and *Rubus* spp. were characterized by a significantly higher projective cover on average than in 2021, and this difference is statistically significant. For *Elymus repens* and *Medicago falcata*, the ratios of the frequency of occurrence of plots with different projective covers in 2021 and 2024 differ to a lesser extent but are still statistically significant. For *Calamagrostis epigejos* and *Erigeron annuus*, the dominance structure in 2021 and 2024 was very similar (the difference is statistically insignificant).

**Table 2.** Total frequency of species dominance belonging to different florocenotic elements (%).

| Year of observation | 2021 | | | | | 2024 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vegetation area | SWM | WM | FP | KR | BR | SWM | WM | FP | KR | BR |
| Number of accounting plots | 916 | 556 | 1016 | 1109 | 570 | 810 | 533 | 1191 | 1069 | 659 |
| Aquatic (A) | 0.1 | . | 0.3 | 0.7 | 0.4 | . | 0.2 | 0.1 | 0.7 | 0.8 |
| Meadow (P) | 28.2 | 23.7 | 28.6 | 3.2 | 4.9 | 32.7 | 26.5 | 32.7 | 9.5 | 8.8 |
| Weedy (R) | 2.7 | 16.4 | 8.8 | 26.8 | 42.8 | 1.0 | 11.4 | 5.2 | 21.0 | 33.5 |
| Forest (S) | . | 0.7 | 8.3 | 3.3 | 27.9 | 0.6 | 8.6 | 19.9 | 3.0 | 35.8 |
| Steppe (ST) | 19.1 | 5.6 | 3.2 | 29.9 | 8.0 | 35.4 | 18.8 | 11.9 | 28.5 | 3.8 |
| Semi-desert (SD) | . | . | . | . | . | . | 2.1 | . | . | 0.2 |
| Desert (D) | 0.1 | . | . | . | . | 2.8 | 0.9 | . | 0.8 | . |

**Table 3.** Frequency of achieving different degrees of species dominance (projective cover) in the studied areas (%). * – the factual values of $\chi^2$ exceed the critical values for $p < 0.05$.

| Year of observation | 2021 | | | | | 2024 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dominant species | n | Projective cover, % | | | | n | Projective cover, % | | | | $\chi^2$ |
| | | 20–40 | 40–60 | 60–80 | 80–100 | | 20–40 | 40–60 | 60–80 | 80–100 | |
| *Rubus* spp. | 243 | 0.29 | 0.23 | 0.30 | 0.18 | 471 | 0.06 | 0.14 | 0.33 | 0.48 | 235* |
| *Solidago canadensis* | 308 | 0.25 | 0.18 | 0.28 | 0.29 | 394 | 0.13 | 0.19 | 0.29 | 0.39 | 46* |
| *Elymus repens* | 385 | 0.68 | 0.22 | 0.10 | 0.01 | 538 | 0.58 | 0.34 | 0.08 | . | 43.9* |
| *Medicago falcata* | 359 | 0.35 | 0.26 | 0.25 | 0.14 | 327 | 0.38 | 0.34 | 0.23 | 0.04 | 35.4* |
| *Calamagrostis epigejos* | 68 | 0.84 | 0.15 | 0.01 | . | 148 | 0.76 | 0.22 | 0.01 | . | 6.4 |
| *Erigeron annuus* | 36 | 0.79 | 0.13 | 0.08 | . | 48 | 0.81 | 0.19 | . | . | 4.82 |

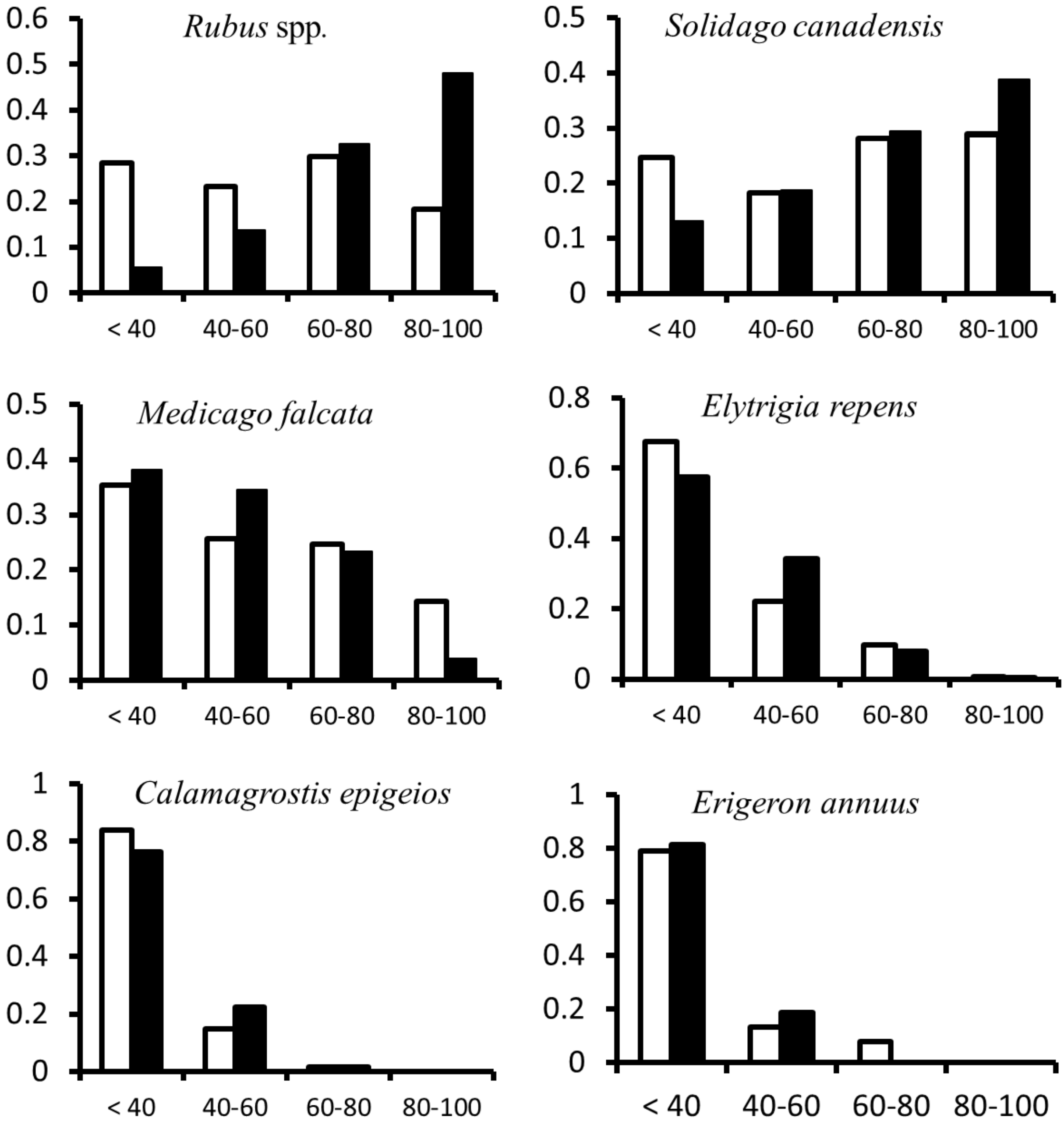


**Fig. 2.** Frequency of achieving different degrees of species dominance (projective cover) in the studied areas. The x-axis shows species projective cover category in %, and the y-axis shows the proportion of accounting plots with a certain projective cover of the species to the number of plots with its dominance. White bars represent 2021, black bars represent 2024.

## Discussion

Thus, the results of the comparison of the frequency and degree of dominance of species in five areas of synanthropic vegetation in the vicinity of the city of Maykop in 2021 and 2024 can be summarized as follows:

1. The phytocenotic positions of a significant portion of species (approximately 30%) identified in the studied vegetation areas as key or incidental dominants were similar in both observation periods. This includes the positions of five of the eight alien dominants: *Asclepias syriaca*, *Bidens frondosa*, *Parthenocissus quinquefolia*, *Erigeron annuus*, and *Solidago canadensis*. The latter species was characterized by similar dominance frequencies in 2021 and 2024, but achieved a higher frequency of achieving coverage of over 60% in the second observation period.

2. Native weed species, as well as alien species *Ambrosia artemisiifolia*, *Erigeron canadensis*, and *Xanthium orientale*, generally had lower dominance frequencies in 2024 compared to 2021, or were not detected as dominant at all. Notably, among native species, the biennial *Melilotus officinalis* and trampling-resistant *Polygonum aviculare* and *Trifolium repens* (a facultative ruderal according to A.L. Ivanov, 2019) exhibited similar dynamics. Only two such species with low dominance frequencies (*Carthamus lanatus* and *Senecio vulgaris*) showed the opposite trend.

3. Approximately 40% of key dominant species exhibited higher dominance rates in the studied vegetation areas in 2024 compared to 2021. These species included meadow, forest, and xerophilous (steppe, semi-desert, and desert) species. Furthermore, the annual *Bromus sterilis* and *Calamagrostis epigejos* were recorded to have increased their dominance in 2024.

Overall, over the three-year period, the dominance frequency of some synanthropic species decreased, while others remained unchanged; some meadow species decreased, while others increased; forest and xerophilous species primarily increased. Moreover, changes in the dominance frequency of individual species, regardless of their origin or ecological preferences, across different parts of the study area were, as a rule (for more than 80% of key dominants), synchronous (unidirectional), i.e., not random.

It can be assumed that the identified changes are related to several simultaneous processes in the study area. Thus, the prevalence of weed (synanthropic) dominants, as shown in Table 2, was highest in 2021 in the riverside zones of the Belaya and Kurdzhips rivers. A similar situation was observed during the second observation period. Moreover, a significant decrease in the prevalence of many weed species, including alien ones, may indicate a slight reduction in anthropogenic pressure on the surveyed vegetation areas or the continuation of the community recovery process after past disturbances. In particular, a significant decrease in the prevalence of *Ambrosia artemisiifolia, Erigeron canadensis*, and *Xanthium orientale* likely indicates a smaller area of disturbed soil cover in 2024 compared to 2021, while the prevalence of *Polygonum aviculare* and *Trifolium repens* indicates a reduction in the frequency and/or intensity of grass trampling. The reduction in human-driven disturbances in recent years (and possibly for longer) has likely contributed to the increase of forest restoration processes. Evidence of this is presumably the increase in the frequency of dominance of forest and forest edge species, primarily the genus *Rubus* (Grudzinskaya, 1953; Kazeev et al., 2013).

The combined dominance of forest, meadow, and steppe flora elements in the studied vegetation areas is quite expected, given that the study area is in the transition zone between meadow steppe and broadleaf forest zones (Kostianoy et al., 2021a). Therefore, it can be assumed that the strengthening of the positions of xerophilous species in the studied plant communities is a consequence of changes in weather and climate conditions. Over the past decades, a distinct increase in average annual and summer temperatures has been recorded in the Western Caucasus, including the Maykop area, combined with a slight decrease in precipitation during the warm season. At the same time, an increase in the frequency and duration of dry periods is observed in the summer months (Akatov et al., 2014; Globalnoe izmenenie..., 2021 [2]; Kostianoy et al., 2021b; Lurye and Panov, 2006).

The short observation period does not allow us to determine whether the changes in the frequency of species dominance we identified are a manifestation of allogenic and secondary autogenous successions, or anthropic and ecotopic fluctuations (Onipchenko, 2014; Rabotnov, 1983). There is also

[2] Global Climate Change and the North Caucasus Federal District. Toward Adaptation. Roshydromet Climate Center, 2021. Web page. URL: https://cc.voeikovmgo.ru/images/dokumenty/2022/%D0%A1%D0%B5%D0%B2%D0%B5%D1%80%D0%BE-%D0%9A%D0%B0%D0%B2%D0%BA%D0%B0%D0%B7%D1%81%D0%BA%D0%B8%D0%B9%20%D0%A4%D0%9E.pdf (accessed: 07.10.2024).

uncertainty regarding the reasons for the significantly lower frequency of dominance of the biennial *Melilotus officinalis* in 2024, as well as the annual *Bromus sterilis* in 2021. *Melilotus officinalis* is an obligatory ruderal, while *Bromus sterilis* is a steppe species, but also a facultative ruderal (Ivanov, 2019). Accordingly, the direction of change in their participation in the formation of the vegetation cover of the study area is quite consistent with that of the majority of weed and steppe species. On the other hand, changes in the frequency of dominance of *Melilotus officinalis* and *Bromus sterilis* may also be associated with life cycle characteristics of these annual or biennial plants, species, the so-called phytocyclic fluctuation (Onipchenko, 2014; Rabotnov, 1983). It is noteworthy that the distribution of this form of dynamics in the vegetation cover is extremely poorly recorded (Onipchenko, 2014).

An expansion of the dominant range of alien and native species accompanied by a decrease in the dominance frequency of other species is possible even in unchanged environments. Recorded cases of a rapid (over 3–10 years) increase in the degree of dominance of Canadian Goldenrod (*Solidago canadensis*) and the Virginia Creeper *Parthenocissus quinquefolia* in communities of southeastern Belarus resulted in a significant decrease in the abundance of other, both native and alien, dominants (*Calamagrostis epigejos*, *Elymus repens*, *Echium vulgare*, *Melilotus albus*, *Oenothera biennis*, etc.) (Gusev, 2016, 2018; Gusev and Sokolov, 2021). Comparison of the occurrence and cover of alien plant species in test plots of the South African savanna in 2019–2020 and 2024 showed that they are capable of rapid dynamics and, thus, pose a threat to savanna biodiversity (Pyšek et al., 2024). On the other hand, despite the long-term (over 30 years) colonization of the bottom communities of Lake Baikal by North American waterweed *Elodea canadensis*, it has not resulted in a large-scale, total replacement of native vegetation, contrary to initial assumptions. The displacement of native dominants by this alien species was localized – in several, often sheltered bays (Kravtsova et al., 2010). However, although shifting of the baseline spatial ranges and temporal patterns of dominant species are documented, the consequences of these changes for ecosystems remain poorly understood, which is a significant gap in phytoecology (Akatov et al., 2023; Avolio et al., 2019; Pyšek et al., 2024). The results of our observations in the vicinity of Maykop did not reveal expansive trends in the dynamics of alien species. In particular, an increase in the projective cover of *Solidago canadensis* was detected over a three-year period, but the average frequency of its dominance did not change significantly. *Parthenocissus quinquefolia* had a low frequency of dominance in both observation periods. The native *Calamagrostis epigejos*, which is considered an expansive species by some authors (Borodulina et al., 2019; Somodi et al., 2008; etc.), began to dominate the communities somewhat more commonly, but without a significant increase in its projective cover.

## Conclusions

Observations of the nature and scale of changes in the distribution and abundance of dominant plant species, especially alien and expansive ones, as well as those sensitive to certain factors, constitute a critical task of phytomonitoring. Above, we demonstrated the potential of a new approach to this: assessing the frequency and degree of species dominance in relatively large areas of vegetation over different years. To this end, we compared dominance data for 106 plant species obtained in this way in 2021 and 2024 at five synanthropic vegetation sites near the city of Maykop. The results showed that three-year changes in the dominance frequency of individual species at these sites, regardless of their origin or ecological preferences, are predominantly synchronous in direction and therefore not random. Moreover, the direction of such changes is driven by the intrinsic environmental requirements of species, and therefore may be a consequence of reduced anthropogenic pressure on the surveyed vegetation areas and, as a result, increased reforestation processes, as well as a response to changing weather and climate conditions in the study area in the summer season. The short observation period does not allow us to determine whether the observed changes are a manifestation of allogenic and autogenic successions, or anthropic, ecotopic, and phytocyclic fluctuations. Longer-term studies are required to address this issue. However, the results already demonstrate that studies based on the proposed approach effectively demonstrate the long-term dynamics of common species over large areas and can be used to identify changes in their growing conditions.

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