A theoretical perspective on the role and functions of soil resources in the Information and Knowledge Society

ABSTRACT

Much has been written about the soil over time, from different perspectives, however, the soil as an entity, as well as its role and functions are far from being fully recorded. In the Information and Knowledge Society, soil still has a significant role to play, in terms of its functions at the community level. We set out to make some scientific remarks and examples on these issues. Also, the soil is subjected to analysis as a cosmic-telluric-biotic product, in its gradual transition from the Hunting and Agrarian Society to the Society based on technology, information, and knowledge. What we have managed to summarize is a summum of definitions of the soil, and a conglomeration of functions, carefully nuanced and delimited, which open the way for the reader from the soil seen as a resource-support of the technosphere to the soil treated as a primary scientific concern.

Keywords: soil protection, the Information Society, sustainable agriculture.

1. INTRODUCTION

"Soil is considered one of the most complex ecological systems on Earth, a key component of our geographic environment, and also an integral part of the biological world. The soil is also equivalent to a multifunctional system, supporting the essential functions of life. For humans, the soil, by nature, has particular characteristics different from those of other environments, as important for the ecosystem. As a support and habitat for plants, the soil provides the main connections in the food chain of the biological cycle of elements, from the synthesis of organic matter to the products resulting from its mineralization" [18].

The soil is intimately involved in all cyclical biogeochemical processes that lead to the survival and sustainability of life on Earth. The pedosphere, which includes both the surface of the earth and that of shallow aquariums, is vital for performing a variety of tasks, including:

- providing an environment that is suitable for the growth of organisms and serves as a deposit for water, nutrients, and energy sources;
- active intermediate in the processes or mechanisms that control the bioenergetic equilibrium of the biosphere and landscape;
- involvement in all global biogeochemical cycles involving water, oxygen, nitrogen, phosphorus, sulfur, etc.

These processes have been ongoing in the past, are ongoing today, and will be ongoing in the future, albeit with different intensities and rhythms in various ecosystems across the world. The soil is the primary means of agricultural production because it can support plant life, but the existence and growth of human society will be influenced by the quality and quantity of higher terrestrial plants for a very long time because they must provide food and

raw materials for clothing, shelter, and other community-specific needs for humans. Through the bio-geo-chemical cycles of matter, soil resources have historically and currently supported ecosystem health by serving as a supply of raw materials for industry. The soil also serves as the foundation for all elements of the survival and ongoing growth of human communities by supplying the energy and materials required for daily existence.

2. MATERIAL AND METHODS

To be able to record the role and implicitly the undeniable importance of soil resources at the level of the Information and Knowledge Society, we turned our attention to reference and large-scale works that deal with the subject in question over a long period. Starting from the theoretical research, we proposed to make a foray into the functions that soil resources have in the management of the matter circuit and the daily life of the community. From our perspective, we consider that today, as well as in the future, information, and knowledge about soil resources and the functions they fulfill are more than necessary. Although human communities are on the verge of developing beyond what we could ever imagine, we believe that regardless of the stage of development in which we will find ourselves, surely soil resources will be the basis of our development.

3. RESULTS AND DISCUSSION

3.1 Defining the soil with the development of society

Even in soil science, the word "soil" has a variety of connotations, as do many other popular nouns [1]. The soil is viewed as "the natural environment for the growth of terrestrial plants, whether or not it has distinct horizons" [2-6] in the traditional meaning to which we are accustomed. The majority of interest in the soil is still centered on this connotation, which is still the mainstream sense of the word. Because it "supports plants that supply food, medicine, and other requirements" [1, 2], "filters water, and assures waste recycling," [3-6], and [1-3], the vast majority of people] believe that soil is significant. In this respect, the soil has a very excellent thickness, which is mostly governed by the rooting depth of the plants [1-6]. The soil covers the whole surface of the earth, except bare rock, locations with constant frost, deep water, and the barren ice of glaciers.

The idea of soil, its function, and its significance in society have gradually changed over time, shifting from a "naturist" to a "technical" concept in various stages [7]. For instance, "according to the function it gives to those who define it," [8] is how soil is defined. The US Natural Resource Conservation Service defines soil as a natural body from a morphological perspective as follows: "(...) a natural body composed of solids (minerals and organic matter), liquids, and gases that appear at the surface of the land, it occupies space and is characterized by horizons or layers, which are distinguished from the original material by the addition, loss, transfer, and transformation of energy and matter or the ability to support plants rooted in a natural environment" [4-6].

This definition expands on the one found in "Soil Taxonomy - A Basic System of Soil Classification for Making and Interpreting Soil Surveys" [2] to include soils in Antarctica, where pedogenesis takes place but where the climate is too harsh to support the superior vegetal forms. These definitions attempt to express the essence of the function that soil plays in the growth of society, as seen in Fig. 1 [9, 10].

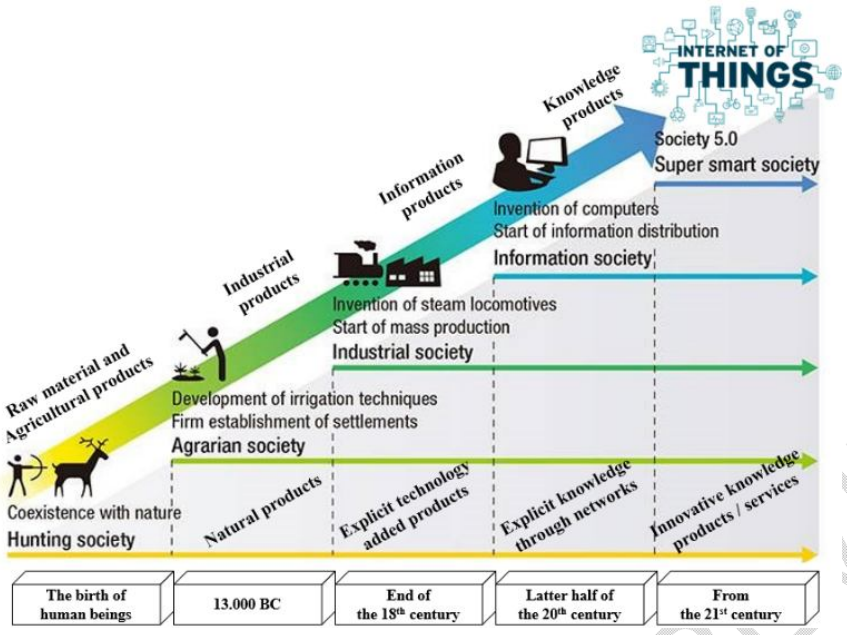

Fig. 1. The soil implications in the development of society [9, 10]

The Society for Soil Science provides another definition, which has issues regarding soil research and protection and bears the stamp of another entity on American soil. The soil is thought to be, depending on its genetic and environmental components: "(...) unconsolidated mineral or organic matter on the Earth's surface that is affected by macro- and microorganisms, conditioned by relief, and climatic factors (including effects of water and temperature), for a time acting on the parent material. A soil's physical, chemical, biological, and morphological features set it apart from the source material." [11].

3.2 Defining the soil with its characteristics

If on the American continent the soil is seen as "a dynamic non-renewable natural resource, essential to life, because the movement and quality of water, land use, and vegetation productivity are all closely related to the soil" [8], in Europe things are slightly nuanced. Although we produce the majority of our food and construct our homes on land, we cannot survive without "good soil" [12]. Based on "knowledge of specific features, attributes with well-defined numerical values derived by diverse methodologies, procedures of measurement, determination, and standardized calculation" related to the soil [7], this conclusion was made. Next, it is demonstrated in [13] that to fully and accurately define and comprehend soil at the local level, it is required to look at the soil cover, or pedosphere (Fig. 2), over a very broad geographic scale, even at the subcontinental level. or continental, in connection to climate zones and the anthropogenic factor's escalating influence.

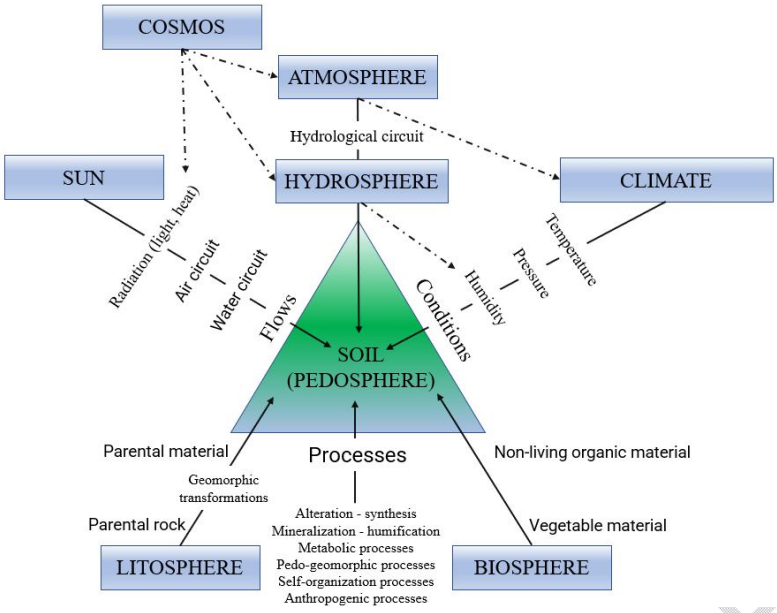

Fig. 2. Soil as a cosmic-telluric-biotic product of the synergistic interaction of energy flows, mass, and information with soil processes in various conditions[18]

The soil is the end product of a variety of processes that are influenced by environmental factors and continuously adapt to changes in the environment, whether they are natural or artificial. These processes also record and memorize the key moments in the evolution of a community through particular phenomena, processes, and characteristics. In the paragraphs that follow, we'll go into great detail on the functions and roles that soil plays at the community level.

3.3 The role and functions of the soil in the community

The soil serves crucial, universal purposes in both human society and the environment. By gathering and giving nutrients and energy to living species as well as by ensuring other conditions favorable to the development of these organisms, they are crucial for sustaining the existence of biodiversity on Earth.

The soil is one of the most valuable natural resources used by man to get the plant products he needs because of the tasks it performs (see Fig. 3). The most critical medium for the formation of biomass is soil, similar to aquatic bodies. The soil is the primary means of production in agriculture and forestry and is utilized by man in the process of growing plants. It is thought of as a renewable resource, provided that its use does not compromise its functionality. At this point, the importance of soil is universally acknowledged, not only in the development and promotion of sustainable agriculture, but also in the preservation of biodiversity, combating global climate change, and "the development of the economy as a whole" [7].

The soil also serves as a physical environment for technological and industrial buildings, a source of raw materials, and a safeguard for cultural legacy, which are all connected to non-agricultural human activity (situation exemplified in Fig. 4).

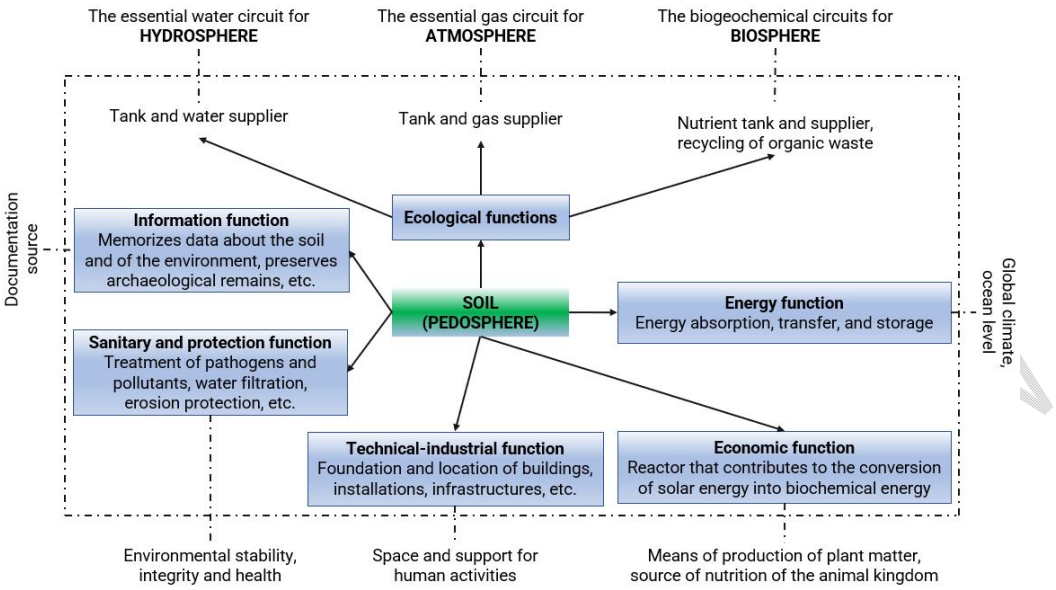

Fig. 3. The multiple functions or "ecosystem services" in which the soil participates[18]

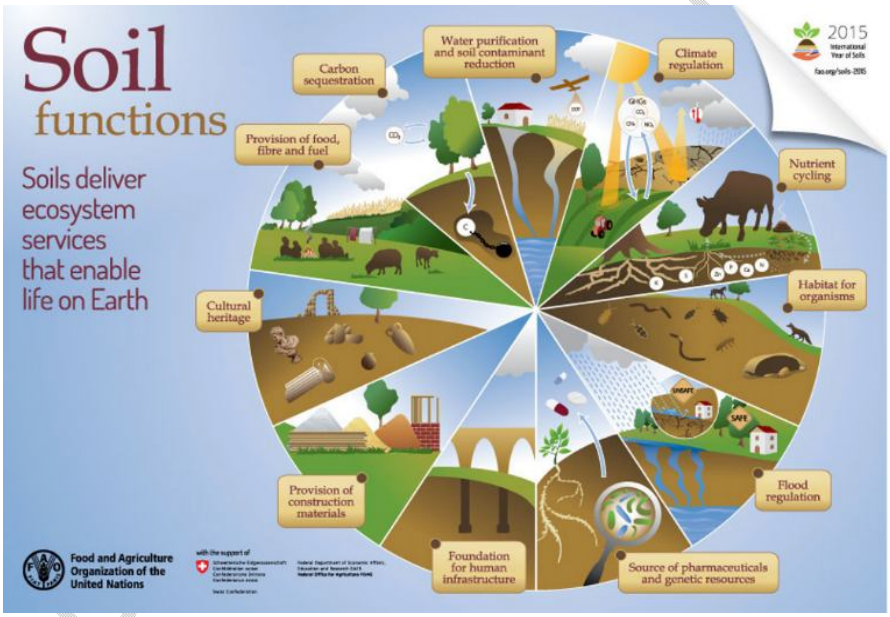

Fig. 4. Soil performs various functions in the community [14]

The tasks that the soil performs in society are described in further depth below, beginning with the ecological function and concluding with the information function, demonstrating their indisputable importance step by step.

Without a doubt, the ecological function of soil is one of its most representative functions. Whether we are talking about the need for development from more than 200 years ago or the one from today, soil resources have always been and will continue to be a reliable point

of reference in the creation of society's future identity. Soil resources not only supply the raw minerals and resources required by industry but also:

- contributes to the regulation of the composition of the atmosphere and the hydrosphere by the participation of the soil in the circuit of the chemical elements and the water in nature, respectively;
- contributes to the stability of the relief, protecting the deep layers of the bark;
- has the role of attenuating the sudden variations of some soil characteristics, regulating the development conditions of the plants;
- acts as a protection filter, preventing contamination with pollutants;
- has the role of a purification system of foreign organic substances or pathogenic microorganisms that have reached the soil;
- ensures the conditions of protection, functioning, and normal evolution of the biosphere;
- determines the genetic protection of some species and implicitly of biodiversity;
- represents the development habitat of soil organisms.

The economic function of soil:

- contributes to the production of phytomass which serves as a basic raw material for the production of food, clothing, and fuel, through the functions of the soil as a reservoir and continuous supplier of water and nutrients that give it the most important property, namely fertility;
- role in regenerating the production capacity of ecosystems, through the essential contribution to the circuit of chemical elements in nature.

The energetic function of soil:

- the accumulation of chemical energy resulting from the conversion of solar energy through the process of photosynthesis into organic substances and their partial accumulation in the soil in the form of humus. This energy can be released into the soil through the process of decomposition (mineralization) of organic substances;
- mediates the exchange of energy and substances between the lithosphere and the atmosphere, and has the role of absorbing solar radiation (in a sufficient proportion to the development of plants and animals, without affecting them) and heat transfer to the atmosphere.

The industrial function of soil:

- plays an important role in infrastructure for various constructions and installations, roads, highways, aerodromes, stadiums, etc., or space for the installation of underground cables and pipes;
- provides raw materials for various industries (clay, sand, clay, etc).

The informational function of soil:

- signal for triggering seasonal biological processes;
- records and faithfully reflects the stages of historical evolution by preserving relic characters or archeological relics.

As the interface of the cosmos with the lithosphere and biosphere, the soil is crucial to the healthy operation of terrestrial and aquatic ecosystems, as illustrated in Fig. 5 [15], which depicts the earth as a giant plant that is constantly producing phytomass, the building block for the growth of organisms, through automorphic processes. Life would not exist and would not develop without phytomass, nutrition with carbs, proteins, and other substances, as well as the required energy. The quantity of major- and micronutrients, as well as organic matter, that are absorbed and stored, is referred to as the number of nutrients [15], and the soil

plays a crucial part in this circuit. Organic compounds, like leaves and root tips, are broken down into simpler compounds by soil-dwelling organisms so that plants can use them.

To promote plant growth, fertilizers add phosphates and nitrogen, but the plants don't take all of it up. The surplus may infiltrate lakes and rivers where it may impact aquatic ecosystems. Another crucial but frequently overlooked component of the climate system is the soil. After the seas, it is the second-largest "CO_2 depression" or carbon sink. We can lessen the effects of climate change and adapt to it by restoring important land ecosystems and managing land in urban and rural regions sustainably. According to the existing land use (Fig. 6), considerable amounts of carbon and nitrogen in soils may be released into the atmosphere [16]. The distribution of greenhouse gas emissions can shift due to permafrost thawing, forest planting, or deforestation. A significant impact of climate change on agriculture can be seen in the subsequent use of land.

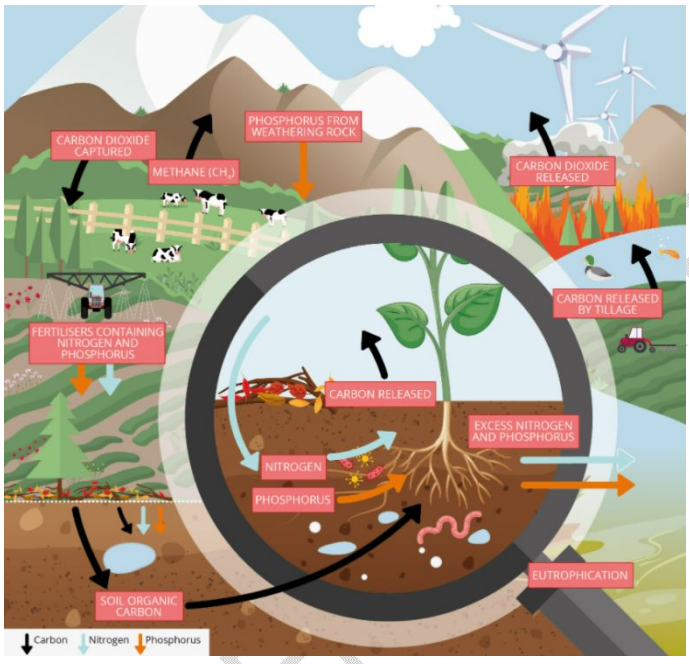

Fig. 5. Soils and nutrient circuits in nature [15]

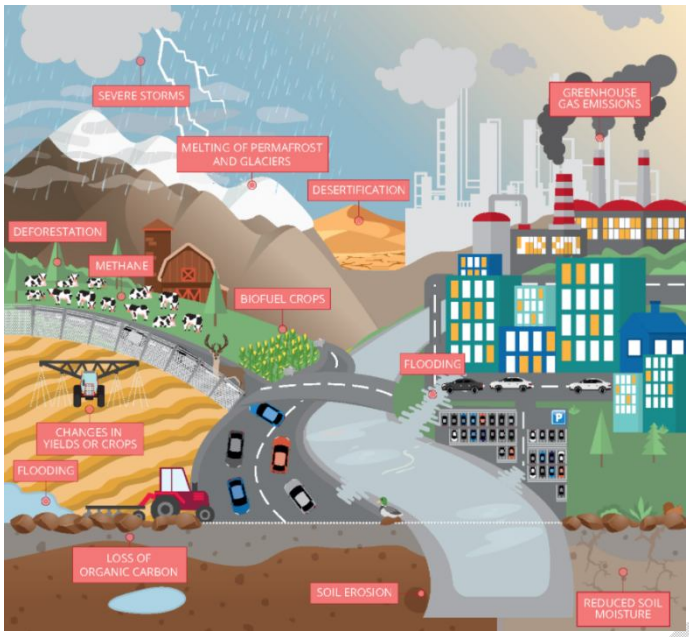

Fig. 6. Soils and climate change [16]

"Thesoil, the object of study of pedology, is the layer on the surface of the Earth's crust, formed by the action of the biosphere on the products of disintegration and alteration of rocks, able to sustain plant life. The soil is a system:

- structural - is an organized and structured environment, the constituents being in a close interdependence both vertically and horizontally;
- natural - formed under the influence of natural factors;
- complex – the product of the interaction of 5 factors;
- polyphasic - developed over time in several phases;
- open - exchanges with other geospheres and is in a continuous transformation;
- multifunctional - performs multiple functions;
- polydispersity - its solid phase is in different degrees of dispersion: molecular or ionic dispersions (salts); colloidal dispersions (clay, humus, hydroxides); coarse dispersions or suspensions (dust, sand);
- heterogeneous - because it consists of 3 phases (solid, liquid, gaseous)" [18].

Fig. 7. Soil and United Nations Sustainable Development Goals [17]

In the draft Soil Law (Parliament of the Republic of Moldova, 2008), Article 4, the functions of the soil are mentioned, stating that the soil represents the essence of terrestrial ecosystems, as in Law 246/2020 (Parliament of Romania) [13, 17]:

- specific living environment, the basis of terrestrial ecosystems, the habitat of humans, animals, plants, and soil organisms;
- storage of energy preserved in the form of hummus;
- the environment for the decomposition and biochemical transformation of organic residues, of buffering, transformation, and filtration of substances, regulating substrate of the circuit, and the formation of surface and groundwater quality and air;
- an archive of natural and cultural history;
- the environment that stores the raw material, the space for localities and recreation, the land for agricultural and forestry use, as well as for other economic and public purposes.

Regarding the aforementioned, in our opinion, the soil should be seen as a multisystem with a unique dynamic that in terrestrial ecosystems serves a variety of roles, including ecological, industrial, social, and technical-economical ones. The soil is given a very important role by the established goals of sustainable development (Fig. 7) [17], with its attributions being about the theme of goals nos. 2, 3, 6, 11, 12, 13, and 15.

The following are the most crucial roles that may be mentioned in light of the intensification of polluting processes and the clear desire to acquire more and more resources (a particular feature of the Information and Knowledge Society): the filtering, buffering, and transformation functions - which are crucial for the preservation of soil resources as well as for preventing disruptions to the soil-plant-animal-human food chain - as well as the functions of water conservation and carbon sequestration through organic matter - whose significance is heightened by global climate change. We also think that society as a whole and science both have a responsibility to protect the soil and stop it from degrading because the soil is and will continue to be for a very long time the basis for maintaining our existence.

4. CONCLUSION

The quest for new resources to replace those that are so essential for daily life in the Information and Knowledge Society has made soil protection a hotly debated topic. And this is despite the fact that there exist international corrective policies and anti-pollution measures that, if implemented and regularly followed, can save and conserve numerous soil resources and impacted or degraded lands.

The variety of definitions and roles ascribed to the soil caught our attention as we casually browsed literature articles and the soil protection pages of websites run by international organizations (UN, FAO, NRCS, EEA, SSSA, etc.) that have long-standing concerns in the area. Since energy flows, mass, and information are synergistically interacting with soil processes in various stages of development, with cyclic dynamics, on the surface of the Earth's crust, we were able to acknowledge in the few pages of this paper the essence of concerns for defining the soil as a cosmic-telluric-biotic product.

With a focus on ecological, economic, energy, industrial, and informational aspects, the importance of soil is also well-emphasized. Additionally, it is appropriate to note that although recent soil resources are protected by legislation, they must be returned to and reintroduced into the natural flow of matter. Where necessary, steps must be taken to protect and preserve the soil, which can still serve as the foundation for other human endeavors. Even though the activities that the soil supports help to define its role as clearly as possible, we should never lose sight of the fact that, no matter where technology takes us (including IoT, drones, and related mobile applications), the soil will always serve as a marker of progress from one generation to the next.

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