The Role of Fallows in Sustainable Development

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Abstract: Abandonment of crop production on agricultural lands for several or more years is a widespread practice not only in Europe but also around the world. Economic and political considerations lead to the abandonment of crop production on the poorest lands, although sometimes agriculturally valuable lands are also excluded from farming. Fallow land can be afforested, designated as a dedicated protection area, exposed to natural succession, or used to grow biomass for energy purposes. However, the most important role of agricultural land should be to ensure food safety. The set-aside land with high production potential should be treated in a special way. While lying fallow, the soil can have its fertility sustained or even improved considerably. To this aim, uncultivated land should be properly protected by growing a permanent cover of plant species which will have a positive influence on the soil’s physical, chemical, and biological characteristics. Depending on the geographical location, different plant species will have a beneficial effect on set-aside soil. Given economic and environmental considerations, the best solution is to sow a mixture of grasses and legumes, which can improve substantially the biodiversity on fallow fields, raise the soil’s fertility, ensure high CO₂ sequestration ratios, and influence beneficially the soil’s nutritional status and nutrient management. Soil protection can be provided for many years with little effort. The most recent reports implicate that it is possible to achieve several economic and environmental aims simultaneously in the course of the management of land excluded from agricultural production. These aims include the improvement of biodiversity, control of greenhouse gas emissions, generation of energy, and readiness to resume production of commodity plants. Proper management of fallows corresponds well with the challenges defined in the Green Deal for Europe or the US Green New Deal.

Keywords: fallow land; marginal land; natural fallow; fertility soil; fallow management; set-asides fields

1. Introduction

Fallowing and setting aside some land had been an inherent element of farming since its earliest days until the mid-19th century, which was when shifting cultivation was gradually being replaced by crop rotation. A field that previously had been set aside was then used for cultivation of perennial leguminous plants, especially clover. These plants were able to shade the field’s area well, reducing the spread of weeds and enriching the soil with nitrogen. In later years, fallows and fields of leguminous plants were replaced with tuber crops fertilized with farmyard manure [1,2]. With the development of agriculture, the original role of set aside lost its importance. Currently, the practice of setting aside some fields is most often motivated by political and economic considerations and is a consequence of the unprofitability of crop cultivation [3–5]. Other important reasons are the climatic and geographical conditions, which determine the fertility of soils [6–8]. It is currently estimated that over 80 million hectares of agricultural land, including 18 million ha in Europe, are excluded from agricultural production [9]. This corresponds to 15.1% of all cultivated land in the European Union [10]. Universal access to such capital means as fertilizers, plant...
the rate and direction of changes during the ongoing degradation of fallow or set-aside land depends on several factors:

- the genesis and type of soil (organic soils, mineral soils),
- the type of soil,
- the current condition of the soil (level of cultivation, fertility, nutritional status, etc.),
- the level of agricultural technology (fertilization, soil tillage, plant protection, etc.),
- the up-to-date selection of crops and their rotation,
- the purpose of setting aside the land parcel (controlled with or without a preservation system, short-term or multi-annual).

According to Dzienia [15], the time for which some land is laid aside should first and foremost ensure:

- stability of the ecosystem (maintaining and shaping homeostasis),
- maintenance of structure-forming processes,
- growth and development of soil microorganisms (mineralization and humification of organic compounds),
- prevention of the soil’s degradation and fatigue (removal of pollutants: toxins, mycotoxins, nitrosamines, pesticides, etc.),
- and prevention of water and wind erosion.

Inadequate fallowing and setting aside of land can lead to its degradation, promote water and wind erosion, deplete humus, and result in the leaching of nutrients. It also creates a serious threat of weeds invading fields adjacent to fallows [16–19]. A set-aside should be submitted to treatments in order to control the rate and direction of changes in its plant cover. The direction in the plant succession on set-asides varies depending on several factors, including climate, type of soil, its content of nutrients, number of diaspores of weeds in the soil under a fallow, previous agritechnical treatments, the duration of the fallowing period, the rate of colonization by particular plant species and their ability to colonize a field, or the impact caused by herbivores [20]. The lack of proper control rapidly leads to valuable lands being overgrown with shrubs and trees [16]. Succession of shrubs and trees can be most often observed on uncultivated fields located near forests (Figure 1).

Appropriate soil protection during the fallow period is more beneficial thus the soil can undergo a kind of regeneration. An adequately composed plant cover can guarantee an increase in the soil’s fertility, which means that it can be easily restored to agricultural production.

The purpose of this study has been to collect updated information on the possibilities of protecting effectively unused farmland, paying special attention to soil fertility—a kind of guarantee for sustainable development. The paper presents data from the references concerning the effect of land fallowing on the physical, chemical, and biological properties of soil.

The method of managing soil excluded from production may generate benefits or losses in ecosystems.
Figure 1. A succession of plants on a set-aside left for a—3 years, b—20 years; c—cultivated field.

2. Methods of Maintaining Set-Asides

Over the past few decades, the progress and increasing intensification of agriculture has resulted in many countries, particularly in European ones, in food overproduction. In the late 1980s, under the Common Agricultural Policy (CAP), a program was launched in the European Union countries to set aside some farmland (Set-Aside Land Option). Its purpose was to offset increasing food production and to equalize prices in the global markets [21,22]. The obligation to set aside some farmland was binding until 2008 [23]. In the EU, farmland can still be set aside, although it should not continue for more than one plant growing season if agriculturally valuable farmland is excluded from cultivation. A set-aside must be subjected to agrotechnical treatments to prevent the spread of weeds, although the use of chemical herbicides is forbidden (Figure 2).

Figure 2. A properly preserved set-aside field—a mixture of perennial grasses.
Food overproduction has also given a stimulus to dedicating more attention to environmental protection issues. Since the 1980s, the European Union has been passing laws and adopting agricultural and environmental programs to promote the protection and reinforcement of biodiversity. In order to sustain high biological diversity in agricultural landscapes, the European Union in its Common Agricultural Policy imposed the obligation on the EU member states to implement agri-environment schemes [24]. This approach promotes the protection of soils [25,26]. One of the most recent strategies is worded in the Green Deal for Europe. It proposes a complex approach to sustainable development, new energy challenges, protection of biodiversity (including soils), reduction of the emissions of greenhouse gases, and sustainable management of nutrients, which contributes to the production of food in a more eco-friendly manner.

One of the most serious problems, both economically and environmentally, is the persistent abandonment of agricultural production on land plots suitable for farming [5]. To face the global challenges due to the growth of human population, poverty, migration, climate change, depletion of biodiversity, and degradation of soil and water resources, it is necessary to make improvements in land use and management on a global scale. There are many technical solutions designed for the sustainable development of land and to prevent or reverse soil degradation. However, socio-cultural, institutional, economic, and political barriers hinder the implementation of such solutions on any larger scale [19,27–32].

The issue of sustainable land management has been raised by the United Nations. The scope of threats to which agricultural land is exposed, as well as methods of countering them, are specified in Goal No. 15: sustainable land management. The main tasks in this area are the fight against desertification, the regeneration of degraded lands, including those affected by drought, and floods, and achieving a world that is neutral in terms of land degradation. Abandoning agricultural land or improper management of fallow land is one of the key threats to sustainable land management. Inappropriate treatment of agricultural land threatens sustainable development because land degradation and mistreatment reduce the quality of life, reduce agricultural incomes, and undermine poverty reduction strategies. Therefore, sustainable land management is a key priority for all countries around the world [13,33–37].

At present, there are several concepts in Europe and the world on how land unsuitable for agriculture can be managed. Depending on the type of land, i.e., arable land of different value for farming, marginal land, or abandoned land, it can be managed differently [38,39]. The subject literature comprises many publications concerning the ways to deal with lands set aside for agricultural production [9,23,29,40,41]. Concepts for the development of fields excluded from cultivation are presented in Table 1.

<table>
<thead>
<tr>
<th>Land Development Concept</th>
<th>Source</th>
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<tbody>
<tr>
<td>Leaving the land without any intervention—natural succession</td>
<td>[40,41]</td>
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<tr>
<td>Afforestation</td>
<td>[16,41]</td>
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<tr>
<td>Inclusion of set-aside land for the purposes of agro-environment schemes</td>
<td>[23,24]</td>
</tr>
<tr>
<td>Using the agricultural land for the purposes of renewable energy production (including the production of biomass, and construction of solar panel farms)</td>
<td>[9]</td>
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<tr>
<td>Intentional preservation of agriculturally valuable lands by growing a cover of perennial plants in order to maintain soil fertility</td>
<td>[18,19]</td>
</tr>
<tr>
<td>Using the land as a zone protecting the surface waters from pollution or counteracting soil erosion</td>
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The latest concept in the management of set-aside land, recommended by researchers and practitioners, consists of the implementation of solutions that keep set-aside fields profitable and able to play three or even four functions. They include the offsetting emissions of CO₂, energy generation, strengthening biodiversity, and the possibility of resuming food production once a set-aside field is terminated, for example when a food crisis appears due to drought or another emergency [42–44].
2.1. Natural Succession on Set-Aside Soils

The idea of leaving soil alone and allowing for its natural overgrowing by plants has a large number of supporters. Abandoning agricultural land and its gradual overgrowing with shrubs and trees is common in Europe and the world, and after the collapse of the Soviet Union, it appeared on a particularly large scale in Eastern Europe [16]. Many researchers point to a considerable increase in biodiversity in such areas, especially in the first years after agricultural production was terminated. The pool of plant species increases, turning into an important stimulus to the settlement of such an area by insects [45,46]. In this strategy, initially, plants develop from a bank of seeds and fragments of plants capable of vegetative reproduction that are contained in the soil. In the following years of fallowing, the share of perennial plants increases [20]. A higher number of plant species blooming at different times promotes the development of pollinating insects. In the later stage, fallowed land is overgrown with shrubs and finally with self-sowing trees. Thus, the self-reproduction of a forest occurs.

Such a return to the natural state provides shelter for a growing number of animal species. The first to settle in areas excluded from agricultural cultivation are small rodents and birds, and these are followed by such species as foxes or hares [47,48]. Tree stands, especially over larger areas, which are several years old can shelter larger animals (roe deer, red deer) and give rise to the formation of a forest that will have characteristics of primary woodland. The growing forest strengthens biodiversity and promotes the sequestration of greenhouse gases but, at the same time, can be terminated at any time. A forest that has developed spontaneously over a few years can be a source of energy and valuable biomass [49].

In Europe, the natural afforestation of former farmland with alder species is common. The symbiotic fixing of nitrogen by actinomycetes associated with different species of alder trees contributes to a considerable improvement in the quality of soil under farmland set aside in this manner. However, relatively little is known about the extent of this beneficial effect dependent on the type of soil and its content of nutrients [41]. Undesirable effects of natural succession on farmland include very high costs of returning such land to agricultural production, loss of valuable ecosystems (for example meadows), excessive depletion of soil’s nutrients, severe infestation of weeds over adjacent fields, and large damage caused by wild animals on fields near forests [5,50–52] (Figures 1c and 3).

2.2. Afforestation of Fallows

One of the most common strategies in the management of fallow or set-aside land, well-established for decades now, is afforestation [50]. Afforestation is most often carried out on the poorest soils. Low profitability of production due to the poor quality of land, when combined with subsidies allocated in many countries to afforestation landowners to grow wood on poor soils (Figure 4).

The process of afforestation is difficult, time-consuming, and unpredictable. Due to legal aspects in many countries regarding forest protection, afforestation often leads to an irreversible reduction of the agricultural production space [52,53]. On the other hand, the growth of tree stands on former farmland proceeds more slowly than in renewed forest stands in woodlands. The main reason is a completely different microbiological environment in the two types of habitats. It is extremely difficult to obtain quality wood in the first rotation of planted trees [54]. Afforestation of abandoned agricultural land or marginal land can also be treated as a measure to rehabilitate land degraded by fires or to mitigate the effects of droughts. In this case, the improvement of soil fertility is the major objective [53].

In terms of soil fertility, afforestation of abandoned agricultural land is beneficial. In the first few years after planting deciduous trees, changes are mild in character. Acidification of soil is commonplace and the concentrations of nutrients in soil decrease [55,56]. Twenty years after the tree planting, changes in the soil are much more evident. First and foremost, the soil content of organic carbon increases. Depending on the type of soil and tree stand
growing on fallow land, the soil content of organic carbon can increase by more than 20%. The total nitrogen content increases as well, although less than that of C\textsubscript{org} \cite{57,58}.

Figure 3. Returning afforested land to agricultural production.

Figure 4. Afforested farmland after 20 years.

When planning afforestation in a specific area, the following economically important factors need to be considered: structure of agricultural land and woodland, size of farms, and possibilities of employing agro-technical equipment inclusive for the future
Development of agrarian structures [4,39]. When exclusions cover vast areas of fields on predominantly poor soils, it is important to take into account modifications that may appear in the landscape while shaping plant communities [59]. Being one of the main sectors involved in landscape management, agriculture is particularly responsible in this context [42]. The existing landscape is often unique, presenting its specific image as well as features and functions of its structure reflecting its individual history of development. Proposed solutions should account for such shaping of the landscape, together with tree stands, that will correspond well to the contemporary knowledge about the protection and management of the natural environment [7,27,60]. Afforestation of arable land should be designed to avoid any collision with the planned forests and cultivated fields. Many researchers emphasize that the area of land allocated to afforestation in every country depends on a variety of factors, but the need to ensure food security is invariably the most important one [61].

2.3. Agro-Environment Schemes in the Protection of Fallows

One of the numerous measures designed to offset intensive agricultural production consists of agro-environment schemes (AESs). Different types of land, often of poorer quality, are used for the implementation of such schemes [24]. Allocation of fallow fields to AESs is one of the most beneficial ways to protect set-aside soil [62]. The most common objective of such programs is to protect rare plant and animal species [63,64]. All measures connected with the protection of biodiversity also have a beneficial effect on the properties of the soil which is submitted to an agro-environment scheme [19]. Agro-environment schemes are designed to cover a period of several years and frequently provide for the possibility of extending their duration by a few more years. During an AES, the farmer is obliged to maintain a specific plant cover and cannot use any agricultural chemicals or cut the plants prematurely. This approach to soils excluded from production ensures specific, obligatorily monitored protection, which guarantees the maintenance of soil fertility, and in most cases leads to its enhancement [23,25,26,46,65].

2.4. Allocation of Set-Asides for Energy Purposes

The latest guidelines, consistent with pro-environment obligations, indicate that the production of biofuels and biomass should not interfere with the production of food. Hence, it is recommended to use marginal, set-aside, and abandoned land for energy purposes [49,66,67].

2.4.1. Biomass Production

On land unsuitable for agriculture (including fallow land), many species of plants can potentially be grown for energy purposes, for example, perennial grasses (Figure 5), other perennials and shrubs as well as wood species (birch or poplar). The effect of such diverse plant covers on soils is unquestionably varied [49,68]. For the preservation of soil fertility, it appears that the most beneficial solution is to cover set-asides with long-lasting and fast-growing perennial grasses and dicotyledonous perennials [69]. Large quantities of biomass can be harvested from set-asides without the use of any fertilization [70].

Growing short-rotation crops for energy purposes on set-asides or marginal land also leads to the betterment of the properties of such land. The well-developed root system of plants improves the porosity of soil and its hydraulic conductivity, which contributes to better aeration of soil. Residues of roots in the soil add to the pool of organic carbon and total nitrogen in the soil. The positive effect of young tree stands is attributed to their production of large amounts of underground biomass [71,72]. The high productivity of plantations of energy willow, for example, necessitates the amendment of soil with nutrients as the available forms of phosphorus, potassium, and magnesium are slowly being depleted [73]. Plantations of energy crops can be effectively fertilized with sewage sludge of digested waste. These substances have a positive effect on the fertility of soils, especially poorer ones [74,75]. Short-rotation energy crops can uptake large amounts
of nutrients from waste products, which facilitates their recycling [76]. Short-rotation energy crops are better at absorbing nitrates(V) and can sequester more CO$_2$ from the atmosphere than traditional crops cultivated on such land [77]. Stolarski et al. [74] point to the possibility of increasing the productivity and the energy value of yields harvested from crops, especially on less fertile soils with inferior suitability for production of edible crops, by selecting the energy crops adequately and applying fertilizers. By replacing mineral fertilizers with sewage sludge, it is possible to decrease the energy input into the production of miscanthus biomass by as much as 34% [78].

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Figure 5. Energy biomass from perennial grasses growing on set-asides.

2.4.2. Building Solar Panel Farms on Fallows

Set-asides, marginal land, and especially degraded areas are well suited for the construction of ground-mounted solar panel installations. Photovoltaic farms should be established on land of extremely low quality and intended for use for a minimum period of ten years [9,35,79]. However, when a land plot is covered with solar panels, it is difficult to expect soil improvement. As reported by Ravi et al. [80], over 25 million ha of land will be transformed into solar panel farms over the next 30 years. Furthermore, the demand for land to construct access roads or energy transmission grids adds to the total surface area of the land occupied by solar farms. It is estimated that about 1/3 of a farm is the area covered by solar panels, whereas the remaining area is occupied by the infrastructure needed for the farm to operate [81]. All the work involved in the construction of a solar panel farm can aggravate the degradation of soil. A solar panel farm not only modifies the landscape (Figure 6) but also leads to changes in the land relief, density of soil, or removal of native vegetation [82,83]. In consequence, the physical, chemical, and biological properties of soil are altered. Significant changes are observed in the soil’s capacity to retain water and nutrients. It is less likely to maintain the vegetation and ecological processes connected with the growing plants [84–89]. A seven-year-long experiment conducted by Choi et al. [90] demonstrated a large decrease in the concentrations of organic carbon and
total nitrogen in soil under a solar panel farm. To counteract soil degradation, studies are carried out on a proper selection of plants, that will not collide with the generation of energy on such farms and, on the other hand, will protect the fertility of soil and sequester CO$_2$ effectively [91].

Figure 6. A photovoltaic farm on set-aside land.

2.5. Protection of Soils Excluded from Production
2.5.1. Plant Species Recommended for Conservation of Arable Land

Several perennial plant species are recommended for growing a plant cover on set-aside fields, owing to their soil-protective characteristics. The selection of plants should be strictly guided by the site-specific climatic and soil conditions. The properties that all plants dedicated to the protection of set-asides should share are high productivity, durability, competitiveness on a given site, the economic management of water and nutrients, as well as tolerance to temperature fluctuations. Many grass and leguminous plants possess such characteristics. To ensure the best possible protection of set-aside soil, it is recommended to cover it with at least a few species of perennial plants. The available literature provides recommendations to use mixtures of legumes with grasses and, less often, grasses alone to grow a plant cover on the land laid fallow for many years [44,92–97]. The following grass species are recommended: Bromus inermis, Bromus sterilis, Bromus Trisetum, Lolium perenne, Phleum pratense, Phalaris arundinacea, Panicum virgatum, Arundo donax, and even Miscanthus sinensis or Spartina pectinata. Among the leguminous plants, Galega orientalis, Medicago sativa, Trifolium repens, and Melilotus suaveolens are particularly suitable for multi-annual set-aside fields [93,94,98–106]. Legumes are capable of entering into symbiosis with atmospheric nitrogen-fixing nodule bacteria, which enables them to grow well without nitrogen fertilization. Leguminous plants grown on set-asides are also credited with the ability to sequestrate CO$_2$ effectively and to absorb and retain hardly available macro- and micronutrients [107–111]. The above method of handling fields excluded from agricultural production guarantees good biodiversity, protects fields from weed infestation, improves the aesthetic quality of the landscape, and does not impede in any way the restoration of farming on set-aside fields [22,42,48,112].
2.5.2. Effect of Fallowing on the Chemical Properties of Soil

The way a set-aside soil is maintained influences its chemical properties and has a direct impact on its fertility (Table 2). Modification of the soil’s fertility characteristics largely depends on whether or not the soil has a plant cover. An important link in the cycling of elements consists of the organic matter left on a field and undergoing mineralization, as this process enables the return of previously absorbed nutrients to the soil [94]. It is one of the few possibilities for improving the soil content of available nutrients in fields temporarily excluded from agricultural production [113]. One of the factors that most strongly affect the chemical parameters of set-aside soil is the type of plant community grown on fields excluded from production. Correctly selected species growing on set-asides allow the soil to maintain its resources of available nutrients. When soil temporarily laid aside is properly maintained, its fertility can improve [70]. The literature data implicate a close correlation between the amount of biomass obtained from the surface of a set-aside field and potential changes in the soil. The more biomass is produced, the more distinct changes occur in the soil environment, having a positive effect on soil fertility [108]. Plants covering set-aside land plots differ in their potential to produce biomass, depending on their species, quality of set-aside soil, and climatic conditions [114]. Long-term research has demonstrated that mixtures of legumes with grasses or legumes grown as a monoculture are most beneficial in this regard [18]. A constant supply of organic matter, left on the surface of set-aside fields each year after harvest, results in a rise in the content of organic carbon in the soil.

Fodder galega or its mixture with awless brome, used for protection of set-aside and fallow land, shows a high ability to accumulate macronutrients. This is the outcome of the high production potential of both plant species during a single growing season. Both the aerial organs and the well-developed root system of these plants, a rich source of organic substances in the soil, are distinguished by exceptional productivity [18,108,115,116].

Natural plant communities have a lesser effect on the soil content of organic carbon than mixtures of legumes with grasses. After several years of being uncultivated, a set-aside field develops a plant cover, which is dominated by grasses. Hence, similar effects are obtained by keeping a set-aside field with a monoculture of grasses or grasses grown in the course of natural succession [18,117]. On the other hand, keeping farmland as a black fallow has a negative effect on the content of organic carbon in set-aside soils. Intensive mechanical soil tillage intensifies the mineralization of organic matter, especially in its topmost layer. Mechanical cultivation leads to the physical disturbance of the superficial soil horizon, increasing its content of $O_2$, in addition to which plant residues lying on the surface of the soil become dispersed and have more extensive contact with soil particles, which accelerates the decomposition of organic matter [114,118].

One of the main factors determining the concentration of total nitrogen in set-aside soils is the share of individual plant species that protect the soil [118]. The presence of legumes in cultivated fields is particularly beneficial owing to their ability to bind free nitrogen. Also, on soils set aside for many years, it is recommended to keep leguminous plants in order to maintain soil fertility [119,120]. The positive effect of leguminous plants after agricultural production was resumed on set-aside fields was noted by Tonitto et al. [121]. When a set-aside field is overgrown with naturally growing plants or with a sown monoculture of grasses, the soil content of total nitrogen stabilizes [18,117]. In contrast, if a set-aside field is kept as black fallow without plants, the total nitrogen concentration in the soil decreases. Soil tillage treatments accelerate the rate of mineralization in a set-aside field, and the lack of a plant cover facilitates the migration of nitrogen compounds to groundwater [18,122]. However, keeping leguminous plants on set-asides creates a risk of excessive accumulation of nitrogen in soil, assimilated during the growing season of the plants.

This is one of few unfavorable features of legumes used to protect soils temporarily excluded from production. This risk is higher in fields covered with a monoculture of legumes. Such a vegetation cover after mineralization poses the risk of mineral forms of nitrogen migrating into the depths of a soil profile and to groundwater [123]. When a
set-aside is terminated, the annual N losses may reach from 100 up to 300 kg N·ha$^{-1}$ [122]. The choice of an appropriate method for the management of soil set-aside can largely influence the soil content of nitrogen mineral forms. Thus, it is possible to decrease the leaching of nitrates into deeper soil horizons [123]. According to Eggenschwiler et al. [124], mixtures of perennial legumes with grasses moderate this threat. They do not pose any serious risks to the environment due to the translocation of mineral nitrogen compounds and are in this regard a much more beneficial solution to protect set-aside soils than natural plant communities or sown grass monocultures. Maintaining a set-aside as a bare fallow, due to the high risk of groundwater pollution with nitrates, is not recommended as a way of maintaining agriculturally valuable land resources as fallows for many years [123].

The way agriculturally valuable farmland is protected has a significant influence on the content of available forms of macronutrients in set-aside soils [113,125]. Very good effects in terms of maintaining soil resources of available forms of macronutrients can be achieved when set-aside fields are overgrown with leguminous plants or their mixtures with grasses. Owing to the specific features of these plants, such as the ability to take up minerals unavailable to other species or to absorb nutrients from deeper soil horizons, they create an opportunity to enrich the soil resources of available phosphorus, potassium, or magnesium. It is worth emphasizing that the improvement of the soil’s stocks of these nutrients can take place even in deeper soil horizons, down to 60 cm [113]. Natural vegetation and grass monocultures offer far less beneficial effects as regards the shaping of nutrient resources in set-aside soil [126]. According to Wójcikowska-Kapusta et al. [127], the way set-asides are managed does not affect the soil content of available phosphorus. The amount and distribution of precipitations have a strong impact on the concentrations of available nutrients in set-aside soil. They directly affect the rate of translocation, especially of phosphorus and potassium. The lack of a plant cover on set-aside fields promotes the leaching of less stable forms of these elements. Bare fallow, unlike the plants covering set-aside fields, does not provide a supply of available forms of macronutrients, which results in their gradual depletion [44,94]. Natural plant communities growing on set-asides may result in a slight decrease in the concentration of available forms of macronutrients. This was observed in the first years after starting a set-aside [56].

The way a set-aside is kept can also modify the soil content of available micronutrients. The concentration of micronutrients in soil excluded from production is influenced by the presence or absence of a plant cover, the type of plants growing on the soil, and the duration of the set-aside period [96]. A break in cultivation contributes to a rise in the content of available forms of trace elements. This is mainly a consequence of the increased quantity of organic matter originating from the plants growing on set-aside land and remaining on it. A permanent vegetation cover reduces erosion and leaching, which limits the translocation of micronutrients. Perennial or even annual sward results in the formation of humic compounds, which may promote the formation of salts or simple chelated complex compounds. This in turn prevents excessive leaching of micronutrients from the superficial layer of the soil [96,128]. Any higher accumulation of available forms of micronutrients in set-aside soil either bare or overgrown by naturally developed plant cover can be a consequence of the progressive acidification of soil. During the set-aside period, some unfavorable processes in the sorption complex take place, and the share of H$^+$ cations increases while that of base cations, mainly Ca$^{2+}$, decreases. Abandoning even some of the agritechnical treatments in a field excluded from production may lead to an increase in the content of available forms of both micronutrients and heavy metals [129].
Table 2. Changes in basic chemical parameters of set-aside soils.

<table>
<thead>
<tr>
<th>Chemical Parameter</th>
<th>C</th>
<th>N</th>
<th>pH</th>
<th>P</th>
<th>K</th>
<th>Mg</th>
<th>Ca</th>
<th>Zn</th>
<th>Mn</th>
<th>Cu</th>
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<tr>
<td>Source</td>
<td>[18,19,25,28,29,41,55,57,58,93,102,114]</td>
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2.5.3. Effect of Fallowing on the Physical Properties of Soil

Fallowing and setting aside farmland has an impact on the physical properties of soil. When soil tillage and cultivation technologies are abandoned, the soil structure transforms the natural (primary) form characteristic of a given soil [121,129]. The presence of leguminous plants on such land, which are ascribed to a specific role in the shaping of the soil’s structure, is another stimulating factor of the above changes [111,129]. The scope of changes concerning the soil’s physical properties depends on the duration of fallowing. Changes in the physical characteristics of soils over a short time of fallowing are rather small, and it is only the soil’s air permeability that is altered. This is a beneficial effect, as networks of unobstructed pores, unaffected by soil tillage practices, develop [129,130]. According to Ignaczak [131], the moisture and temperature of set-aside soil remained higher than in cultivated soil. In the study on different fallowing systems, Podstawka-Chmielewska and Kurus [132] showed that soil moisture was weakly correlated with the amount of rainfall. The researcher claimed that this was a consequence of the presence of a plant cover, which through transpiration modified the soil moisture and therefore had a stronger effect on this parameter than the rainfall itself. Another study, by Oliver et al. [133], also demonstrated a beneficial effect of a plant cover growing on set-aside land on water retention. According to these scholars, this is of large importance when set-asides are terminated, especially in dry climatic conditions, because a properly selected plant cover growing on fallow land leads to a significant increase in yields harvested from that land when used for farming again. Fullen [134] and Marks et al. [14] maintain that the overall course of changes in the physical features of soil left fallow should be considered beneficial.

2.5.4. Effect of Fallowing on the Biological Properties of Soil

The way set-aside soils are maintained determines a number of the soil’s biological properties. Many researchers underline the considerable impact of the biomass left on set-aside fields and the activity of microorganisms which it enhances. The lack of intensive agricultural production reduces the export of nutrients from set-aside fields, and then the released nutrients become a stimulus to the elevated biological activity of microorganisms. The decomposition of biomass contributes to a rise in the organic carbon stocks in set-aside soil, which in turn contributes to a more intensive activity of soil microorganisms [70,117,135]. Of particular importance for the development of microorganisms dwelling in set-aside soils is the presence of leguminous plants. Legumes grown on set-asides promote the soil’s fertility, which improves its biological activity and raises the counts of microorganisms. In set-asides protected with a cover of grasses and legumes, the counts of beneficial bacteria and fungi can even treble in comparison to their abundance in set-asides not sown with legumes. Biederbeck et al. [99] emphasized that conditions in set-aside soils are better than in cultivated soils for the growth and development of bacteria and fungi. These authors suggest that this arises from better water retention in soils under set-asides. The type of plants used for the conservation of set-aside soils may have a positive effect on the soil’s quality when agricultural production is resumed. Also, a plant cover composed of fodder galega or its mixture with awless brome maintained on a field set aside for several years is better at limiting the counts of pathogenic fungi than a naturally developed plant community or a bare fallow [136].
3. Prospects and Directions of Research on Fallow Land

Prospective directions of research and management of fallow land for sustainable development.

- Development of low-cost technologies for securing set-aside areas.
- Continued research on more effective CO\(_2\) and NO sequestration in set-aside areas.
- Research on obtaining biomass for energy purposes and biochar.
- Promoting the use of fallow land to achieve several goals at the same time: significant CO\(_2\) sequestration, improvement of soil fertility, and obtaining renewable energy.
- Development of recommendations for the selection of vegetation that can function in fallow areas for a period of 2–5 years and longer than 5 years.
- Searching and selecting vegetation for dry and shaded areas.
- Development of perennial multi-species mixtures consisting of more than 2 species to improve biodiversity.
- Development and creation of perennial mixtures for sowing fallow areas intended for bees and other pollinators.
- Developing effective ways to improve the fertility of weaker soils during their fallow period.

4. Conclusions

Soil resources should be given special care. Soil resources are constantly being depleted due to construction developments, degradation, or natural erosion. Voices advocating a complete halt to the loss of farmland are increasingly more common in debates about new challenges. For this and many other reasons, agricultural land deserves special protection. The current laws in many countries seem insufficient. In the face of new challenges, transparent legal regulations are needed to secure the productive potential of soil, sustain the objectives related to nature protection, and achieve ambitious energy targets. The property law should not be a shield for mishandling soil resources, which often leads to soil degradation. A basic portfolio of obligations of the owner of agricultural land may be introduced in order to safeguard the productive potential of soil. In the EU legal system, a single cut of grass grown naturally is sufficient to obtain the entirety of direct payments. This, however, contributes very little to the protection of the environment and the soil itself, and should not be financed. Many studies prove that agriculturally valuable land resources must be protected. It is possible to enhance the soil’s fertility at a low cost during the fallowing period, in addition to which quite large amounts of renewable energy can be obtained, biodiversity supported, and the CO\(_2\) balance improved. Many beneficial solutions in this regard have been developed. Depending on the climatic and soil conditions, the most productive plant species can be selected. This way, the tasks attributed to contemporary agriculture can be performed much more efficiently, safely, and, at the same time, with a smaller financial investment.

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