

1. Raev, I., B. Rosnev, A. Alexandrov, E. Popov, G. Popov, T. Lubenov, H. Tsakov, P. Mirchev, M. Glushkova, Z. Vasilev, G. Spiridonov. Virgin Forests of Bulgaria. 2005. Publisher: FRI-BAS – KNNV, Editor: Ivan Raev, ISBN: 954-9746-11-9 https://www.researchgate.net/publication/259646681_VIRGIN_FORESTS_OF_BULGARIA_VIRGIN_FORESTS_OF_BULGARIA

The main objective is long-term conservation of virgin forests, which means forests of autochthonous tree species on the territory of Bulgaria, that have retained to a high extent their primary properties. The main tasks implemented in the framework of the project for attainment of this objective are: to work out criteria and indicators for selection of virgin forests; to work out criteria and indicators for assessment of virgin forests; to explore and identify virgin forests in Bulgaria; to provide description of the environmental conditions underlying the formation of virgin forests; to provide description of forests classified as virgin forests with a focus on biodiversity, types of forests and sustainable management practices; to map virgin forests by geographic regions and total for Bulgaria on the basis of field studies and satellite images, topographic and economic maps; to work out a conceptual paper concerning a strategy for conservation of virgin forests in Bulgaria; to raise the awareness of the need of concerted efforts for protection and reasonable management of virgin forests in Bulgaria among broad circles of stakeholders; recommendations on monitoring and future research.

2. Velizarova, E., T. Stankova, **M. Glushkova**, G. Xanthopoulos, V. Konstantinov, D. Dimitrov. 2014. Fuel types identification for forest fire risk assessment in Bulgaria. Advances in Forest Fire Research, Chapter: Fire Risk Assessment and Climate Change, Viegas, Domingos Xavier (ed.) Imprensa da Universidade de Coimbra, 1159-1164, ISBN: 978-989-26-0884-6, http://dx.doi.org/10.14195/978-989-26-0884-6_126

Knowledge of the spatial distribution of fuel types is essential for implementation of the fire models predicting fire behavior, severity and spread. In the present study, the most commonly used fuel classifications systems currently employed worldwide and the associated methods for generating a fuel type classification has been examined and compared. Based on a critical analysis of the state-of-the-art and on the main advances achieved in different classification systems, a simple quantitative methodology for development of a fuel type model has been developed. The results obtained showed that Austrian stands are characterized by a higher fuel load concerning both – live and dead biomass. The load of the dead material ranged from 13.3 t/ha to 47.0 t/ha and the load of the live fuel material was within the range 1.60 kg/m² - 2.08 kg/m². The density of the crown was also higher and equal to 0.354 kg/m². The moisture content of the live leaves branches and dead material for Austrian pine and beech stands was relatively low in comparison with those for the other tree species.

3. Zhiyanski, M., Glushkova, M., Sokolovska, M., Vilhar, U., Lozanova, L. 2017. Soil quality. In: The Urban Forest: Cultivating Green Infrastructure for People and the Environment. Chapter: Soil quality, Springer, 2017, ISBN:978-3-319-50279-3. DOI: 10.1007/978-3-319-50280-9.

The focus of this book is on urban “green infrastructure” (GI) – the interconnected web of vegetated spaces, ranging from street trees and private gardens to neighborhood parks and peri-urban forests, which provide essential ecosystem services in densely populated areas. The concept of green infrastructure embodies the view that biotic systems are just as vital to the functioning of a modern city as any other type of infrastructure, be it roads, water, sewage, power, or communication. At the same time, green infrastructure is different – more dynamic, more heterogeneous, and often more fragile – because it is alive.

Urbanization is the main driver of rapid land-use change around the world, with important consequences for soil quality and quantity. Urban soils, in addition to their slow formation due to long-term natural processes, are decisively modified by urbanization. High levels of soil disturbance and new substrates added to the soil due to human activities change the morphology of the soil profile and the overall soil processes and functions. This is important because soils play an essential role in sustaining the provisioning of ecosystem services (ES). However, the protection of urban soils is still poorly considered in the planning and development of urban areas – and there is a lack of knowledge regarding the potential of different types of vegetation cover and plant species to moderate the degradation of, or even improve, urban soils.

4. Modesto, I. S., C. Miguel, F. Pina-Martins, **M. Glushkova**, M. Veloso, O. Paulo, D. Batista. 2014. Identifying signatures of natural selection in cork oak (*Quercus suber* L.) genes through SNP analysis. *Tree Genetics & Genomes*. DOI 10.1007/s11295-014-0786-1, (**IF =2.451**).

Cork oak (*Quercus suber* L.) is an evergreen tree species endemic to the western Mediterranean Basin with a major economical, social and ecological relevance, associated with cork extraction and exploitation. In the last years, cork oak stands have been facing a significant decline, which may be aggravated by the climate changes that are predicted to occur within cork oak distribution range during this century. Under this scenario, the assessment of adaptive genetic variation is essential to understand how cork oak may cope with these threats and to delineate strategies for the management of its genetic resources. In this study, six candidate genes possibly significant for environmental adaptation were analysed in cork oak populations from its entire distribution range. Signatures of natural selection were investigated using population genetic statistics and environmental association tests under alternative scenarios of population genetic structure. Signals of balancing selection were detected in the putative non-expressor of pathogenesis-related gene 1 (NPR1), involved in plant defence response against pathogens, in auxin response factor 16 (ARF16), a gene implicated in root development, in RAN3, also involved in developmental processes, and in glutamine synthetase nodule isozyme (GS), involved in nitrogen fixation. Furthermore, for ARF16, a class I heat shock protein (sHSP) and GS, associations were found between SNP allele and haplotype frequencies and several spatial and climatic

variables, suggesting that these genes may have a role on cork oak local adaptation. In this study, the first steps were taken into gathering information on cork oak adaptation to environmental conditions.

5. Zhiyanski M., **M. Glushkova**, A. Ferezliev, L. Menichetti, J. Leifeld. 2015. Carbon storage and soil property changes following afforestation in mountain ecosystems of the Western Rhodopes, Bulgaria. iForest– doi: 10.3832/ifor1866-008 [online 2016-05-06] **(IF 5 yrs=1.318)**.

Land-use changes and afforestation activities are widely recognized as possible measures for mitigating climate change through carbon sequestration. The present study was conducted to evaluate the effect of afforestation on (i) soil physical and chemical properties and soil carbon stocks in four mountain ecosystems and (ii) whole ecosystem carbon storage. The four experimental sites, situated in the Western Rhodope Mountains (Bulgaria) were characterized by typical forest-related land-use conversions. The four sites were a Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco) plantation (Rd1) established on former cropland, a mixed black pine (*Pinus nigra* Arn.) with Scots pine (*Pinus sylvestris* L.) plantation (Rd2) established on former cropland, a cropland (RdA1) and an abandoned land with uncontrolled extensive grazing (RdA2) historically used as cropland. Soil parameters, *i.e.*, sand content, pH, organic C and N contents, C/N ratio and soil organic carbon (SOC) stocks, were significantly affected by land use and land-use history. Conversion from cropland into forestland significantly reduced soil bulk density and coarse fragments at 0-10 cm depth. Compared with adjacent cropland and abandoned land, soils in coniferous plantations were acidified in their upper layers. Sites Rd2 and RdA2 contained the least SOC owing to the previous long-term arable cultivation (>100 years). Analysis of the ecosystem C stock distribution revealed that most of C in forests was stored in the aboveground tree biomass. Our study confirmed that afforestation of cropland turned the soil into a C sink for theselected mountain region, but showed conflicting results when afforestation occurred on abandoned cropland.

6. Sen, A., M. Zhiyanski, **M. Glushkova**, K. Petkova, J.P.A. Ferreira, H. Pereira. 2016. Chemical composition and cellular structure of corks from *Quercus suber* trees planted in Bulgaria and Turkey, Wood Science and Technology, DOI 10.1007/s00226-016-0836-y, ISSN 0043-7719, Online ISSN 1432-5225, pp.1-16.60. **(IF 2015 = 1.642)**.

The chemical composition and cellular structure of corks from cork oak (*Quercus suber*) trees grown in Bulgaria and Turkey were studied for the first time to gain insight into the quality of cork from areas external to the species natural distribution. The cellular structural arrangement of Bulgarian and Turkish corks was similar to Portuguese cork, but chemical composition differed significantly. In general, Bulgarian and Turkish corks contained higher amount of ash and lignin and lower amount of extractives than Portuguese cork. Bulgarian cork contained less suberin and more polysaccharides than Turkish and Portuguese corks. The differences in the suberin/lignin ratio (1.4, 1.1 and 2.0 in corks from Bulgaria, Turkey and Portugal, respectively) suggest differences in mechanical behavior, namely in

compression. Suberin composition was similar in all corks, but differences in relative proportion of families and compounds were present, indicating natural variation related to cork origin. Lipophilic extractives differed between corks: Betulinic acid was the main triterpene in Bulgarian cork, while friedelin dominated the lipophilic extractives in Portuguese and Turkish corks. A new lupane-type pentacyclic triterpene was found in Bulgarian and Turkish corks.

7. Stankova, T., V. Gyuleva, I. Tsvetkov, E. Popov, K. Velinova, E. Velizarova, D. N. Dimitrov, H. Hristova, K. Kalmukov, P. Dimitrova, **M. Glushkova**, E. Andonova, G. P. Georgiev, I. Kalaydzhiev, H. Tsakov. 2016. Aboveground dendromass allometry of hybrid black poplars for energy crops. *Annals of Forest Research* 59(1), pp. 1-14, <http://www.afrjournal.org/index.php/afr/article/view/552>, DOI: 10.15287/afr.2016.552, (IF 2015 = 0.741).

Cultivation of energy crops is concerned with estimation of the total lignified biomass (dendromass) production, which is based on the plantation density and individual plant dendromass. The main objective of this study was to investigate the allometry of aboveground leafless biomass of juvenile black poplar hybrids (*Populus deltoides* x *P. nigra*), traditionally used for timber and cellulose production, and to derive generic allometric models for dendromass prediction, relevant to energy crop cultivation in Bulgaria. The study material comprised a variety of growth sites, tree ages and clones, specific to poplar plantings in Bulgaria. We used three principal quantitative predictors: diameter at breast height, total tree height and mean stand (stock) height. The models were not differentiated by clone, because the black poplar hybrids tested were not equally represented in the data, and the inclusion of tree age as a predictor variable seemed unreliable, because of the significant, up to 3 years, variation, which was possible within the narrow age range investigated. We defined the mean stand (stock) height as a composite quantitative variable, which reflected the interaction between the time since planting (age), site quality and the intrinsic growth potential. Stepwise and backward multiple regression analyses were applied to these quantitative variables and their products and sets of adequacy and goodness-of-fit criteria were used to derive individual biomass models for stem and branches. Then we developed compatible additive systems of models for stem, branch and total lignified biomass in log-transformed form. Finally, the prediction data were back-transformed, applying correction for bias, and were cross-validated. Three systems of generic equations were derived to enable flexible model implementation. Equation system M1 proposes a stem biomass model based on tree and stand heights and stem diameter, and a model for branches including mean stand height and breast height diameter; this model displayed the best goodness-of-fit characteristics. Model system M2 uses only the tree height and diameter and therefore is most relevant to dendromass determination in single trees or harvested saplings, while model M3 allows fast and sufficiently accurate biomass estimation of standing poplar stock, because it employs the average stand height and the individual tree diameters. All models are applicable to predict lignified aboveground biomass of juvenile *Populus deltoides* x *P. nigra* trees of diameter up to 21 cm and total height up to 16 m.

8. **Glushkova, M.** 2008. Morphometric variation and differentiation of European chestnut (*Castanea sativa* Mill.) in Bulgaria. *Sylva Balcanica*, 9 (1), 29-40.

During two consequent years (2001, 2002) eleven populations of European chestnut (*Castanea sativa* Mill.) were studied to assess morphometric variation of seven quantitative traits of nuts: thickness, width, height, weight and width/height ratio (shape index) and length and width of the hylum. Fifteen to twenty old trees aged 80 to 150 were randomly selected and samples of fifty mature fruits from each tree were collected. Significant differences in all nut traits were found out among populations and among trees within population. Some populations and some genotypes responded differentially to the year condition in each of the character studied. The most differentiated traits are nut weight, width and thickness and most remarkable differences among populations were proved in nut weight. Between some pairs of traits very high correlations were found. The strongest positive correlations were observed thickness, width, height and weight of nut. The populations were grouped according to the degree of dissimilarity on the basis of Euclidian distance and Complete link clustering algorithm. All the populations from the locality of Berkovitsa and two populations from Belasitsa Mt. – Petr₉₀₀ and Bel₅₅₀ discriminate from the other group with larger fruit sizes, nut weight and smaller shape index. Morphometric differentiation between chestnut populations, based on phenotypic distances of fruit characters, showed to be in rather high congruence with spatial patterns of population's distribution.

9. Zhiyanski, M., **M. Glushkova.** 2013. Carbon storage in European chestnut ecosystems in Belasitsa, SW Bulgaria. *Sylva Balkanica*, 14 (1), pp 61-75.

This work is focused on carbon storage of various components (above-ground biomass, forest floor and soil) of selected European chestnut (*Castanea sativa* Mill.) forest ecosystems developed on Chromic Luvisols in Belasitsa Mountain, SW Bulgaria. Variations were obtained for soil carbon stock in studied chestnut ecosystems. More carbon is sequestered in chestnut biomass of older forest CF1 (31.1 t C ha⁻¹) compared with the other two stands CF2 and CF3 (14.4 – 19.6 t C ha⁻¹). Concerning carbon stored in soil system the picture is different. The mean value of carbon stored in forest floor layers of all studied ecosystems was 19.8 t C ha⁻¹ while the highest stock was determined for the pure chestnut stand CF3 – 23.8±0.8 t C ha⁻¹. In soils carbon is mainly accumulated in the superficial 0 - 10 cm and decreased toward deeper layers. In the mixed forests CF1 and CF2 the carbon stock in this soil layer was estimated at 20.1 t C ha⁻¹ and 21.2 t C ha⁻¹, respectively. The values obtained were lower in comparison with the same layer under the pure chestnut stand CF3 (34.1 t C ha⁻¹). The carbon stock in both forest floor and 0-50 cm soil was higher in CF3 (84.04 t C ha⁻¹) compared with CF1 (59.77 t C ha⁻¹) and CF2 (50.50 t C ha⁻¹). Following the estimations of carbon stock including above ground biomass, the total stock in the studied chestnut forests could be ordered as follows: CF3 (105.8 t C ha⁻¹) > CF1 (102.1 t C ha⁻¹) > CF2 (76.3 t C ha⁻¹). The pure chestnut forest CF3 characterized with the highest total carbon stock per hectare and only 20.6 % from it is accumulated in the aboveground tree biomass. This confirms the high potential of carbon sequestration in soil system under pure and mature chestnut forests. At the same time the carbon in older mixed chestnut ecosystems dominated by beech in tree composition (CF1) was also high but 33.8 % of carbon is accumulated in the

aboveground chestnut biomass, while 21.0% of carbon is sequestered by chestnut trees in the other mixed stand CF2, dominated by chestnut. In CF3 the accumulation is mainly in forest floor and in mineral soil (especially in the superficial soil layer), which shows favourable conditions for the incorporation of organic substances in soil system under pure chestnut stands in mature growing phase.

10. Stankova T., V. Gyuleva, E. Popov, K. Velinova, E. Velizarova, D. N. Dimitrov, K. Kalmukov, **M. Glushkova**, P. Dimitrova, H. Hristova, E. Andonova, G. P. Georgiev, I. Kalaydzhev. 2015. Allometric relationships for aboveground biomass of juvenile black poplar hybrids. *Silva Balcanica*, 16(2), 5-28.

The main objectives of this study were to investigate the allometry of aboveground biomass of juvenile black poplar hybrids (*Populus deltoides* x *P. nigra*) traditionally cultivated for timber and cellulose production and to derive biologically plausible and statistically sound biometric models for stem, branch, leaf and total aboveground biomass prediction from easily measurable tree and stand characteristics. We examined a number of model formulations based on breast height tree diameter and total tree or mean stand height as predictor variables of the aboveground tree biomass following a two-stage fitting procedure, and we considered a set of goodness-of-fit criteria to derive the allometric relationships. We used data collected in industrial poplar plantations to parameterize the functions and validation data from nursery stock for final model adjustment. Two systems of compatible generic equations were developed to estimate stem, branch, leaf and total aboveground biomass of hybrid black poplars. Model system M1 uses only the two principal tree dimensions. It can therefore be applied for determination of aboveground biomass in single trees or harvested saplings when information on the stand height is absent. Model system M2, which is based on mean stand height and tree diameter, can be used to assess rapidly and accurately the biomass of standing poplar stock.

11. Zhiyanski, M., M. Glushkova, L. Kirova, Filcheva, E. 2016. Quantitative and qualitative features of soil humus in mountain treeline ecosystems. *Silva Balcanica*, (приета за печат)

The ecosystems in treeline mountainous regions are considered as vulnerable to climate change, since these areas will experience stronger temperature fluctuations at regional scale than the global climate and are exposed to different intensity of land use and to land use change, both affecting their functioning and services. Forests, pastures and meadows with different land-use intensity in the treeline region of Central Balkan were studied to define the effects of the management intensity and different land uses on the quantitative and qualitative features of soil humus. Forest floor and mineral soils samples were analyzed. Land use change caused a slight decrease in organic carbon, total nitrogen contents, soil pH and the overall soil organic carbon stock 45 years after the afforestation activities as well as caused differences in the amount of humic and FAs. Similar effect was observed after conversion of natural beech forest to spruce plantation 67 years after the change. The presence or lack of management activities in the created coniferous plantations in the treeline zone were not a

prerequisite for betterment humification processes and further incorporation of organic substances in the mineral soil in forest land uses. Opposite could be concluded for mountain grasslands, where relatively long term intensive grazing is hence with an increase of carbon content in superficial soil and improved soil fertility to some extents. The potential effect of land use and management intensity on carbon storage capacity in treeline ecosystems could be estimated by assessing the quantitative features of soil humus. They are important, but could not be applied as enough informative indicators for the effects of land use change and management impacts in treeline ecosystems.

12. **Glushkova, M. 2017.** Allozyme variation of chestnut populations (*Castanea sativa* Mill.) in Bulgaria. *Silva Balcanica*, 18 (2), 2017, (приета за печат)

In this study the allozyme variation in 8 chestnut populations (*Castanea sativa* Mill.) was studied. The studies were performed using standard methods for isozymes determining of genotypes (Huang et al, 1994a, 1994b). The large number of effective alleles was found thus proves the existence of a large genetic diversity. For population Petrich₇₀₀ the higher number of effective alleles was obtained and the highest value for the expected heterozygosity is calculated for population Tsaparevo. For Petrich₉₀₀, Petrich₇₀₀, Samuilovo and Slavianka populations, lower values for the expected heterozygosity were obtained in comparison with the experimentally calculated. The positive values obtained for the inbreeding coefficient in Belasitsa, Brezhani, Tsaparevo and Churichene populations indicate for lack of heterozygous individuals. The cluster analysis classifies Petrich₉₀₀, Petrich₇₀₀ and Samuilovo populations as more similar to each other, which correspond to its geographic location. The most distinct from the three major groups is Brezhani. It is also geographically the most remote population compared to the others, indicating the existence of a relationship between the genetic and geographic distances.

13. Пандева, Д., **М. Глушкова.** 2005. Разпространение и формово разнообразие на видове от род *Acer* по северните склонове на Люлин планина. *Наука за гората*, 3, 63-70.

Изследвани са популации на *Acer pseudoplatanus* L., *A. platanoides* L., *A. hyrcanum* F.M. и *A. campestre* L. по северните склонове на Люлин планина. Тези видове се срещат предимно по границите на букови и габърви насаждения със семенен или издънков произход, върху средно богати до богати свежи месторастения при надморска височина над 800-850 m.

Въпреки преобладаващия издънков произход на естествените горски екосистеми изследваните групи и индивиди от явор, шестил, полски и хиркански клен са в добро здравословно състояние. Преобладават правостъблените индивид със симетрични корони и добри растежни показатели. Установено е наличието на следните форми при обикновения явор и полския клен: *Acer pseudoplatanus* var. *erythrocarpa* Carr., *Acer pseudoplatanus* var. *chlorocarpa*, *Acer cvampestre* var. *marsicum* (Guss.) и *Acer campestre* var. *campestre*.

14. **Glushkova, M.** 2007. Variation in Quantitative Traits of Bark in Sweet Chestnut (*Castanea sativa* Mill.) Populations from Belasitsa and Western Balkan Mt. Forest science, 2, 27-39.

The present study aimed to characterize variability of sweet chestnut (*Castanea sativa* Mill.) populations with respect to morphological traits of bark, with a view to its conservation and sustainable use. Chestnut bark samples were taken from eleven sample plots from two geographically distant regions. A large variability within and among populations was observed, related to type of bark fissuring. The most variable trait is the depth of bark fissuring and relatively less variable is the width of bands. Maximum differentiations among individuals, consider all investigated characters, is expressed in population Bel₄₅₀ and minimum is found in Berk₆₀₀. The most deviant population, considering bark characters is Berk₆₀₀. Although Berk₈₀₀ and Berk⁴⁰⁰ also belong to a distinct cluster from the majority of populations. Individuals from Belasitsa Mt. are with narrow banded, shallow fissured bark in opposite to those from Western Balkan Mt., where the trees with wide-banded, deep-fissured bark dominate significantly. Correlation between traits was found to be high between the depth of bark fissuring and the weight of chestnut nuts. With regard to selection and breeding the most valuable are individuals with deep-fissured bark, which have larger and heavier fruits.

15. **Глушкова, М., М. Жиянски, К. Генов.** 2008. Възможности за използване на обикновения орех (*Juglans regia* L.) в устойчиви агролесовъдски системи (Обзор). Управление и устойчиво развитие, том 19, № 1, 35 – 41.

Агролесовъдството е потенциална алтернатива на конвенционалните методи за устойчиво управление на земята. То очертава възможност пред земеделските производители и местните бизнес-предприемачи за разработване на краткосрочни и дългосрочни инвестиционни програми, оценка и намаляване на стопанския риск, вследствие диверсификацията на продуктовата гама. Същевременно агролесовъдството предлага рентабилен подход за превръщането на нископлодородните земи в плодородни за продължителен период от време.

Настоящата разработка представя обобщен обзор върху възможностите за използване на обикновения орех (*Juglans regia* L.) в изграждането и поддържането на устойчиви агролесовъдски системи. Биологичните особености на ореха определят съвместимостта му с много растителни видове, което позволява създаването на уникални агролесовъдски комбинации, които в максимална степен използват предимствата и съответстват на изискванията на местните и регионалните пазари. Високата цена на дървесината и редовните доходи от производството на плодове го правят изключително желан дървесен вид за създаване на агролесовъдски системи.

16. Жиянски М., М. Соколовска, **М. Глушкова**. 2008. Залесяването като инструмент при прилагане на механизма „Съвместно изпълнение” на Протокола от Киото. Управление и устойчиво развитие, том 19, № 1, 46 – 50.

Киото Протоколът включва три пазарно базирани механизма, които спомагат за ефективното намаляване на цените на енергията. Един от тях е механизмът за изготвяне на проекти за Съвместно Изпълнение (СИ) или Joint Implementation (JI), който позволява ползването на кредити за намалени емисии и е сформирани от инвестиции в други индустриални области. Горите са ресурс, акумулиращ въглерод от глобалното атмосферно „депо” на въглероден диоксид. Посредством неговото усвояване е възможно постигане на по-голяма икономическа полза от прилаганите методи за залесяване и мерките за повишаване продуктивността на дървесната компонента В статията са представени потенциалните възможности и насоките за прилагане на проекти по СИ в сектор LULUCF в България, а именно: залесяване на горски територии и пустеещи земи; управление и превенция на горски пожари; защита на горите срещу болести и вредители; промени в прилаганите лесовъдски практики.

17. Глушков, С., Л. Тричков, И. Марков, **М. Глушкова**. 2008. Използване на биомасата за отопление на обществени сгради в България – първи стъпки. Наука за гората, 2, 65-75.

Отоплението на обществените сгради в България през зимните месеци е един от основните проблеми на общините. В последните години поради липса на средства, отоплителните инсталации са амортизирани и снабдяването им с традиционните течни горива е затруднено. Като нова алтернатива се явява отоплението на сградите с енергийни трески (чипс). Анализирани са в техническо и икономическо отношение отоплението на три обществени сгради в гр. Ардино (две училища и една болница), където старата отоплителна инсталация е подменена с нова, изгаряща дървесна биомаса – чипс в периода 2006/08 г. Изследвано е качеството на дървесната биомаса по абсолютна влажност и размери. Установено е, че те отговарят по качество на изискванията на датския стандарт за фини трески, който засега е единственият пригоден за нашите условия. Преминаване отоплението на общинските сгради на възобновяеми енергийни източници ще позволи икономия от 30-50% на бюджетните им средства, с което ще се компенсира в голяма степен сегашният им финансов недостиг. На този етап обаче, не е постигнат очакваният социален ефект за местното население.

18. **Glushkova, M.**, M. Zhyanski, K. Velinova. 2010. Nut Quality Assessment of Chestnut Cultivars from “Ivanik” Clone Collection. Forest Science, No 1, 3-14.

Chemical composition of eight native and non-native cultivars from ‘Ivanik’ nursery plantation – Southwestern part of Bulgaria, was investigated. High variability in chemical composition among cultivars was found out, corresponding to the high genetic variability between cultivars. Cultivar I – 5/3, which is bred from *Castanea mollissima*, produced nuts with lowest moisture content. The highest moisture content was found for *C. crenata* x

sativa cultivars. Cultivar Zlatarevo had the highest total sugar content. Marigoule and Hemus showed the lowest values in crude protein, but highest were recorded for *C. crenata* cultivars. Lower in potassium and phosphorous content were mainly cultivars, bred from *C. mollissima* and with higher content were those, bred from *C. crenata*.

19. Глушков, С., И. Марков, **М. Глушкова**. 2010. Техника и технология за попартиден добив на семена в районната семедобивна станция в Разлог. Наука за гората, кн. 2, 85-99.

Горското семепроизводство в България има създадени традиции от началото на миналия век, когато са започнали първите залесявания. От 1995 г. е пусната в действие най-новата семедобивна станция за попартиден добив на семена от малки партиди с тегло от 1 до 500 kg. Годишната производителност на съоръжението е над 100 t. Добитите шишарки са от отделни плюсови дървета, клонове на семенни градини или от семепроизводствени насаждения. Предварителното подсушаване на „свежите“ шишарки се осъществява в складово стопанство в метални бокс палети. Сушенето на шишарките се извършва в стелажна сушилна, а обезкриляването на семената – на немски комплекс „Strekel&Schreoder“.

Резултатите показват, че предварителното подсушаване на шишарките в складовото стопанство при режим: средна дневна температура 15-27° C и относителна влажност на въздуха - 35-48%, съкращава срока на предварителното подсушаване почти с три месеца и половина. Рандеманът на добитите семена от бял бор, черен бор и смърч са по-високи или граничат с тези, посочени в Инструкцията. Средният процент на кълняемост на семената първо качество е над 96%. Изследваната потвърди високата производителност на семедобивната станция за попартидно сушене, осигуряваща семена с високи посевни качества.

20. Глушков, С., И. Марков, **М. Глушкова**. 2010. Изследване процеса на послойно сушене на шишарки от иглолистни дървесни видове. Наука за гората, кн. 3, 53-63.

Оптималната дебелина на слоя за сушене на шишарките е важна характеристика, тъй като чрез нея се оптимизира семедобивът в технологично и техническо отношение. Чрез нейното оптимизиране може да се постигне максимален добив на годни семена. Изследвана е промяната на дебелината на слоя шишарки в зависимост от влажността им. Проведени са изследвания от 1 до 5 слоя шишарки, като е определено нарастването на обема им и семенния добив в зависимост от продължителността на сушене и влагата на материала. Като основен критерий за определяне на оптималното послойно сушене е приет максималният среден процент на динамиката на семенния добив, който е правопрпорционален на максималното средно набухване на отделните слоеве. При изследването максимален добив на семена е получен при сушенето на бялборови шишарки на 4 слоя, а за черенборовите и смърчови шишарки е установено максимално набухване и съответно максимален добив при 3 слоя сушене.

21. Жиянски, М., М. Глушкова. 2011. Перспективи за смекчаване на климатичните промени като предизвикателство пред горското стопанство. Управление и устойчиво развитие, Управление и устойчиво развитие, 1/2011 (28), pp 251-255.

През изминалите няколко десетилетия се наблюдава много бързо изменение на екологичните и икономическите условия. Във връзка с климатичните промени местните политики за развитие на горския сектор в повечето страни от ЕС са фокусирани върху съчетаването на различни финансови схеми за компенсиране на загубите, в комбинация с цели, насочени към опазване на биологичното разнообразие, водните ресурси, ландшафта и околната среда като цяло. В статията се разглеждат някои перспективи пред горското стопанство за смекчаване на климатичните промени и за устойчиво развитие на регионите.

22. Велинова, К., М. Глушкова. 2011. Съдържание на фотосинтетични пигменти, общ белтък и свободен пролин в асимилационния апарат на популации от обикновен кестен (*Castanea sativa* Mill.). Наука за гората, кн. 1-2, 27-36.

Проучването е свързано с определяне състоянието на пигментния фонд, съдържанието на общ разтворим белтък и степента на пролинова акумулация в асимилационния апарат на четири популации от обикновен кестен (*Castanea sativa* Mill.) от района на Южна България за оценка на тяхната физиологична активност и приспособимост към конкретните условия на месторастене. Три от експерименталните опитни площи са заложени в кестенови насаждения, разпространени по северните склонове на Беласица (ДГС Петрич), а четвъртата - в Северозападен Пирин, в района на с. Брежани (ДГС Симитли). Проследените параметри, пряко свързани с физиологичния статус на популациите показват, че Самуилово₄₅₀ се отличава като най-жизнена и физиологично активна, което предполага и по-голяма устойчивост и приспособимост към условията на средата. Установените високи нива на свободен пролин за популация Петрич₇₀₀, я определят като по-уязвима към неблагоприятните условия на средата.

23. Dimitrova, P., V. Gyuleva, T. Stankova, M. Glushkova, S. Nenkova, I. Valchev, T. Andreykova, S. Petrin. 2016. Analysis of some feedstock properties of fast-growing broadleaved species for energy crops. Forest Science, (приета за печат)

Some important for fuel production feedstock properties of the stem wood of juvenile black locust trees and clones, hybrid black poplars and Paulownia clones were analyzed. A tendency to bulk density increase with age was manifested and for the studied poplar clones this parameter reached values 300-400 m³/kg . The bulk density of black locust was around 450-600 kg/m³ and was the highest across all ages and species. The poplar wood showed the highest calorific value, but the contents of cellulose, lignin and ash were in most favorable proportion in the stem of *Paulownia* trees.

24. Глушков, С., М. Глушкова. 2001. Технология за производство на декоративни фиданки чрез вегетативно размножаване. Механизация на земеделието, бр. 1, 9-11.

Разгледани са възможностите за производство на декоративен посадъчен материал чрез вегетативно размножаване с помощта на прилаген на проста и с ниска капиталоемкост технология. За целта е избрана полиетиленова оранжерия с относително опростена конструкция и удобна за експлоатация. За поддържане на необходимата температура и влажност в оранжерията е монтирана оросителна система на италианската фирма "CLABER", която осигурява непрекъснато, дребно дисперсно разпръскване на водата, интензивно мъглуване с минимален диаметър на капките и равномерно разпределение на капките вода по повърхността на лехата и резниците, заложи за вкореняване.

Вкореняването на резници от сребрист смърч достига до 64% за срок от два месеца, като резниците формират до 5 броя корени със средна дължина 25 mm. За резниците от аризонски кипарис е постигнат максимален процента на вкореняване 36%, а за лавзоновия лъжекипарис – 88% за 3 месеца период на вкореняване. Най-добри резултати са постигнати при третиране на резниците с индолил-маслена киселина в концентрация 0.25-0.5%.

25. Милев, М. Н. Илиев, М. Глушкова. 2000. Проучване върху автовегетативното размножаване на сребристия смърч. В Сборник от Четвъртата научна конференция "Размножаване на декоративни растения", 7-9 Октомври, София: 248-250.

The aim of the study is to look for an opportunity for a successful autovegetative propagation of the Colorado spruce (*Picea pungens*). The results show that appropriate donors for obtaining cuttings are individuals aged to 10 years. The cutting itself should be done in April before the start of vegetation. Cuttings should be treated with indolil butyric acid powder with a 0.50% concentration. The substratum must contain organic materials. Following the proposed conditions the rooting reaches 64% in 2 months. The cuttings have developed a functional root system with average 5 roots with length 25 mm for 20 days after root formation.

26. Глушкова, М. 2006. Вариабилност на обикновения кестен (*Castanea sativa* Mill.) по типа на купулите в популации от Беласица и Западна Стара планина. В: Сб. Доклади от Международна научна конференция на тема: "Науката в условията на глобализация през XXI век", 1-2 Юни, Стара Загора, т. I, 184-189.

The paper presents results of the study on the variability of cupules of *Castanea sativa* Mill. in populations from Belasitsa Mt. and Western Balkan Mt. Three hundred cupules from each of 11 populations were collected and the width and height of the cupules and the length and density of the prickles were measured. Surprising amount of between-population variation in studied characters was proved. Individuals with medium-sized cupule (f. *typica*) prevail in the investigated populations – 73%. Individuals which form big-sized cupules are only 18% from the total number of the trees. Very often the smallest cupules have undeveloped fruits and seeds. The smallest cupules are generated by individuals from population Samuilovo₆₅₀

and the biggest ones – from Berkovitsa⁶⁰⁰. They are also characterized with the smallest and the biggest fruits, respectively. Considering length, thickness, hardness and density of the prickles, the cupules are classified as follows: f. *rarispina* Khar., f. *brevispina* Khar. and f. *longispina* Khar. Dominant participation for f. *brevispina* was observed, followed by f. *longispina*. Individuals with cupules from *rarispina* type appear rarely. Their absence was observed only in population Petrich⁵⁰⁰.

27. **Глушкова, М.** 2006. Кълняемост на семената на обикновения кестен (*Castanea sativa* Mill.) при неконтролирани режими на култивиране. В: Сб. Доклади от Международна научна конференция на тема: “Науката в условията на глобализация през XXI век”, 1-2 Юни, Стара Загора, т. I, 179-183.

The soil germination of *Castanea sativa* Mill. seeds studied in natural conditions (nursery) and in greenhouse under relatively constant conditions. Average duration of seed dormancy, commence and end of germination process, average number of days to reach 50% germination and average number of days to reach maximum germination were studied. The average percentage of soil germination of seeds of various individuals was determined. Significant variation of soil germination was observed depending on individual peculiarities of investigated trees, seed material condition and climatic conditions during growing period. Sufficient increase of average germination was obtained for the seeds grown in greenhouse. The analysis of variance of the studied adaptive traits showed that they vary in wide range and are indicative for the presence of high adaptive ability of some *Castanea sativa* Mill. populations.

28. **Glushkova, M.** 2007. Distribution of sweet chestnut (*Castanea sativa* Mill.) genetic resources in Belasitza Mountain. In: I-st Balkan Regional Workshop “Sustainable Management of Sweet Chestnut Ecosystems”, 2-5 November 2005, Blagoevgrad, Bulgaria: 127-136.

Due to the decline, provoked by biotic and abiotic factors and specific ecological requirements the distribution of *Castanea sativa* Mill. in Belasitza was studied. On the base of phenotypic investigations differences in fruit and leaf morphometric parameters have been proved to be statistically significant traits of interest. The correlation between investigated traits and form diversity was estimated. Using cluster analysis the attempt to discriminate populations studied was made.

29. **Glushkova M., V. Gjuleva, K. Genov. D. Pandeva.** 2007. Ex situ conservation of *Castanea sativa* Mill. – present state of some clonal archive. In: I-st Balkan Regional Workshop “Sustainable Management of Sweet Chestnut Ecosystems”, 2-5 November 2005, Blagoevgrad, Bulgaria:137-142.

An attempt to summarize the results from the forty years breeding work on establishment of clonal archives in Bulgaria is made. The positive and negative aspects of present state have been discussed. Renovation and/or reestablishment of all valuable cultivars, including *in*

vitro cultures and cryopreservation approaches are recommended. Good basis for selection and breeding of new cultivars are individuals with big fruits – *macrocarpa* type established in Belasitsa and Western Balkan Mt. It is also necessary the plantations of *Castanea cfenata* and *Castanea mollissima* to be restored and used as a fundamental for breeding new, resistant to diseases plants. To provoke the interest at the different national and international levels, the results obtained should be mutually disseminated and the alternative positive activities should be integrated in the forestry practice.

30. Gjuleva V., **M. Glushkova**, K. Genov. 2007. Conservation of *Castanea* genetic resources in Bulgaria through tissue culture. In: I-st Balkan Regional Workshop “Sustainable Management of Sweet Chestnut Ecosystems”, 2-5 November 2005, Blagoevgrad, Bulgaria: 143-152.

The current state of *Castanea sativa* Mill. considering health status, distribution and ecological requirements reveals a serious decline of the chestnuts forest stands in Belasitsa Mountain and Berkovitsa Mountain. At the basis of the investigations on micropropagation by *de novo* shoots formation, rooting, somatic embryogenesis and cryopreservation of *Castanea sativa* throughout the world, the positive results of the *in vitro* propagation of chestnut in Bulgaria is discussed. It is recommended *Castanea sativa* to be integrated as a species in the *ex situ* conservation and improvement strategy in Bulgaria.

31. **Glushkova, M.**, V. Gyuleva, K. Velinova, G. Georgiev. 2012. Nutritional Quality of Nuts from Seven Sweet Chestnut (*Castanea sativa* Mill.) Ecotypes from Bulgaria. In: Proceedings of International Conference “Ecology – Interdisciplinary Science and Practice”, Sofia, 25-26 October, 2012, pp 116-122.

Consumer demands for healthy, safe and high quality food is increasing significantly during the last decades. The consumption of fruits, particularly nuts, has become more important in human nutrition, due to the protection provided by the antioxidant compounds. In recent years, the consumers have been showing an increased interest in chestnut fruits because of their nutritional qualities and potential beneficial health effects.

Therefore the chemical composition of nuts from seven Bulgarian sweet chestnut ecotypes was studied: Belasitza, Kukovo, Izvora, Gega, Brejani, Kresna and Petrich. Results showed great variability of all of the studied parameters. Chestnut nuts were characterized by high moisture content (~50%), high levels of starch (52 mg 100 g⁻¹ dry matter - d.m.) and low fat content (4 mg 100 g⁻¹ d.m.). Nuts contained significant amount of fibre (7% d.m.) and were very rich in K (~850 mg 100 g⁻¹) and Mg (~50 mg 100 g⁻¹). The average content of nutrients was in the normal range for this type of products, but compositional data showed great variability as a function of variety. Belasitza showed the highest content of sucrose and fibre. Izvora presented the highest protein content and Belasitza presented the lowest calcium content, probably due to the specific soil conditions in the area of origin. These results provide additional information about the nutritional value of each ecotype and would be valuable reference to chestnut quality for the nutritionist, breeders and growers.

32. **Glushkova, M.**, V. Gyuleva, P. Dimitrova, K. Velinova. 2012. Variation in Germination Capacity and Seedling Growth of Sweet Chestnut (*Castanea sativa* Mill.) Populations. In: Proceedings of International Conference “Ecology – Interdisciplinary Science and Practice”, Sofia, 25-26 October, 2012, Part One, pp 123-128.

The study objective was to compare intraspecific variation of 8 sweet chestnut populations (*Castanea sativa* Mill.) in a number of adaptive traits. Analyses of variance for germination rate, germination energy, start date and end date of germination process, stem height, collar diameter and central root length revealed significant population effect. The results obtained showed well expressed discrimination of studied populations in average stem height, thus illustrating the geographic heterogeneity in growing characteristics within this species. Correlation of mean stem height collar diameter, central root length of seedlings with mean seed size/seed weight were remarkably high, which indicated that the larger the seeds the larger the average seedling would be in seedling height, diameter and root length. It was observed also that larger seeds of *C. sativa* have better germination capacity, corresponding to better quality, genetic potential and adaptive ability.

33. Gyuleva, V., M. Tchorbadjieva, **M. Glushkova**, K.Velinova. 2012. Esterase discrimination and growth of Paulownia elongata and its hybrids in three different regions in Bulgaria. In: Proceedings of International Conference “Ecology - Interdisciplinary Science and Practice”, Sofia 25-26 October 2012., Part One, pp. 152-161.

The phenotypic diversity of α -esterase of different Paulownia elongata and its hybrids has been investigated. An attempt was made to identify and discriminate different Paulownia elongata clones, based on coefficient of similarity and cluster analysis. A further attempt for early forecast of growth and adaptivity of these clones in the region of Lukovit, Karlovo and Svilengrad, based on the percentage of survival, height and base stem diameter of the different clones tested has been implemented.

34. Gyuleva V., **M. Glushkova**, K. Velinova, P.Dimitrova. 2012. Ecological-biological peculiarities of some Paulownia species growing in Bulgaria and prevention of potential negative consequences for Environment. In: Proceedings of International Conference “Ecology-Interdisciplinary Science and Practice”, Sofia 25-26 October 2012, Part One, pp. 162-169.

In recent years there was increasing interest in the species of Paulownia due to the possibility of alternative use for timber production or energy crops. Based on the information gathered on the growth and the condition of the experimental cultures of hybrid and pure species of Paulownia growing in different parts of Bulgaria, as well as the data from the scientific literature on eco-biology of these species the attempt for risk assessment of colonization has been done. To overcome the potentially negative consequences for the environment and forest genetic conservation different measures have been proposed.

35. Глушкова, М. 2014. Вариабилност на обикновения орех (*Juglans regia* L.) в предпланинските части на Западни Родопи. В: Сборник научни публикации на Института за гората „145 години БАН”, 155-162.

Проучването е извършено в района на предпланинските части на Западни Родопи и обхваща части от държавния горски и селскостопански фонд, прилежащи към територията на Държавните горски стопанства (ДГС) Белово, Пещера, Кричим и Асеновград. Определени са основните биометрични показатели и е оценен физиологичният статус и здравословното състояние на ореховите дървета. Изследвана е вариабилността на стопански ценни белези: растежни параметри, форма и размери на плодовете, размери на листата и мъжките реси, фенологични признаци (начало на разпукване на пъпките, начало и край на цъфтежа и зреенето на плодовете). Извършена е оценка на продуктивността, очакваното плодосъстояние и типа плодосъстояние на изследваните дървета.

Получени важни резултати за вариабилността на обикновения орех (*Juglans regia* L.) в предпланинските части на Западни Родопи. Установена е висока степен на вариабилност на морфологични и фенологични признаци, характеризиращи продуктивността и качеството на плодовете, които имат важно стопанско значение и могат да бъдат използвани като критерии при бъдеща селекционна дейност.

36. Глушкова М., К. Генов. 2005. Кестените в долината на река Струма. в-к „Български фермер“, бр. 703.

В отговор на читателски въпрос се представя информация за районите на разпространение, биологичните особености, екологичните изисквания и растежните характеристики на обикновения кестен. Описани са качеството на плодовете му и възможностите за добив на широк спектър от продукти. Охарактеризирани са районите, в които е подходящо неговото отглеждане, традициите по създаване на култури за плодпроизводство у нас и тяхното здравословно състояние към момента. Дадени са препоръки за правилното му отглеждане.

37. Глушкова М., К. Генов. 2005. Агресивни чуждоземни видове заплашват плодните земи. в-к „Български фермер“, бр. 721.

Описани са най-често срещаните у нас инвазивни дървесни и храстови видове. Посочени са техните биологични особености и причините, поради което те бързо завземат нови територии, измествайки местните представители на дървесната растителност. Направен е преглед на първите залесявания с тези видове у нас и са посочени най-засегнатите райони в страната.

38. Глушкова, М. 2006. Къде може да се отглежда кедър? в-к „Български фермер“, бр. 760.

Представена е информация за биологичните особености и екологични изисквания на представителята на род Кедър, първите залесявания у нас и площта на създадените

култури. Предвид нарастващият проблем със съхненето на иглолистните гори у нас, който става все по-осезаем през последните 2-3 десетилетия се изтъкват предимствата на атлаския кедър, за който се смята, че е подходящ за отглеждане в много райони на страната и заслужава да бъде въведен в залесителната практика у нас.

39. **Glushkova, M.** Adaptive Traits Variation of Sweet Chestnut Seeds. Scientific-expert symposium with international participation: “Role and Significance of Forest Seed in Forest regeneration”, 50th anniversary of Forest Seed Science and Technology in Croatia, 28-29 October 2009, Zagreb, Croatia, Book of Abstracts, pp. 44.

The germination of *Castanea sativa* Mill. seeds was studied in natural conditions (nursery) and in green house under relatively constant conditions. Significant variation of soil germination was observed depending on individual peculiarities, seed material and climatic conditions during the growing period. Sufficient increase of average germination was obtained for the seeds grown on greenhouse. The analysis of variance of the adaptive traits showed that they vary in wide range and are indicative for the presence of high adaptive ability of some *Castanea sativa* populations.

40. Gluschkov, S., I. Markoff, **M. Glushkova.** 2009. Equipment and technology for the extraction of coniferous seeds in regional station for forest seed production „Razlog“. Scientific-expert symposium with international participation: “Role and Significance of Forest Seed in Forest regeneration”, 50th anniversary of Forest Seed Science and Technology in Croatia, 28-29 October 2009, Zagreb, Croatia, Book of Abstracts, pp. 36.

Forest seed production in Bulgaria has a tradition since the beginning of the last century when they first started afforestation. In 1995 the new forest seed station in Razlog was put into operation for small seed lots, of weight from 1 to 500 kg. Annual productivity of this station is over 100 t. Harvested cones are from different superior trees or clones of seed orchards, or forest seed plantations. Preliminary drying of fresh cones takes place in a warehouse in metal box pallets. Internal transportation is carried out by electric truck. Drying takes place in shelving drying. Cleaning of seeds is done in the “Strekel & Schroeder” Complex (Germany).

41. Zhyanski, M., M. Sokolovska, **M. Glushkova.** 2011. Management of carbon sequestration in Bulgarian forest soil. COST FP0803 Conference “Carbon balance after disturbances and drought”, June, 27-th – July 1-st, Barcelona, Spain, Book of Abstracts, pp.38.

Forests are multifunctional systems and their role as a carbon sink is of a great importance in mitigating climatic changes. Forest area in Bulgaria covers 4.138 million hectares, and 3.738 million hectares (90%) are woodlands. This paper focuses on analysis of carbon stocks in Bulgarian forest soils and outlines the main direction for future management of carbon sequestration in Bulgarian forest soils under climatic changes. On the basis of data collected from 143 experimental plots, which presents a part of the International Co-operative Programme on the assessment and monitoring of air pollution effects on forests (ICP Forests

Level 1), the management of carbon sequestration in forest soils was analysed. Sites were selected on the basis of the presence of woodland on a 16 x 16 km, 8 x 8 km and 4 x 4 km national grid and covered a wide range of tree species and soil types. Samples were analysed by 0-20 cm soil depth for soil carbon concentrations and bulk densities by standard methods. These data are compared with those obtained from other national surveys and the uncertainties involved in measuring and calculating of carbon stocks are discussed. Carbon stocks across the different forest soil types increased in the order: *Rankers / Regosols* < *Fluvisols* < *Luvissols* = *Planosols* < *Cambisols* < *Vertisols*, *Chernozems* and *Rendzinas*. The averaged total C stocks of Bulgarian soils in the upper 20 cm soil depth, ranged between 128 and 443 tCO₂eq ha⁻¹ represented between 32 to 60 % of the total 0-100 cm soil C stocks (319 to 1809 tCO₂eq ha⁻¹). Carbon content varied with soil depth, soil type and forest type. The distribution of carbon stock in 0-25 cm depth in different soil types in Bulgaria is also presented. *Cambisols* contributed most to the total soil carbon stock in Bulgarian forests, followed by *Luvissols*, *Phaeozems* and *Litosols*. The eroded and superficial soil realized about 64 % from the total soil carbon stock and this provoke the special need for urgent measures, recommendations and policies for prevention of soil degradation.

42. **Glushkova, M.**, K. Velinova. 2011. Chemical composition of eight chestnut cultivars from “Ivanik” plantation – Southwestern part of Bulgaria. Proceedings of COST Action FA 0905 “Minerall Improved Crop Production for Healthly Food and Feed”, 23-26 November 2011, Venice, Italy, Book of Abstracts.

In this study, chemical composition of eight native and non-native cultivars from “Ivanik” nursery plantation - South-western part of Bulgaria, were investigated. High variability in chemical composition among cultivars was found, corresponded to the high genetic variability between cultivars. Cultivar I – 5/3, breded from *C. mollissima*, produced nuts with lowest moisture content. The highest moisture content was found for *C. crenata x sativa* cultivars. Higher starch content showed cultivars, breded from *C. crenata*. Cultivar Zlatarevo had higher total sugar content, much higher than the average values reported by the most of the researchers. Cultivars Marigoule and Hemus showed the lowest values in crude protein, but highest were recorded for *C. crenata* cultivars. Lower in potassium and phosphorous content were cultivars, breded from *C. mollissima* and with higher content were those, breded from *C. crenata*. All of the cultivars are needed of mineral supplementation in order to correct Ca:P imbalance.

43. Modesto, I. S., C. Miguel, F. Pina-Martins, **M. Glushkova**, M. Veloso, O. S. Paulo, D. Batista. 2012. Population Frequency data of SNP Markers in Cork Oak. . BMC Proceedings, IUFRO 2012 Conference “Genetics of Fagaceae and Nothofagaceae”– INRA, 9-12 October, 2012, Bordeaux, France, Book of Abstracts.

The Mediterranean Basin is a hotspot for phylogeographical and evolutionary studies, being described as a region where several glacial refuges subsisted and characterized by a complex geographical history, considerable climatic heterogeneity and long-term impact of human activities, all of which had influence upon the evolution of Mediterranean flora. Considering

the relevance of this subject for the conservation of genetic resources, cork oak is a preferential target of genetic diversity, evolutionary history and selection studies, for which powerful informative markers such as Single Nucleotide Polymorphisms (SNPs) are critical. In a previous work, 454 transcriptome sequencing of 8 cork oak populations from within the species distribution range was carried out and 402 putative Single Nucleotide Polymorphisms (SNPs) were identified. Aiming at assessing useful variable markers, the goal of this work was to validate SNPs detected preferentially in known genes, resorting to Sanger sequencing method and population genetic diversity analyses. Thirty four putative nonsynonymous SNPs from different genes were selected. Primers were design to amplify fragments comprising these SNPs, which were subsequently sequenced. From the putative SNPs selected, it was possible to amplify 22 fragments. So far, 11 SNPs were validated, 3 could not be detected and the remaining SNPs are undergoing the validation process. Based on some of the validated SNPs, a preliminary phylogeographical study was performed and the population genetic structure and selection signals identified are discussed. Interesting results are already being obtained from a preliminary data analysis, which revealed a signal of balancing selection in a gene involved in defense against pathogens. This study shows that transcriptome pyrosequencing can be a useful tool to find variation in genes of interest in non-model organisms that can be applied for population analyses, opening the way to understand population differentiation and adaptation.

44. Ribeiro, C. AM, A. Rodrigues, C. Miguel, **M. Glushkova**, F. Simoes, H.M. Almeida, J. Matos, J. Pereira, O. S Paulo, D. Batista. 2012. Unraveling Population Genetic Variation of a Candidate Gene for Bud Burst in Cork Oak. BMC Proceedings, IUFRO 2012 Conference “Genetics of Fagaceae and Nothofagus”–INRA, 9-12 October, 2012, Bordeaux, France, Book of Abstracts.

The succession of cold and warm periods during the Quaternary came along with large changes in the geographic range of tree species, and subsequent adaptation to these changes is suggested to have occurred by extant population differentiation. The detection and study of adaptive loci in the genome gives the possibility to understand which genes are being shaped by natural selection and evaluate the potential capacity of a species to adapt to new local conditions. Given that future climate changes are expected, a better understanding of the molecular basis of population divergence and patterns of adaptation in nature is of vital importance. Bud burst is one of the traits that should be most affected by climate changes. In cork oak (*Quercus suber* L.) the phenology of bud burst is controlled by a wide array of genes and, investigate these candidate genes can lead to a better understanding of adaptive variation related with climatic differences, allowing us to get some details on the underlying evolutionary changes of this species. Recently Derory et al. (2006) reported the identification of differentially expressed candidate genes in sessile oak (*Quercus petraea* Liebl.) during the transition from quiescent to developing buds. Here, we intend to assess cork oak potential capacity for adaptation to climatic changes by analysing population differentiation and diversity in bud phenological traits and test for associations with environmental variables. We selected six natural cork oak populations showing contrasting phenological timings, sampled in several Mediterranean locations including Bulgaria. Assessment of candidate

gene (ASI, alpha-amylase/subtilisin inhibitor) nucleotide diversity revealed 1SNPs/31bp in a fragment length of 498 bp, among which singleton, synonym and nonsynonym mutations were detected. Allele and haplotype frequencies were correlated with environmental variables, such as temperature, precipitation, insolation, and also with phenological traits in order to test for association between genotypic and phenotypic variation of bud burst in cork oak.

45. Ribeiro, C. AM, A. Rodrigues, H.M. Almeida, **M. Glushkova**, D. Batista, O. S Paulo. 2013. Patterns of Cork Oak (*Quercus suber* L.) Population Differentiation in Candidate Genes for Adaptive Traits. The XIV Congress of the European society for Evolutionary Biology, 19-24 August, 2013, Lisbon, Portugal, Book of Abstracts, pp. 116.

Cork oak is the most abundant tree in Portugal, which together with its economical and social importance, has granted it the status of National Tree. It is the only species that produces renewable commercial cork, occurring across a vast range of climatic conditions in its natural range of distribution, the Mediterranean region, where it exists for over 60 Ma. So processes of local adaptation are likely to have occurred. Identifying candidate genes underlying genetic differences for adaptive traits can help to understand how species have adapted to their environment and to predict how they will respond to future climatic changes, which is a special concern in regions such as the Mediterranean Basin, where a substantial decrease in precipitation and a pronounced warming is expected in the near future. Here, we intend to assess cork oak potential capacity for adaptation by analysing population differentiation and diversity in candidate genes related with adaptive traits and test for associations with environmental variables. Five candidate genes for bud burst and osmotic stress were analyzed (in total, 1890 bp) in 25 populations from its distribution range. From the 19SNPs analyzed, several showed differences between populations, which might be involved in adaptive responses of cork oak. Our analysis, showed the presence of common haplotypes among various populations but some differences in the frequency of alleles between populations. A correlation study of allele frequency/genotype with phenotypic and environmental conditions, revealed some significant correlations between specific heterozygous genotypes and characteristics such as plant height, altitude and rainfall. We expect that further exploitation of these data will bring some insights on the molecular basis controlling local adaptation.

46. Modesto, Inês S, C. Miguel, F. Pina-Martins, **M. Glushkova**, M. Veloso, D. Batista, O. S Paulo. 2013. Identifying Signatures of Natural Selection in Cork Oak (*Quercus suber* L.) Genes. The XIV Congress of the European society for Evolutionary Biology, 19-24 August, 2013, Lisbon, Portugal, Book of Abstracts, pp. 118.

Cork oak (*Quercus suber* L.) is an evergreen tree species holding a great economical and social relevance within its distribution range, the western Mediterranean Basin, associated with cork production. This tree is exploited mainly in orchards known as *montado*, which comprise great biodiversity. Despite its importance, cork oak stands have been facing a significant decline and climate changes expected to occur during this century may aggravate

this decay. In this scenario, the assessment of adaptive genetic variation is essential to understand how cork oak may cope with these threats and to delineate management strategies of its genetic resources. In this work, we started by validating single nucleotide polymorphisms (SNPs) detected through the analysis of cork oak pyrosequenced transcriptome, for a set of putative functional genes. Six fragments were then selected to be analysed with the purpose of finding signatures of natural selection. Samples from populations representing the species' entire distribution range were sequenced and several neutrality tests were performed as well as environmental association tests. Two gene fragments showed signals of balancing selection: the *Arabidopsis thaliana* orthologs non-expresser of pathogenesis related 1 (*NPRI*), involved in plant defence response against pathogens, and *auxin response factor 16* (*ARF16*), a gene previously identified as a candidate gene for drought resistance. Additionally, in a *class I heat shock protein* (*HSP*), one amino acid position was detected as possibly being under positive selection and associated with several precipitation variables, revealing its potential relevance in adaptation to local climatic conditions. In this study the first steps were taken to start unveiling important information on cork oak adaptation to biotic and abiotic environmental conditions.

47. Modesto, I. S., C. Miguel, F. Pina-Martins, **M. Glushkova**, M. Veloso, O. S. Paulo, D. Batista. 2013. Assessing Adaptive Genetic Variation in Cork Oak (*Quercus suber* L.) Through SNP Analysis. "XIII Congresso Luso-Espanhol de Fisiologia Vegetal" - Sociedade Portuguesa de Fisiologia Vegetal, ITQB - Oeiras, Portugal (Julho, 2013), Book of Abstracts, pp. 408.

Cork oak (*Quercus suber* L.) is an evergreen tree species endemic to the western Mediterranean Basin with a major economical, social and ecological relevance, associated with cork extraction and exploitation, mainly in agro-forestry-pastoral systems known as montados. In Portugal, where the largest stands of cork oak are located, this species assumes particular importance supporting Portugal's leading position as the major cork world producer. Despite its significance, cork oak stands have been facing a significant decline by the lack of regeneration mostly due to severe drought periods, bad management and susceptibility to several diseases. Moreover, this decay may be aggravated by the climate changes that are predicted to occur within cork oak distribution range during this century. In this scenario, the assessment of adaptive genetic variation is essential to understand how cork oak may cope with these threats and to delineate management strategies of its genetic resources. In this study, single nucleotide polymorphisms (SNPs) of six putatively functional genes, linked to several biological processes, were analysed in order to find signatures of natural selection. Samples from populations representing the entire cork oak distribution range were sequenced and several neutrality tests were performed as well as environmental association tests. Signals of balancing selection were detected in two gene fragments: the *Arabidopsis Thaliana* putative orthologs non-expresser of pathogenesis related 1 (*NPRI*), involved in plant defence response against several pathogens, and auxinresponse factor 16 (*ARF16*), a gene implicated in root cap cell differentiation. Furthermore, *ARF16*, which has been previously identified as a candidate gene for drought resistance in *Quercus robur* L. (Spiess et al. 2012), seems to be associated with precipitation in the driest month, suggesting

a possible important role of this gene in tolerance to dry conditions. Additionally, in a class I heat shock protein (HSP) one amino acid position was identified as possibly being under positive selection and associated with precipitation seasonality. Therefore, both ARF16 and HSP could be potentially relevant to cork oak adaptation to local climatic conditions, namely to drought stress. In this study, the first steps were taken into gathering important information on cork oak adaptation to biotic and abiotic environmental conditions.

48. Ribeiro, C. AM, A. Rodrigues, C. Miguel, H.M. Almeida, **M. Glushkova**, O. S Paulo, D. Batista. 2013. Looking for Molecular Clues of Local Adaptation in Cork Oak Through Candidate Gene Approach. “XIII Congresso Luso-Espanhol de Fisiologia Vegetal” - Sociedade Portuguesa de Fisiologia Vegetal, ITQB - Oeiras, Portugal (Julho, 2013), Book of Abstracts, pp. 410.

Cork oak has recently earned the status of National Tree due to its economical and social importance in Portugal, where it is associated with a worldwide leading cork industry. It is the only species that produces a renewable layer of cork with commercial value and is currently the most abundant tree in the country. It is believed that this species is present in the Mediterranean region for over 60 million years, occurring presently across a vast range of climatic conditions in its natural range of distribution. Identifying candidate genes associated with adaptive traits can help to understand how species have adapted to their environment and to predict how they will respond to future climatic changes. This is a special concern in the Mediterranean basin, where a substantial decrease in precipitation and a pronounced warming is expected in the near future. Previous studies evaluated the nucleotide diversity of bud burst candidate genes in sessile oak populations across latitudinal and altitudinal gradients (Alberto 2009), and contrasting relationships between the diversity of candidate genes and variation of bud burst in natural and segregating populations of European oaks has been reported (Derory et al. 2010). Here, we investigated candidate genes (CG) for bud burst and osmotic stress to assess nucleotide diversity and differentiation in cork oak natural populations and contrasting populations growing under a drought tolerance-controlled trial. Molecular signatures of selection were investigated by: (i) analysing population genetic differentiation in CG sequences for different geographical and phenological groups; (ii) testing associations between CG alleles/genotypes and environmental/phenotypic variables; (iii) quantifying CG expression in plants exposed to different levels of water stress versus control plants using quantitative real-time PCR (qRT-PCR). Preliminary results show that allele frequencies differ between populations in spite of some common haplotypes are shared by most populations, which could suggest divergence from a common ancestor. On the other hand, populations from Spain and France were identified as the most distinctive. Also, we detected some significant correlations between specific heterozygous genotypes and characteristics such as plant height, altitude and rainfall. Expression analysis of CGs associated with osmotic stress is being conducted. We expect that further exploitation of candidate genes' data will bring novel insights into the molecular basis underlying local adaptation.

49. Modesto, I., C. Miguel, F. Pina-Martins, **M. Glushkova**, M. Veloso. O. Paulo, D. Batista. 2013. Testing Associations between Genetic and Environmental Variation in Cork Oak (*Quercus suber* L.). IUFRO Tree Biotechnology Conference, May 26th-June 1st, 2013, Asheville, NC, USA.

The main focus of the study was to assess adaptive divergence in cork oak populations through the analysis of six putatively functional gene fragments, selected from cork oak RNA-seq data obtained by 454 pyrosequencing, in order to find genes possibly involved in adaptation to the environment. Our analyses suggest that variation in both putative *ARF16* and *HSP* gene fragments is likely involved in cork oak response to drought stress. This information can be of major importance in the scenario of climate change expected to occur in the Mediterranean Basin during this century, where a great increase in drought periods and their rigor are foreseen. In this study, the first steps were taken to start unveiling the genetic basis of cork oak local adaptation, which can be used to define strategies for the management of this species' genetic resources and reforestation of decaying populations.

50. Petrin, S., E. Velizarova, P. Tsekova, I. Valchev, S. Nenkova, T. Stankova, **M. Glushkova**, D. Dimitrov. 2014. Plant's fuel chemical specificity of the main bulgarian forest types. Eighth National Conference on Chemistry 'Chemistry for Sustainable Development', 26 -27 June 2014, Sofia, Book of Abstracts, pp. 58.

In this study, wood fibre (WF) and technical hydrolysis lignin (THL) were used as lignocellulosic materials. To produce copper sulphide lignocellulose nanocomposites and a two-component Cu(I) reduction system at a saturated steam were used. The modification process was at a module of 1:6, and the ratio of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ to $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ components was 1:2 for 45% of lignocellulose materials. The antibacterial activity of the modified lignocelluloses was tested against gram-positive (*Bacillus subtilis* 3562) and gram-negative (*Escherichia coli* K12 407) bacteria. The results showed that the THL-based material exhibits a better antibacterial activity, compared to the WF material. The obtained modified materials can be used to prepare lignocellulose-based fibre boards with good antibacterial properties.

51. **Glushkova, M.**, M. Zhiyanski. 2016. Potential of peri-urban forests for carbon storage and climate change mitigation: Case study – European chestnut ecosystems in Belasitsa Mountain, SW Bulgaria. XVIIIth International Scientific Conference "Management and Sustainable Development, 25-27 March 2016, Yundola, Bulgaria, Book of Abstracts, pp. 91.

Climate regulation represents an important ecosystem service and a tool that contributes to meeting CO₂ mitigation objectives. Carbon sequestration is a natural process that significantly contributes to regulation of climate by the capture and a long-term storage of atmospheric carbon. The contribution of forest trees, to the reduction of atmospheric carbon dioxide, through storage and avoided emissions has been recently widely debated, focusing on their role for protection, maintenance, enhancement and restoration of ecosystems' services. Regulatory services are the most important ecosystem services provided by urban and peri-urban forests (e.g. local climate regulation, water cycle and CO₂ sequestration,

mitigation of natural hazards etc.). Biodiversity supporting services, improvement of landscape and the quality of life they provide give additional important opportunities for physical outdoor activities and recreation and have positive effect on human well-being. In this order, the aim of this work is to analyse carbon storage of various ecosystem compartments (above-ground biomass, forest floor and soil) of selected European chestnut (*Castanea sativa* Mill.) peri-urban forest stands in Belasitsa Mountain, SW Bulgaria. Additionally the study is focused on identification and evaluation of ecosystem services, provided by these forests and their potential for climate regulation. We investigate two mixed and one pure chestnut stands. The woody biomass was calculated per hectare and then the values, obtained were converted to carbon stock. In soils carbon is mainly accumulated in the superficial 0–10 cm and decreased toward deeper layers. The pure chestnut forest characterized with the highest total carbon stock per hectare but only 20.6 % from it is accumulated in the aboveground tree biomass. Furthermore, we analyse the potential of carbon sequestration for maintenance and enhancement of ecosystem services of chest-nut ecosystems for long term planning, concerning sustainability and resilience of peri-urban forests in Belasitsa Mountain.

52. Zhiyanski, M., **M. Glushkova**, M. Georgieva, S. Nedkov, S. Dimitrov. 2016. Toward better understanding the ecosystem services in urban environments through assessment and mapping “TUNESinURB”. XVIIIth International Scientific Conference “Management and Sustainable Development, 25-27 March 2016, Yundola, Bulgaria, Book of Abstracts, pp. 93.

An essential feature of modern society in the world is rapid, progressive population growth with increased urbanization processes and turbulent pace of development of new technologies, along with the development of advanced technological tools and concepts. As a consequence of economic development and progress, technological and anthropogenic pressure on nature increases. This causes negative changes in the condition and operation of the components of natural ecosystems. TUNESinURB aims to create an ecosystem-based information system on urban ecosystems and their ecosystem services through the application of a set of indicators for assessing and mapping with a view to better understanding and implementation of sectoral policies for device and Development territories. The implementation of TUNESinURB the one hand will contribute to the implementation and enforcement arrangements of the country in connection with the evaluation and mapping of ECS in urban ecosystems, and on the other hand the results of the project will be a significant contribution to European efforts to define indicators and valuation of ecosystem services of green infrastructure in urban areas.

53. Zhiyanski, M., S. Nedkov, S. Doncheva, **M. Glushkova**. 2017. Framework for assessment of urban ecosystems state and supply of ecosystem services at different scales. International Scientific Conference on Ecosystem Services “Mapping and assessment of ecosystem services – science in action”, 6-7 February 2017, Sofia.

Urban landscapes provide a number of benefits for the human society through supply of ecosystem services. Mapping of ecosystem services has broad application potential since it is an extremely valuable method for visual representation of qualitative and quantitative spatial data. Green infrastructure in the cities is of the key importance as a source of range of benefits like air filtration, city climate regulation and carbon storage, connectivity between natural systems, biodiversity, community cohesion etc. In present study an approach to assess and map climate regulation ecosystem service in urban areas at national level is proposed. As urban condition is dependent on many factors, the combination of building and land cover types in urban territories is informative complex indicator for assessment the urban ecosystems condition. The value of parameter “carbon storage in green infrastructure” applied to the complex indicator gives information about the capacity of carbon stored in different urban landscapes and for the role of greening in climate regulation. The share of carbon in urban green areas in both soil and vegetation is not dominant but their capacity to store carbon (tC/ha) is utmost. The carbon storage in soil and vegetation is strongly influenced by the land cover type in the area therefore the assessment has to be carried out in accordance with an analysis of the spatial infrastructure of the respective territory. The proposed approach for mapping the carbon storage in green infrastructure of urban territories as indication for climate regulation ecosystem service can be further applied in implementing the requirement of the EU Biodiversity strategy.

54. Nedkov. S., M. Zhiyanski, M. Nikolova, **M. Glushkova**, A. Gikov, P. Nikolov, L. Todorov. 2017. Assessment and mapping of climate regulation ecosystem service in Bulgaria. COST FP 1204 Conference “[Green Infrastructure: Nature Based Solutions for Sustainable and Resilient Cities]”. 4- 7 April, 2017, Orvieto, Italy, pp 87.

Urban landscapes provide a number of benefits for the human society through supply of ecosystem services. Mapping of ecosystem services has broad application potential since it is an extremely valuable method for visual representation of qualitative and quantitative spatial data. Green infrastructure in the cities is of the key importance as a source of range of benefits like air filtration, city climate regulation and carbon storage, connectivity between natural systems, biodiversity, community cohesion etc. In present study an approach to assess and map climate regulation ecosystem service in urban areas at national level is proposed. As urban condition is dependent on many factors, the combination of building and land cover types in urban territories is informative complex indicator for assessment the urban ecosystems condition. The value of parameter “carbon storage in green infrastructure” applied to the complex indicator gives information about the capacity of carbon stored in different urban landscapes and for the role of greening in climate regulation. The share of carbon in urban green areas in both soil and vegetation is not dominant but their capacity to store carbon (tC/ha) is utmost. The carbon storage in soil and vegetation is strongly influenced by the land cover type in the area therefore the assessment has to be carried out in

accordance with an analysis of the spatial infrastructure of the respective territory. The proposed approach for mapping the carbon storage in green infrastructure of urban territories as indication for climate regulation ecosystem service can be further applied in implementing the requirement of the EU Biodiversity strategy.

55. **Glushkova, M.,** M. Zhiyanski, I. Markoff, S. Glushkov. 2017. The contribution of chestnut coppice forests in providing ecosystem services for carbon storage and climate change mitigation: A case study. Book of Abstracts, EuroCoppice Final Conference FP1301 “Coppice forests in Europe: a traditional natural resource with great potential”, 19th - 21st June, 2017, Limoges, France.

Coppice forests are particularly species-rich habitats that make a contribution to the preservation of cultural and historical diversity and provide important regulation services (e.g. local climate regulation, water cycle and CO₂ sequestration, mitigation of natural hazards etc.) and biodiversity supporting services. The aim of this work was to analyze carbon storage of various ecosystem compartments (above-ground biomass, forest floor and soil) of selected coppice forest stands of European chestnut (*Castanea sativa* Mill.) in Belasitsa Mountain, SW Bulgaria, as well as to identify the ecosystem services, provided by these forests. It was found that the mature mixed coppice chestnut stands of Belasitsa are characterized with relatively high carbon stock, large part of which was accumulated in the above-ground biomass. The pure chestnut stands have the highest potential for carbon storage, mostly in the forest floor and mineral soil (topsoil), indicating the existence of favorable conditions for the inclusion of organic substances in the soil system. An analysis of the results showed that coppice chestnut forests in Belasitsa Mountain have a high potential for carbon capture and sequestration and are of essential importance in maintaining and enhancing ecosystem services in the region, in climate change mitigation and for increasing of sustainability and productivity of forests in regional long-term planning.