agriculture

MDPI

Article

Soil Properties of Fallow Land Invaded by Black Cherry (*Padus serotina* (Ehrh.) Borkh.)

Paulina Bączek [1], Aleksandra Halarewicz [2,*], Daniel Pruchniewicz [2], Magda Podlaska [2] and Dorota Kawałko [3]

1 Department of Plant Protection, Wrocław University of Environmental and Life Sciences, Grunwaldzki Sq. 24a, 50-363 Wrocław, Poland; paulina.baczek@upwr.edu.pl
2 Department of Botany and Plant Ecology, Wrocław University of Environmental and Life Sciences, Grunwaldzki Sq. 24a, 50-363 Wrocław, Poland; daniel.pruchniewicz@upwr.edu.pl (D.P.); magda.podlaska@upwr.edu.pl (M.P.)
3 Institute of Soil Science, Plant Nutrition and Environmental Protection, Wrocław University of Environmental and Life Sciences, Grunwaldzka St. 53, 50-357 Wrocław, Poland; dorota.kawalko@upwr.edu.pl
* Correspondence: aleksandra.halarewicz@upwr.edu.pl

Abstract: The extensive spread of the invasive black cherry, *Padus serotina*, has been observed on abandoned agricultural land in Central and Eastern Europe. However, the impact of this species on invaded agroecosystems is still unknown, including the possibility of returning these ecosystems to agricultural production. In order to evaluate the selected soil properties of fallows invaded by *P. serotina*, their texture, field water capacity, reaction, and content of organic carbon, total nitrogen, and available forms of potassium and phosphorus were determined for 100 study plots. Taking into account the influence of soil conditions on floristic composition, the area covered by individual plant species in the study plots was also included in the analysis. A relationship was found between the presence of all the developmental stages of *P. serotina* and an increase in the phosphorus content in the soil. With the growth of a black cherry shrub layer, the content of soil nitrogen and potassium increased. An increasing proportion of *P. serotina* in the herb layer contributed to soil acidification and reduced the water content available for plants in the arable layer at 20–40 cm. The possible impact of *P. serotina* on soil properties may be an additional premise when considering the possibilities and benefits of the recultivation of fallow land invaded by this species.

Keywords: *Prunus serotina*; plant invasion; abandoned fields; soil properties

check for updates

Citation: Bączek, P.; Halarewicz, A.; Pruchniewicz, D.; Podlaska, M.; Kawałko, D. Soil Properties of Fallow Land Invaded by Black Cherry (*Padus serotina* (Ehrh.) Borkh.). *Agriculture* **2023**, *13*, 2148. https://doi.org/10.3390/agriculture13112148

Academic Editor: Jun Wang

Received: 19 October 2023
Revised: 9 November 2023
Accepted: 10 November 2023
Published: 14 November 2023

1. Introduction

The abandonment of agricultural land is a widespread land use change in various regions of the world and is common in Europe's temperate regions [1]. In historical times, the main reason to set aside land was the need to restore soil fertility. Over time, the decline in the profitability of extensive (low-input) and small-area farming systems has resulted in more and more abandoned/fallow farmland [2–4]. The analysis of the range of fallow lands and the possibility of their reuse are issues currently being addressed on a global scale [5–7]. It is assumed that the recultivation of part of previously unused agricultural land will increase the production of food or fodder, and will also allow biomass to be obtained for energy or raw materials for the chemical and pharmaceutical industries [6,8].

The first visible effect of the long-term cessation of cultivation is the recovery of vegetation, leading to the restoration of a community characteristic of local environmental conditions (meadow, shrub, and forest) [9,10]. Changes in the vegetation cover occurring in the process of secondary succession lead to changes in the properties of the soil environment [11], which depend primarily on the length of the fallowing period, climatic conditions, soil type, and topography [12]. These circumstances are likely to contribute to various discrepancies in the assessment of the impact of fallowing on the physicochemical properties of soils. The nitrogen content during set-aside usually shows an upward trend [13]. A decrease in humus resources is observed in silty and loamy soils not used for agricultural production, whereas a slight increase is observed in sandy soils [14]. Long-term fallow, which develops mature forms of succession (trees and shrubs), is conducive to increasing the content of organic matter in the soil while increasing its acidity [8]. The research by Włodek et al. [15], conducted on 7-year-old fallow, revealed an increase in the content of organic carbon and the available forms of magnesium, phosphorus, and potassium in relation to the neighboring arable soils. A negative impact of fallowing (8–10 years or more) on the average content of the available forms of potassium and phosphorus was observed by other authors [8,16].

Fallow fields belong to highly distorted phytocenoses, which favor the encroachment and establishment of alien species, including invasive ones [1,17–19]. Their participation in the process of secondary succession, in addition to a visible impact at the level of the phytocenosis [20,21], causes changes in the abiotic and biotic properties of the soil [22–25].

The most common plant invaders currently observed in Europe and Asia are species of goldenrod (*Solidago canadensis* L. and *Solidago gigantea* Aiton) [26,27]. In Europe, they enter abandoned land and form dense single-species fields [26]. The negative impact of these species on the natural habitat of fallow land has been confirmed in studies by many authors [8,28,29]. However, even long-term fallows with poor soil, dominated by goldenrod, retain the potential to be used for the production of biomass for non-agricultural purposes [8].

In the agricultural landscape of Europe, apart from the alien *Solidago* sp., the uncontrolled spread of the invasive black cherry (*Padus serotina* (Ehrh.) Borkh.) has been increasingly observed [30–32]. Native to North America, *P. serotina* was introduced and spread in Europe's temperate forests first as a timber species. Subsequently, it was repeatedly planted in the understory of plantations to improve their litter quality [33,34]. Its shade-tolerant seedlings and saplings start to grow rapidly when light is available (gaps forming in the overstory) and young trees acquire early the ability to reproduce generatively (seed dispersal by birds) and vegetatively (root shoots), which contributes to the formation of a dense, homogeneous understory layer [35,36]. The issue of the impact of *P. serotina* invasion on vegetation transformations as well as on the soil properties in forest habitats has been discussed many times [34,37–40]. However, the threat represented by the presence of black cherry in agroecosystems has not yet been precisely defined.

An analysis of the impact of this species on the environment of abandoned agricultural land is important for farmlands and fallows considered attractive for crop production, as well as for protected areas.

This study was carried out to reveal the relationships between the presence of black cherry and selected physicochemical properties of fallow soil. Taking into account the influence of soil conditions on the floristic composition, the area covered by individual plant species in the study plots was included in the analysis. We tested the following hypotheses: (1) *P. serotina* significantly modifies the soil properties of fallows; (2) depending on the proportion of *P. serotina* in an individual vegetation layer (herb, shrub, or tree layer), its impact on the soil parameters may vary.

2. Materials and Methods

2.1. Study Area

This research was conducted in Lower Silesia, located in the southwestern part of Poland (Figure 1). This region has a moderate climate dominated by an oceanic influence. The mean annual air temperature is simply 8 °C, with warm summers (mean of 18 °C in July), mild winters (mean of −1.4 °C in January), and an annual precipitation of about 550 mm [41]. Due to the economic conditions and high fragmentation of farms, fallow land makes up a high proportion of the agricultural landscape of the study region. Ten fallows (study sites), each with an area of about 2000 m^2, were chosen for this study. The main criteria for the selection of fallow land were at least a 10-year period of abandonment from agricultural use and the presence of self-seeded black cherry plants in the mature (blooming) stage. The primary propagule sources of the invader were forests, mid-field shelterbelts, and home gardens adjacent to the selected agricultural lands. The selected sites represented different types of soil (Table 1). These data were obtained from publicly available cadastral maps for the region [42]. Soils were classified according to the Polish Soil Classification [43] and the World Reference Base (WRB) classification [44]. For each soil, based on both classifications, the soil type was the same.

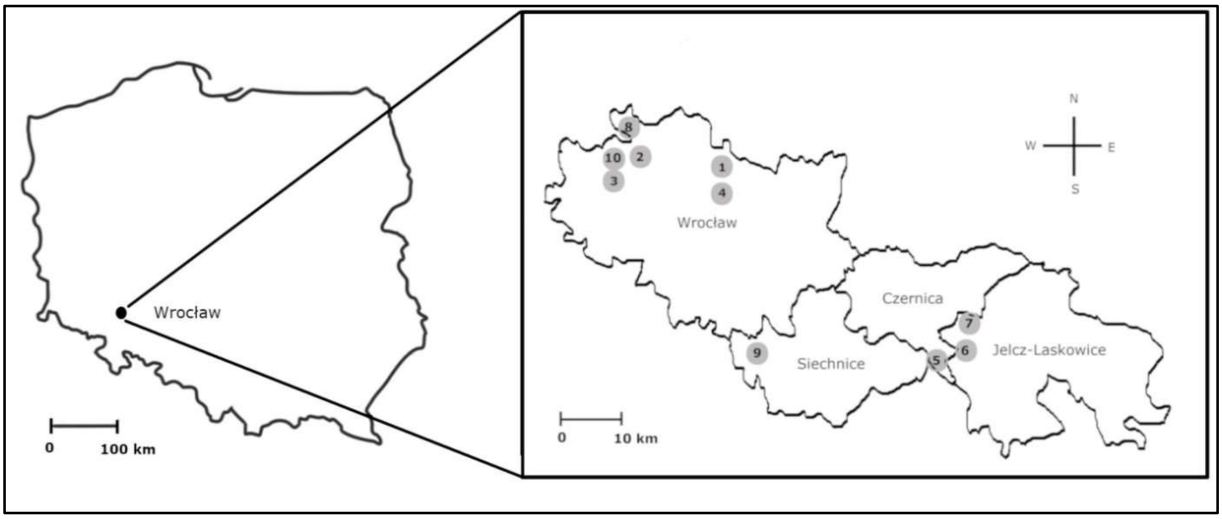

Figure 1. Location of study sites with their numbering (1–10) in accordance with Table 1.

Table 1. General information of study sites.

Site No.	Study Plot No.	Coordinates		Type of Soil
		N	E	
1	1–10	51°10′	17°00′	Phaeozems
2	11–20	51°09′	16°54′	Cambisols
3	21–30	51°09′	16°55′	Podzols
4	31–40	51°09′	17°01′	Cambisols
5	41–50	51°02′	17°15′	Podzols
6	51–60	51°01′	17°19′	Podzols
7	61–70	51°02′	17°19′	Podzols
8	71–80	51°10′	16°54′	Fluvisols
9	81–90	51°01′	17°03′	Phaeozems
10	91–100	51°10′	16°52′	Podzols

2.2. Field Studies, Soil Sampling, and Laboratory Tests

On each of the fallow lands, five study plots (5 m × 5 m) inhabited by *Padus serotina* and five plots free of this species were selected at random within a homogeneous patch of vegetation. They were located at a distance of at least 10 m from the edge of the fallow land and did not include places disturbed by animal activities. The center of each square was marked using a GPS (Table 1). The study plots were used to take relevés. The observations were made in 2017, during the period of the richest vegetation (June–July). The total vegetation cover was determined for three layers: the tree layer (>1.5 m); the shrub layer (0.5–1.5 m); and the herb layer (<0.5 m), covering herbaceous plants, the seedlings of woody plants, and leafy bryophytes (<0.5 m). We visually estimated the percentage cover (5% estimation intervals) of each plant species in the study plots. A total of 100 relevés were obtained from the examined sites. Bryophytes were collected for exact identification in the laboratory. The nomenclature of the vascular plants was based on Mirek at al. [45], whereas the moss nomenclature followed that of Ochyra et al. [46]. Plant communities were identified according to Matuszkiewicz [47].

During the floristic analyses, soil samples were collected from each study plot at the intersection of the diagonals in metal cylinders (V = 100 cm^3), separately for the layer up to 20 cm and 20–40 cm deep. The field water capacity (FWC) measurements were conducted under laboratory conditions with the application of sand and sand–kaolinite blocks [48]. This parameter is a good indicator of the amount of water available to plants in the soil that remains after gravity drainage, and is regulated by transpiration and evaporation.

In addition, in November 2017, a week after moderate rainfall, soil samples with a disturbed structure were taken from each study plot to determine the remaining physicochemical properties. The material was collected with a shovel to a depth of 20 cm, at a point located close to the center of the square. The soil samples, after being transported to the laboratory, were thoroughly cleaned of stones and fragments of roots or rhizomes, and compacted soil lumps were crushed. Samples prepared in this way were dried at room temperature (air-dried samples), without access to direct sunlight, and passed through a sieve with a mesh diameter of 2 mm. In the obtained fine earth (<2 mm), the particle-size distribution was determined using the sieve (for the sand fraction) and hydrometer (for the silt and clay fractions) method [49]. The soil pH was determined in distilled water, potentiometrically, at a soil–liquid ratio of 1:2.5 [50]. Organic carbon (C) was measured using the modified Tiurin method [51]. The total nitrogen content (N) was determined using the modified Kjeldahl method with a Büchi semi-automated analyzer (units K439 + K350) [52,53]. The Egner–Riehm method was used to determine the content of the available forms of phosphorus (P) and potassium (K) [54]. The determination of each parameter was carried out in two replicates, except for the soil reaction, which was determined once.

2.3. Data Analysis

To reveal the main environmental gradients of vegetation for the selected fallows, a detrended correspondence analysis (DCA) was conducted [55]. The analysis was performed for a database of 100 research plots, representing the area covered by individual plant species of herbaceous plants and mosses. The length of the gradient, represented by the first DCA canonical axis, had a standard deviation of 4, which indicated the linear structure of the data. Therefore, a canonical correspondence analysis (CCA) was chosen to assess the impact of the selected properties of soils on the vegetation [55]. The significance of the variables was tested using the Monte Carlo permutation test with stepwise variable selection (499 permutations) [56]. All the ordination analyses were prepared without data transformations. For each evaluated soil variable, we quantified its marginal (simple) effect and its conditional (partial) effect on the species composition. The ordination analyses were performed using the CANOCO software v. 5.03 [55].

In the next step of the analysis, it was decided to determine the relationship between the area covered by black cherry in each of the tree, shrub, and herb layers and the analyzed soil properties. The normal distribution of variables was evaluated with the Shapiro–Wilk test. Levene's test was used to check for the homogeneity of variances. The correlations between the analyzed parameters were determined using Pearson's rank correlation. The interpretation of the strength of correlation relationships was made according to Stanisz [57]. The calculations were performed at $p \leq 0.05$ for the entire dataset. The above analyses were conducted using the Statistica software v. 13 [58].

3. Results

The selected fallows were characterized by a species composition representing mainly semi-natural and anthropogenic meadow communities of the class *Molinio-Arrhenatheretea* and communities of perennial plants in ruderal areas of the class *Artemisietea vulgaris*.

The soil texture was differentiated, from sands (podzols) to silts and silty loams (phaeozems, cambisols, and fluvisols). The obtained value of field water capacity for the arable layer up to 20 cm ranged from 13.2% to 29.9%, and for the depth of 20–40 cm, it ranged from 10.9% to 26.8%. The tested soils were strongly acidic, acidic, or weakly acidic. They were characterized by a varied content of organic carbon, total nitrogen, and the available forms of phosphorus and potassium (0.7–1.8%, 0.07–0.21%, 33.4–115.3 mg kg^{-1}, and 70.0–280.5 mg kg^{-1}, respectively).

The CCA analysis allowed for the identification of general relationships between the occurrence of herbaceous plants and mosses and environmental variables, represented by the selected soil properties. The obtained eigenvalue of the first canonical axis (0.446) indicated its decisive influence on the differentiation of the dataset. This axis explained 4.7% of the total variation in plant species composition and 30.2% of the variation in the relationship between the plant species and the soil properties.

The results of the stepwise selection of variables with the Monte Carlo permutation test showed a significant, independent effect of all seven soil variables (Table 2). Considering the interactions between soil variables acting jointly, the strongest relationship was found between the species composition and the field water capacity determined for the soil layer up to 20 cm deep. Other significant relationships, arranged in descending order according to the value of the explained variability, concerned the vegetation and the content of soil organic carbon, the soil reaction, the potassium and phosphorus concentration, and the field water capacity determined for the soil layer 20–40 cm deep.

Table 2. Results of stepwise selection of analyzed soil variables affecting fallow vegetation, selected in the canonical correspondence analysis (CCA). Designations: FWC (0–20 cm)—field water capacity in 0–20 cm layer, FWC (20–40 cm)—field water capacity in layer 20–40 cm deep, pH—acidity determined in distilled water, C—content of organic carbon, P—content of available forms of phosphorus, N—total nitrogen content, K—content of available forms of potassium.

Variable	Marginal Effect			Conditional Effect		
	Explains (%)	Pseudo-F	P	Explains (%)	Pseudo-F	P
FWC (0–20 cm) (%)	3.9	4.0	0.002	3.9	4.0	0.002
FWC (20–40 cm) (%)	3.8	3.9	0.002	1.2	1.4	0.074
pH	3.0	3.0	0.002	2.5	2.6	0.002
C (%)	2.9	2.9	0.002	3.1	3.2	0.002
P (mg kg^{-1})	2.6	2.6	0.002	1.6	1.8	0.006
N (%)	2.4	2.4	0.020	1.5	1.6	0.124
K (mg kg^{-1})	2.3	2.3	0.002	1.8	1.9	0.002

In the diagram, obtained as a result of the CCA analysis, the study plots were weakly separated in the ordination space of the first two canonical axes (Figure 2). The vector positions indicate that four variables—the field water capacity (FWC) determined for the depths of 0–20 cm and 20–40 cm, the soil reaction, and the potassium concentration—were negatively correlated with the first axis, with the strongest relationship for the last-mentioned variable. The vector of phosphorus content was directed oppositely relative to the vector of soil pH. Species preferring fresh or moist soils, e.g., *Rubus caesius*, were located near the top of the FWC vector for a depth of up to 20 cm (Figure 3). The peak of the FWC vector for the soil depth range of 20 to 40 cm was accompanied by *Fraxinus excelsior*, requiring fertile and moist soils. The organic carbon content, like the total nitrogen content, was strongly correlated with the second canonical axis. The impact of the total nitrogen content on the diversity of the study plots and plant species and its relationship with the other soil variables were weaker compared to the organic carbon content. The indicator species for habitats rich in nitrogen, *Anthriscus sylvestris*, was located along the nitrogen vector, in the zone of its higher values.

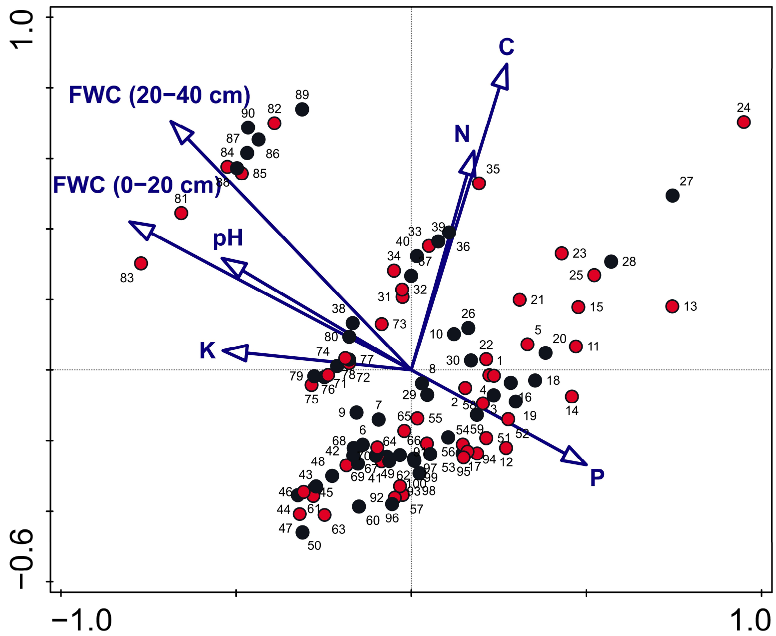

Figure 2. Canonical correspondence analysis (CCA) diagram for the studied plots and soil variables, represented as vectors in the ordination space. Plots with *Padus serotina* are marked as red points, and plots without this species are marked as black points. Numbers of plots are as described in Table 1. Designations of soil variables are given in the description of Table 2.

In the next step of the analysis, the relationships between the cover of black cherry occurring in the tree, shrub, and herb layers and the marked soil properties were determined. The results of the conducted correlations are presented in Table 3.

Table 3. Pearson's correlation between the proportion of *Padus serotina* in the layers of trees, shrubs, and herbs with mosses and physical and physicochemical properties of tested fallow soils. Designations of soil variables are given in the description of Table 2. The Pearson correlation coefficient values (R) are given (n = 50). Variables significant at $p \leq 0.05$ are marked in red.

	R	t (N-2)	*p*
Padus serotina in tree layer			
FWC (0–20 cm)	−0.046	−0.453	0.652
FWC (20–40 cm)	−0.016	−0.158	0.875
pH	−0.031	−0.311	0.757
C	0.079	0.780	0.437
N	−0.041	−0.409	0.683
P	0.312	3.251	0.002
K	0.048	0.480	0.632
Padus serotina in shrub layer			
FWC (0–20 cm)	−0.014	−0.135	0.893
FWC (20–40 cm)	−0.037	−0.367	0.714
pH	−0.175	−1.762	0.081
C	0.166	1.671	0.098
N	0.266	2.730	0.008
P	0.384	4.112	≤0.001
K	0.231	2.354	0.021
Padus serotina in herb and moss layer			
FWC (0–20 cm)	−0.177	−1.776	0.079
FWC (20–40 cm)	−0.215	−2.177	0.032
pH	−0.323	−3.375	0.001
C	0.174	1.753	0.083
N	0.133	1.333	0.186
P	0.504	5.776	≤0.001
K	0.123	1.230	0.222

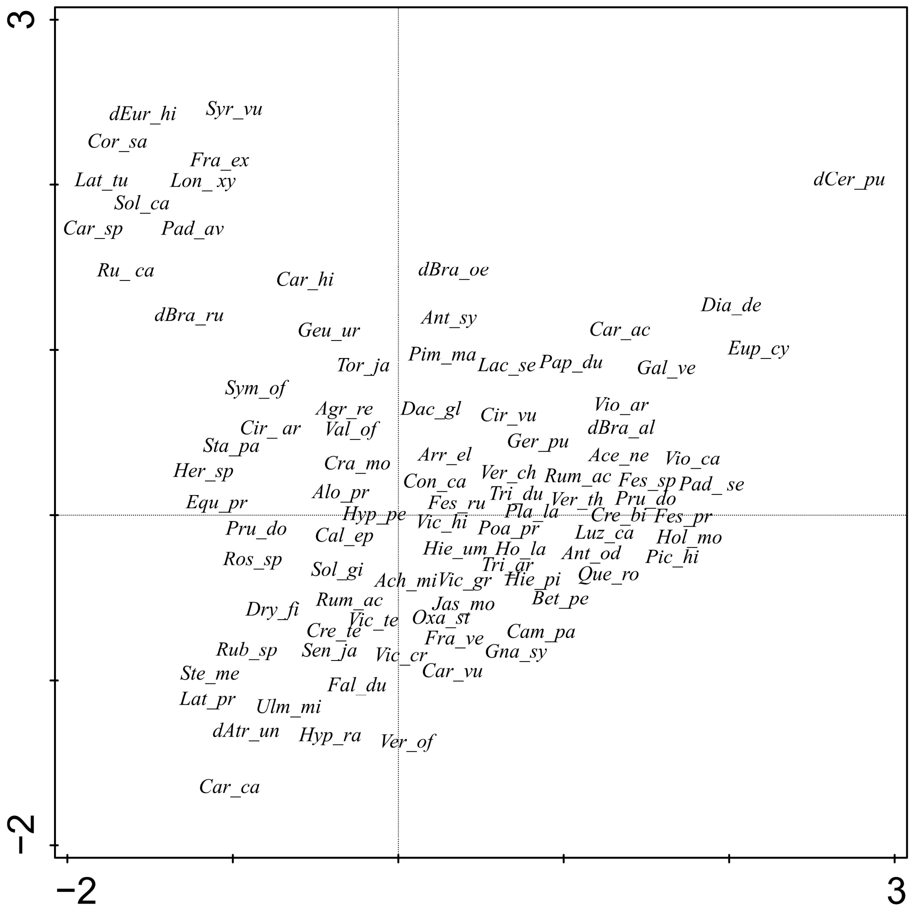

Figure 3. Canonical correspondence analysis (CCA) diagram for the species of the herb and moss layer. The letter "d" before the abbreviation denotes moss species. Species names and abbreviations: *Ace_ne—Acer negundo, Ach_mi—Achillea millefolium, Agr_re—Agropyron repens, Alo_pr—Alopecurus pratensis, Ant_od—Anthoxanthum odoratum, Ant_sy—Anthriscus sylvestris, Arr_el—Arrhenatherum elatius, dAtr_un—Atrichum undulatum, Bet_pe—Betula pendula, dBra_al—Brachythecium albicans, dBra_oe—Brachythecium oedipodium, dBra_ru—Brachythecium rutabulum, Cal_ep—Calamagrostis epigejos, Cam_pa—Campanula patula, Car_sp—Cardaminopsis sp., Car_ac—Carduus acanthoides, Car_hi—Carex hirta, Car_vu—Carlina vulgaris, Car_ca—Carum carvi, dCer_pu—Ceratodon purpureus, Cir_ ar—Cirsium arvense, Cir_vu—Cirsium vulgare, Con_ca—Conyza canadensis, Cor_sa—Cornus sanguinea, Cra_mo—Crataegus monogyna, Cre_bi—Crepis biennis, Cre_te—Crepis tectorum, Dac_gl—Dactylis glomerata, Dia_de—Dianthus deltoides, Dry_fi—Dryopteris filix–mas, Equ_pr—Equisetum pratense, Eup_cy—Euphorbia cyparissias, dEur_hi—Eurhynchium hians, Fal_du—Fallopia dumetorum, Fes_pr—Festuca pratensis, Fes_ru—Festuca rubra, Fes_sp—Festuca sp., Fra_ve—Fragaria vesca, Fra_ex—Fraxinus excelsior, Gal_ve—Galium verum, Ger_pu—Geranium pusillum, Geu_ur—Geum urbanum, Gna_sy—Gnaphalium sylvaticum, Her_sp—Heracleum sphondylium, Hie_pi—Hieracium pilosella, Hie_um—Hieracium umbellatum, Ho_la—Holcus lanatus, Hol_mo—Holcus mollis, Hyp_pe—Hypericum perforatum, Hyp_ra—Hypochoeris radicata, Jas_mo—Jasione montana, Lac_se—Lactuca serriola, Lat_pr—Lathyrus pratensis, Lat_tu—Lathyrus tuberosus, Lon_xy—Lonicera xylosteum, Luz_ca—Luzula campestris, Oxa_st—Oxalis stricta, Pad_av—Padus avium, Pad_se—Padus serotina, Pap_du—Papaver dubium, Pic_hi—Picris hieracioides, Pim_ma—Pimpinella major, Pla_la—Plantago lanceolata, Poa_pr—Poa pratensis, Pru_do—Prunus domestica, Pru_do_s—Prunus domestica subsp. syriaca, Que_ro—Quercus robur, Ros_sp—Rosa sp., Ru_ca—Rubus caesius, Rub_sp—Rubus sp., Rum_ac—Rumex acetosa, Sen_ja—Senecio jacobaea, Sol_ca—Solidago canadensis, Sol_gi—Solidago gigantea, Sta_pa—Stachys palustris, Ste_me—Stellaria media, Sym_of—Symphytum officinale, Syr_vu—Syringa vulgaris, Tor_ja—Torilis japonica, Tri_ar—Trifolium arvense, Tri_du—Trifolium dubium, Ulm_mi—Ulmus minor, Val_of—Valeriana officinalis, Ver_th—Verbascum thapsus, Ver_ch—Veronica chamaedrys, Ver_of—Veronica officinalis, Vic_cr—Vicia cracca, Vic_gr—Vicia grandiflora.*

It was found that the presence of *P. serotina* in each vegetation layer was significantly correlated with an increased concentration of the available forms of phosphorus in the soil. The strongest impact on this variable was observed for black cherry in the herb and moss layers. In addition, a weak positive correlation was found between the area covered by *P. serotina* in the shrub layer and the content of total nitrogen and the available potassium forms. The spread of the studied species in the layer of herbs and mosses contributed to a reduction in the water content available to plants in the arable layer at a depth of 20–40 cm and acidification to a depth of 20 cm. In both cases, these relationships were weak, but statistically significant.

4. Discussion

The modification of the soil environment by vegetation occurs mainly as a result of the supply of organic matter (litter) and the secretion of biologically active compounds (allelopathic effects) [25]. Research by Bączek and Halarewicz [59] confirms the phytotoxic effect of black cherry on white mustard (*Sinapis alba*) and buckwheat (*Fagopyrum esculentum*), the cultivated species commonly used to restore plant production on fallow land. Nutrients released during the decomposition of organic matter can be taken up again and used by plants. The biomass of invasive plant species often contains more elements (mainly C and N) compared to the biomass of the organic matter of native species, and it decomposes faster, which has a significant impact on the inhabited soil [60–65]. The direction and extent of this impact are modified by the properties of a given plant community [66], the initial soil status (including the type of soil and soil formation processes), and the weather conditions [67], which means that there are no general patterns of changes in soil parameters caused by plant invasion [25,68]. The consequence of increased decomposition is often an increase in the level of soil nutrients, which further facilitates the growth and development of invasive species [69].

Previous scientific publications on *Padus serotina* clearly indicate an increase in the nitrogen and phosphorus content in the soils of forest habitats dominated by the discussed species [40,70,71]. Based on the analysis of our own data, a positive correlation was found between the coverage of *P. serotina* and the content of total nitrogen in the soils of post-agricultural land. A similar relationship was noted by other authors for the invasive late goldenrod *Solidago gigantea*, and the opposite in the case of Japanese knotweed, *Reynoutria japonica* [25].

On the study plots invaded by black cherry, we found a higher content of the available forms of phosphorus in relation to the plots without this species. This was probably due to the fact that fresh *P. serotina* litter is richer in both phosphorus and nitrogen and decomposes faster compared to the litter of other native tree species [68,70,71]. Vanderhoeven et al. [68], comparing the content of P in abandoned farmland soils affected by *P. serotina* invasion and free from this species, did not record statistically significant differences. The experiment conducted by these authors concerned older (at least 10 years old) and taller (3–15 m) individuals of *P. serotina* than the plants we analyzed. In the case of another invasive species, *S. gigantea*, an increase in the content of phosphorus in the soils of synanthropic habitats [68] or its decline [8] was observed. In turn, the invasion of *R. japonica* was accompanied by a significant reduction in the P content in inhabited soil [25].

In our own research, we found that an increase in the area of *P. serotina* cover may contribute to an increase in the content of available potassium in the fallow soil. Kozak and Pudełko [8], analyzing the relationship between the presence of *S. gigantea* and the K concentration in post-agricultural soils, noted a decrease in the tested element, while the results of Vanderhoeven et al. [68] indicated no significant interaction between the above variables.

The high acidity of fallow soil in the shallowest layer of the soil profile (0–20 cm) found in our study was associated with an increase in the area covered by the youngest stages of *P. serotina* (seedlings and saplings). This dependence may have resulted both from the course of the decomposition of black cherry leaf litter and from the disturbance in the ionic balance of the soil solution (increased uptake of ammonium ions and alkaline cations) as a result of the increased biomass production in the herb layer [33].

In our research, a negative correlation was found between the field water capacity at a depth of 20–40 cm and the cover of *P. serotina* in the herb and moss layer. This proves the tendency of black cherry to cause soil drying. A similar relationship was noted by Verheyen et al. [37] in forest phytocoenoses ranging from coarse sandy soils to fine loamy soils. On the other hand, a positive effect of *P. serotina* on the podzol soil moisture in mixed forest habitats was reported by Halarewicz and Żołnierz [39]. Soil water serves as a solvent and mobile carrier of soil nutrients.

The parameters of the selected soil factors presented in this paper were obtained on the basis of analyses performed once, during one growing season. They indicate certain dependencies that require verification in the future. The annual influx of new organic matter, soil processes, and the course of weather contribute to changes in the properties of the soil environment [37,61,70]. It seems that many years of experiments conducted on permanent research plots, taking into account various types of fallow soils, will contribute to expanding the knowledge about the process of the secondary succession of fallow lands and will make it possible to estimate the effects of maintaining post-agricultural habitats with the succession of *P. serotina*.

5. Conclusions

The black cherry, leaving forest habitats (the primary planting sites), quickly and uncontrollably invades abandoned agricultural land. Participating in the secondary succession of fallows, it affects the vegetation and soil environment, with consequences that are still not fully known. In this study, we found a relationship between the presence of all developmental stages of *Padus serotina* and an increase in the phosphorus content in the soil. In addition, the increase in the cover of *P. serotina* bushes had a positive effect on the content of nitrogen and potassium in fallow soil. The increase in the proportion of black cherry in the herb layer contributed to soil acidification and a decrease in the water content available for plants in the arable layer 20–40 cm deep.

Author Contributions: Conceptualization, A.H.; methodology, A.H. and D.K.; field data collection, P.B., M.P. and A.H.; laboratory analyses, P.B. and D.K.; validation, M.P., D.K. and D.P.; formal analysis, D.P. and P.B.; investigation, P.B., M.P. and A.H.; writing—original draft preparation, P.B. and A.H.; writing—review and editing, P.B., A.H., D.P., M.P. and D.K.; supervision, A.H.; funding acquisition, P.B. and A.H. All authors have read and agreed to the published version of the manuscript.

Funding: The APC/BPC is co-financed by the Wrocław University of Environmental and Life Sciences.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The data from this study are available upon request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Van der Zanden, E.H.; Verburg, P.H.; Schulp, C.J.E.; Verkerk, P.J. Trade-offs of European agricultural abandonment. *Land Use Policy* **2017**, *62*, 290–301. [CrossRef]
2. Keenleyside, C.; Tucker, G.; McConville, A. *Farmland Abandonment in the EU: An Assessment of Trends and Prospects*; WWF: London, UK; IEEP: London, UK, 2010; 97p.
3. Rounsevell, M.D.A.; Pedroli, B.; Erb, K.-H.; Gramberger, M.; Busck, A.G.; Haberl, H.; Kristensen, S.; Kuemmerle, T.; Lavorel, S.; Marcus, L.; et al. Challenges for land system science. *Land Use Policy* **2012**, *29*, 899–910. [CrossRef]
4. Ellis, E.C.; Kaplan, J.O.; Fuller, D.Q.; Vavrus, S.; Klein Goldewijk, K.; Verburg, P.H. Used planet: A global history. *Proc. Natl. Acad. Sci. USA* **2013**, *110*, 7978–7985. [CrossRef]
5. Siebert, S.; Portmann, F.T.; Döll, P. Global patterns of cropland use intensity. *Remote Sens.* **2010**, *2*, 1625–1643. [CrossRef]
6. Estel, S.; Kuemmerle, T.; Alcántara, C.; Levers, C.; Prishchepov, A.; Hostert, P. Mapping farmland abandonment and recultivation across Europe using MODIS NDVI time series. *Remote Sens. Environ.* **2015**, *163*, 312–325. [CrossRef]

7. Shi, K.; Yang, Q.; Li, Y.; Sun, X. Mapping and evaluating cultivated land fallow in Southwest China using multisource data. *Sci. Total Environ.* **2019**, *654*, 987–999. [CrossRef] [PubMed]
8. Kozak, M.; Pudełko, R. Impact assessment of the long-term fallowed land on agricultural soils and the possibility of their return to agriculture. *Agriculture* **2021**, *11*, 148. [CrossRef]
9. Cramer, V.A.; Hobbs, R.J.; Standish, R.J. What's new about old fields? Land abandonment and ecosystem assembly. *Trends Ecol. Evol.* **2008**, *23*, 104–112. [CrossRef] [PubMed]
10. Lasanta, T.; Nadal-Romero, E.; Arnáez, J. Managing abandoned farmland to control the impact of re-vegetation on the environment. The state of the art in Europe. *Environ. Sci. Policy* **2015**, *52*, 99–109. [CrossRef]
11. Sosnowska, A. Changes of vegetation effects in soil properties in the post-agriculture landscapes (south-eastern Poland). *Misc. Geogr.—Reg. Stud. Dev.* **2019**, *23*, 63–70. [CrossRef]
12. Chudecka, J.; Tomaszewicz, T. Changes of chemical properties of brunic arenosols (rusty soils) after eleven years of their fallowing. *Folia Pomeranae Univ. Technol. Stetinensis. Agric. Aliment. Piscaria Zootech.* **2015**, *320*, 31–40.
13. Chmolowska, D.; Kozak, M.; Laskowski, R. Soil physicochemical properties and floristic composition of two ecosystems differing in plant diversity: Fallows and meadows. *Plant Soil* **2016**, *402*, 317–329. [CrossRef]
14. Strączyńska, S.; Strączyński, S.; Wojciechowski, W. Effect of different land uses on selected properties of the soils. *Soil Sci. Ann.* **2010**, *61*, 227–232. (In Polish)
15. Włodek, S.; Sienkiewicz-Cholewa, U.; Biskupski, A.; Sekutowski, T.R. Comparison of the chosen environmental features of the arable land and fallow. *Ecol. Eng.* **2014**, *38*, 51–59. (In Polish)
16. Tomaszewicz, T.; Chudecka, J. Influence of land use on properties of rusty soils: Fallow and agricultural use in Ginawa. *Agric. Eng.* **2005**, *4*, 311–320. (In Polish)
17. Meiners, S.J.; Pickett, S.T.A.; Cadenasso, M.L. Effects of plant invasions on the species richness of abandoned agricultural land. *Ecography* **2001**, *24*, 633–644. [CrossRef]
18. Meiners, S.J.; Pickett, S.T.A.; Cadenasso, M.L. Exotic plant invasions over 40 years of old field successions: Community patterns and associations. *Ecography* **2002**, *25*, 215–223. [CrossRef]
19. Węgrzynek, B.; Urbisz, A.; Nowak, T. Participation of *Solidago candensis* L. and *S. gigantea* Aiton in abandoned field communities in the Silesian Upland (Poland). *Thaiszia* **2005**, *15*, 267–275.
20. Hejda, M.; Pyšek, P.; Jarošík, V. Impact of invasive plants on the species richness, diversity and composition of invaded communities. *J. Ecol.* **2009**, *97*, 393–403. [CrossRef]
21. Vilà, M.; Espinar, J.L.; Hejda, M.; Hulme, P.E.; Jarošik, V.; Maron, J.L.; Pergl, J.; Schaffner, U.; Sun, Y.; Pyšek, P. Ecological impacts of invasive alien plants: A meta-analysis of their effects on species, communities and ecosystems. *Ecol. Lett.* **2011**, *14*, 702–708. [CrossRef]
22. Chen, H.; Li, B.; Fang, C.; Chen, J.; Wu, J. Exotic plant influences soil nematode communities through litter input. *Soil Biol. Biochem.* **2007**, *39*, 1782–1793. [CrossRef]
23. Elgersma, K.J.; Ehrenfeld, J.G. Linear and non-linear impacts of a non-native plant invasion on soil microbial community structure and function. *Biol. Invasions* **2011**, *13*, 757–768. [CrossRef]
24. Majewska, M.L.; Błaszkowski, J.; Nobis, M.; Rola, K.; Nobis, A.; Łakomiec, D.; Czachura, P.; Zubek, S. Root-inhabiting fungi in alien plant species in relation to invasion status and soil chemical properties. *Symbiosis* **2015**, *65*, 101–115. [CrossRef] [PubMed]
25. Stefanowicz, A.M.; Stanek, M.; Nobis, M.; Zubek, S. Few effects of invasive plants *Reynoutria japonica*, *Rudbeckia laciniata* and *Solidago gigantea* on soil physical and chemical properties. *Sci. Total Environ.* **2017**, *574*, 938–946. [CrossRef]
26. Chytrý, M.; Pysek, P.; Wild, J.; Pino, J.; Maskell, L.; Vilà, M. European map of alien plant invasions based on quantitative assessment across habitats. *Divers. Distrib.* **2009**, *15*, 98–107. [CrossRef]
27. Xu, S.; Li, K.; Li, G.; Hu, Z.; Zhang, J.; Iqbal, B.; Du, D. Canada Goldenrod Invasion Regulates the Effects of Soil Moisture on Soil Respiration. *Int. J. Environ. Res. Public Health* **2022**, *19*, 15446. [CrossRef]
28. Fenesi, A.; Vágási, C.I.; Beldean, M.; Földesi, R.; Kolcsár, L.P.; Shapiro, J.T.; Török, E.; Kovács-Hostyánszki, A. *Solidago canadensis* impacts on native plant and pollinator communities in different-aged old fields. *Basic Appl. Ecol.* **2015**, *16*, 335–346. [CrossRef]
29. Sekutowski, T.; Włodek, S.; Biskupski, A.; Sienkiewicz-Cholewa, U. Comparison of the content of seeds and plants of the goldenrod (*Solidago* sp.) in the fallow and adjacent field. *Zesz. Nauk. Uniw. Przyr. Wrocławiu* **2012**, *584*, 99–111. (In Polish)
30. Deckers, B.; Verheyen, K.; Hermy, M.; Muys, B. Effects of landscape structure on the invasive spread of black cherry *Prunus serotina* in an agricultural landscape in Flanders, Belgium. *Ecography* **2005**, *28*, 99–109. [CrossRef]
31. Adamczak, A. *Acer negundo* L. and Padus serotina (Ehrh.) Borkh. as kenophytes initiating the development of wildwoods on fallow lands. *Przegl. Przyr.* **2007**, *18*, 243–253. (In Polish)
32. Bomanowska, A.; Adamowski, W. Alien plant species in secondary succession. *Thaiszia J. Bot.* **2012**, *22*, 121–141.
33. Starfinger, U.; Kowarik, I.; Rode, M.; Schepker, H. From desirable ornamental plant to pest to accepted addition to the flora? The perception of alien tree species through the centuries. *Biol. Invasions* **2003**, *5*, 323–335. [CrossRef]
34. Lorenz, K.; Preston, C.M.; Krumrei, S.; Feger, K.H. Decomposition of needle/leaf litter from Scots pine, black cherry, common oak and European beech at a conurbation forest site. *Eur. J. For. Res.* **2004**, *123*, 177–188. [CrossRef]
35. Godefroid, S.; Phartyal, S.S.; Weyembergh, G.; Koedam, N. Ecological factors controlling the abundance of non-native invasive black cherry (*Prunus serotina*) in deciduous forest understory in Belgium. *Forest Ecol. Manag.* **2005**, *210*, 91–105. [CrossRef]

36. Closset-Kopp, D.; Chabrerie, O.; Valentin, B.; Delachapelle, H.; Decocq, G. When Oskar meets Alice: Does a lack of trade-off in r/k-strategies make *Prunus serotina* a seccessful invader of European forest? *Forest Ecol. Manag.* **2007**, *247*, 120–130. [CrossRef]
37. Verheyen, K.; Vanhellemont, M.; Stock, T.; Hermy, M. Predicting patterns of invasion by black cherry (*Prunus serotina* Ehrh.) in Flanders (Belgium) and its impact on the forest understorey community. *Divers. Distrib.* **2007**, *13*, 487–497. [CrossRef]
38. Chabrerie, O.; Loinard, J.; Perrin, S.; Saguez, R.; Decocq, G. Impact of *Prunus serotina* invasion on understory functional diversity in a European temperate forest. *Biol. Invasions* **2010**, *12*, 1891–1907. [CrossRef]
39. Halarewicz, A.; Żołnierz, L. Changes in the understorey of Mied coniferous forest plant communities dominated by the American black cherry (*Prunus serotina* Ehrh.). *For. Ecol. Manag.* **2014**, *313*, 91–97. [CrossRef]
40. Halarewicz, A.; Pruchniewicz, D. Vegetation and environmental changes in a Scots pine forest invaded by *Prunus serotina*: What is the threat to terricolous bryophytes? *Eur. J. For. Res.* **2015**, *134*, 793–801. [CrossRef]
41. Sobik, M. Klimat. In *Przyroda Dolnego Śląska*; Fabiszewski, J., Ed.; Polska Akademia Nauk Oddział we Wrocławiu: Wrocław, Poland, 2005; pp. 39–57. (In Polish)
42. Geoportal Dolny Śląsk. Available online: https://geoportal.dolnyslask.pl (accessed on 10 February 2023).
43. Kabała, C.; Charzyński, P.; Chodorowski, J.; Drewnik, M.; Glina, B.; Greinert, A.; Hulisz, P.; Jankowski, M.; Jonczak, J.; Łabaz, B.; et al. Polish Soil Classification, 6th edition—Principles, classification scheme and correlations. *Soil Sci. Annu.* **2019**, *70*, 71–97. [CrossRef]
44. IUSS Working Group WRB. World Reference Base for Soil Resources 2014, Update 2015, International soil classification system for naming soils and creating legends for soil maps. In *World Soil Resources Report No. 106*; FAO: Rome, Italy, 2015.
45. Mirek, Z.; Piękoś-Mirkowa, H.; Zając, A.; Zając, M. *Vascular Plants of Poland. An Annotated Checklist [Rośliny Naczyniowe Polski. Adnotowany Wykaz Gatunków]*; Szafer Institute of Botany, Polish Academy of Sciences: Warsaw, Poland, 2020; 526p. (In Polish)
46. Ochyra, R.; Żarnowiec, J.; Bednarek-Ochyra, H. *Census Catalogue of Polish Mosses*; Institute of Botany of Polish Academy of Science: Kraków, Poland, 2003.
47. Matuszkiewicz, W. *Przewodnik do Oznaczania Zbiorowisk Roślinnych Polski*; Wydawnictwo Naukowe PWN: Warsaw, Poland, 2007; 540p. (In Polish)
48. Pora, E.; Kaszubkiewicz, J.; Kawałko, D. Selected methodological aspects of determination of the water desorption curves of superabsorbents. *Environ. Prot. Eng.* **2015**, *41*, 37–48. [CrossRef]
49. Papuga, K.; Kaszubkiewicz, J.; Wilczewski, W.; Staś, M.; Belowski, J.; Kawałko, D. Soil grain size analysis by the dynamometer method-a comparison to the pipette and hydrometer method. *Soil Sci. Annu.* **2018**, *69*, 17–27. [CrossRef]
50. Van Reeuwijk, L.P. *Procedures for Soil Analysis*; Technical paper 19; International Soil Reference and Information Centre: Wageningen, The Netherlands, 1992.
51. Ostrowska, A.; Gawliński, S.; Szczubiałka, Z. *Methods of Analysis and Evaluation of the Properties of Soils and Plants*; Catalog Institute of Environmental Protection: Warsaw, Poland, 1991; pp. 89–93.
52. Bremner, J.M.; Hauck, R.D. Advances in Methodology for Research on Nitrogen Transformations in Soils. In *Nitrogen in Agricultural Soils*; Stevenson, F.J., Ed.; Wiley: Hoboken, NJ, USA, 1982; Volume 22, pp. 467–502. [CrossRef]
53. Sáez-Plaza, P.; Michałowski, T.; Navas, M.J.; Asuero, A.G.; Wybraniec, S. An Overview of the Kjeldahl Method of Nitrogen Determination. Part I. Early History, Chemistry of the Procedure, and Titrimetric Finish. *Crit. Rev. Anal. Chem.* **2013**, *43*, 178–223. [CrossRef]
54. Egner, H.; Riehm, H.; Domingo, W.R. Untersuchungen über die chemische Bodenanalyse als Grundlage für die Beurteilung des Nahrstoffzustandes der Bodens: II. Chemische Extractionsmethoden zur Phosphor- und Kaliumbestimmung. *K. Lantbrukshügskolans Ann.* **1960**, *26*, 199–215.
55. ter Braak, C.J.F.; Šmilauer, P. *Canoco Reference Manual and User's Guide: Software for Ordination, Version 5.0*; Microcomputer Power: Ithaca, NY, USA, 2012; 496p.
56. Manly, B.F.J. *Randomization, Bootstrap and Monte Carlo Methods in Biology*, 2nd ed.; Chapman & Hall: London, UK, 1997; 399p.
57. Stanisz, A. *Przystępny Kurs Statystyki z Zastosowaniem STATISTICA PL na Przykładach z Medycyny. Tom 1. Statystyki Podstawowe*; StatSoft Polska: Kraków, Poland, 2006; 532p. (In Polish)
58. TIBCO Software Inc. Statistica (Data Analysis Software System), Version 13. 2017. Available online: http://statistica.io (accessed on 10 January 2022).
59. Bączek, P.; Halarewicz, A. Allelopathic Effect of Black Cherry (*Prunus serotina* Ehrh.) on Early Growth of White Mustard (*Sinapis alba* L.) and Common Buckwheat (*Fagopyrum esculentum* Moench): Is the Invader a Threat to Restoration of Fallow Lands? *Agronomy* **2022**, *12*, 2103. [CrossRef]
60. Rothstein, D.E.; Vitousek, P.M.; Simmons, B.L. An exotic tree alters decomposition and nutrient cycling in a Hawaiian montane forest. *Ecosystems* **2004**, *7*, 805–814. [CrossRef]
61. Dassonville, N.S.; Vanparys, V.; Hayez, M.; Gruber, W.; Meerts, P. Impacts of alien invasive plants on soil nutrients are correlated with initial site conditions in NW Europe. *Oecologia* **2008**, *157*, 131–140. [CrossRef]
62. Liao, C.; Peng, R.; Luo, Y.; Zhou, X.; Wu, X.; Fang, C.; Chen, J.; Li, B. Altered ecosystem carbon and nitrogen cycles by plant invasion: A meta-analysis. *New Phytol.* **2008**, *177*, 706–714. [CrossRef]
63. Arthur, M.; Bray, S.; Kuchle, C.; McEwan, R. The influence of the invasive shrub, Lonicera maackii, on leaf decomposition and microbial community dynamics. *Plant Ecol.* **2012**, *213*, 1571–1582. [CrossRef]

64. Castro–Díez, P.; Godoy, O.; Alonso, A.; Gallardo, A.; Saldaña, A. What explains variation in the impacts of exotic plant invasions on the nitrogen cycle? A meta-analysis. *Ecol. Lett.* **2014**, *17*, 1–12. [CrossRef]
65. Jo, I.; Fridley, J.D.; Frank, D.A. More of the same? In situ leaf and root decomposition rates do not vary between 80 native and nonnative deciduous forest species. *New Phytol.* **2016**, *209*, 115–122. [CrossRef] [PubMed]
66. Ehrenfeld, J.G.; Scott, N. Invasive Species and the Soil: Effects on Organisms and Ecosystem Processes. *Ecol. Appl.* **2001**, *11*, 1259–1260. [CrossRef]
67. Ehrenfeld, J.G. Effect of exotic plant invasions on soil nutrient cycling processes. *Ecosystems* **2003**, *6*, 503–523. [CrossRef]
68. Vanderhoeven, S.; Dassonville, N.; Meerts, P. Increased topsoil mineral nutrient concentrations under exotic invasive plants in Belgium. *Plant Soil* **2005**, *275*, 169–179. [CrossRef]
69. Ehrenfeld, J.; Kourtev, P.; Huang, W. Changes in soil functions following invasions of exotic understory plants in deciduous forests. *Ecol. Appl.* **2001**, *11*, 1287–1300. [CrossRef]
70. Koutika, L.S.; Vanderhoeven, S.; Chapuis-Lardy, L.; Dassonville, N.; Meerts, P. Assessment of changes in soil organic matter after invasion by exotic plant species. *Biol. Fertil. Soils* **2007**, *44*, 331–341. [CrossRef]
71. Chabrerie, O.; Verheyen, K.; Saguez, R.; Decocq, G. Disentangling relationships between habitat conditions, disturbance history, plant diversity and American black cherry (*Prunus serotina* Ehrh.) invasion in a European temperate forest. *Divers. Distrib.* **2008**, *14*, 204–212. [CrossRef]