Comparative Efficiency in Nutrient Retention between the Vegetation of the Natural Ecosystems and of the Agro-Systems

Iuliana Florentina Gheorghe

Abstract- Over the last 50 years, the Europe's agricultural sector was supported by the commune agrarian policy (CAP). Although in the beginning the emphasis was on expanding farmland at the expense of the natural ecosystems and on an intensive agriculture in the existing farmland, in the last decades was understood also the need of nature conservation in parallel with the development of agriculture. This support has evolved alongside growing recognition and awareness of the strong links between agricultural production and biological diversity conservation. The Ecology development as science, mainly after the Odum approach, emphasized the role of natural ecosystems in natural capital conservation and biodiversity. Also the ecology studies conducted in the last two decades, have revealed and other services provided by the natural ecosystems besides the generated resources, that fixation carbon dioxide, the reduce diffuse pollution with nutrients, creation a local microclimate, etc

The local microclimate created by natural vegetation areas near of the crops influences strongly the ecological functions of anthropogenic ecosystems , even the in the semi-natural ecosystems, important functions as cycles of nutrient and water (local water balance, nutrient balance and the production of biomass).

The keeping of a mosaic structure (a mixed of crops with pasture, forests, rivers and lakes) is an ideal solution to harmonize the development of society which involves an increase of needs in energy and materials resources; with nature conservation.

KEY WORD- Plant communities, Primary production, Litter decomposition, Water balance, Nutrients balance

I. INTRODUCTION

The land use and the altered carbon and nitrogen dynamics, are two of the primary components of global change. The effect of land use on carbon and nitrogen cycling is a crucial issue of the regional biogeochemistry scale. Previous studies have shown that climate and soil conditions can control net primary production (NPP) at regional scales, and that agricultural land use can influence NPP at local scales through altered the water availability and carbon allocation patterns [1], [13].

Land use practices often include dramatic modification of vegetation and are therefore some of the most direct and common ways that humans impact ecosystems [2], [3]. Cropping is a widespread component of land use, covering over 1.5 x 10^9 ha worldwide [4].

Although cropping has obvious effects on vegetation structure, it also influences ecosystem processes, including the magnitude and direction of the carbon and nitrogen flux between the atmosphere and the soil–vegetation system [3].

Manuscript received April, 2014.

Iuliana Florentina Gheorghe, Ecological University of Bucharest, Faculty of Natural Science and Ecology,Bd. Vasile Milea 1G, Bucharest, Romania.

The decomposition and the nutrient cycling are fundamental for ecosystem biomass production. Most natural ecosystems are nitrogen (N) limited and biomass production is closely correlated with N turnover [5], [6]. Typically external input of nutrients is very low and efficient recycling of nutrients maintains productivity [7]. Decomposition of plant litter accounts for the majority of nutrients recycled through ecosystems. Rates of plant litter decomposition are highly dependent on litter quality; high concentration of phenolic compounds, especially lignin, in plant litter has a retarding effect on litter decomposition [8], [9]. More complex C compounds are decomposed more slowly and may take many years to completely breakdown. The litter decomposition rate is controlled by nature of litter, litter fauna present in the soil, carbon source, microbial biota, temperature and soil moisture. Also the taking of nutrients, resulting from decomposition process, by plants is influenced by the presence of water, root absorption is impossible in a dry soil. For this reason the extensive water balances are discussed in agricultural hydrology. A water balance can be used to help manage water supply and predict where there may be water shortages. It is also used in irrigation, runoff assessment (e.g. through the *RainOff* model [10], flood control and pollution control. Further it is used in the design of subsurface drainage systems which may be horizontal (i.e. using pipes, tile drains or ditches) or vertical (drainage by wells) [11]. Insufficient water supply is the most important single factor governing agricultural production in the arid and semi-arid zones. Understanding the magnitude and dynamics of different components of the crop water balance is crucial to development of technological options for sustainable management of soil and water resources. In addition to rainfall, a thorough knowledge is required of seasonal values of evaporation, weed and crop transpiration, runoff, deep drainage and soil water storage. Rainfall effectiveness in crop and livestock production can be enhanced by reducing evaporation, runoff, weed transpiration and deep drainage. The objective of soil and crop management is to increase crop transpiration, plant biomass, and the harvest index [12]. The present work aims is to calculate the nutrient balance(C and N) in five types of vegetation. The five types of vegetation are present and dominant in a river basin where water balance is deficient in humidity, but compensated by river and groundwater supply.

II. MATERIALS AND METHODS

Using the Action plan for protection of waters against pollution caused by nitrates coming from agricultural sources elaborated by Ministries of Environment and Forests in 2008, we chose to study the area of the Glavacioc catchments (N - 44°27'09"; E - 25°16'32"; elevation – 161 m) because in these papers, it is an important national zone for diffuse nutrient pollution coming from agriculture. This basin was characterized in terms of climatic data, land use, cropping system, soil types, nutrient input, proportion and structure of riparian zone and types of vegetation in riparian zone. General climate data about catchments was provided by National Institute of Meteorology and Hydrology. Information about the cropping system was taken from National Statistical Yearbook for 2007, Agency Payments and Interventions in Agriculture and the Land Register Book. The soil maps (scale 1:200 000) were purchased from Research Institute of Soil Science and Agro-chemistry. For the land use were used digitized maps "Corine land cover 2006", being processed in the ArcView GIS 3.2a. For maps we also used Wikimapia interactive maps and Google Earth web site. Detailed data on the forest area of the study was provided by the Institute for Forest Research and Management. To identify the riparian areas we used topographic maps, forest maps, orto-photo-plans, Wikimapia maps and field trips to validate the information present in the maps. Depending on the degree of representation we chose five types of riparian vegetation: wetland with *Carex* sp. L*ythrum* sp., *Scyrpus* sp., pasture, mixed forest, forest with *Quercus* species (Querceta) and wheat crop. For each zone we estimated: structure of vegetation, dominant species, biomass, primary productivity, C, N stocks and C, N uptake, litter decomposition rate, C and N removal rate, water and nutrients balance in herbaceous layer. The study was conducted in July 2010, during the peak of the vegetation seasons using the Braun- Blanquet method [14].

Accumulation process – primary production and productivity increases of biomass and nutrient stocks.

To estimate herbaceous biomass was used the quadrates method [15]. The herbaceous layer productivity was assessed using the McClaugherty method. To identify and select the typology and types of the forest we used the arrangement study and the trips in the field to validate this information. The typology has been established accordingly: the species composition, total height of the trees, HDB, age of the trees, spatial density of the trees, quantity of the wood/ha and productivity. The biomass of leafs of the trees was estimated used the Leaf Area Index (LAI) method.

Removal process

Litter decomposition loss of biomass and decrease of nutrient stocks. The mixed natural litter was collected from the five riparian vegetation types (wetland –W, mixed forest – F_1, querceta forest – F_2, pasture P, and agriculture land – A) after leaf fall in the autumn and were dried in an oven at 50 ºC for 48 hours.

A. preparing the litter bags

We made the litter bags using a plastic mesh netting standard. The mesh size does not allow entry of litter macro-fauna in bags and prevent the accidental losses of the litter. This material has been cut, were made 90 bags, size of each bag was 20 x 28 cm. In each bag was introduced an amount of 10 g of dry litter. The edges of the bags were closed with a soldering iron. We prepared also, for each zone, 5 litter duplicates. B. Installing the litter bags

Was established the centre of each investigated zone, here was selected a landmark of which were anchored unite with plastic thread 3 rows of bags, on for each replicate. We started installing of the bags in October and we finished the experiment in July next year. The bags were installed in the field, the ground was cleared of natural litter, were placed the bags on soil surface and covered after with natural litter.

C. Collecting the Litter Bags

The litter bags were collected at 6 moments of the time (after 2 weeks, 4 weeks, 8 weeks, 16 weeks, 20 weeks and 28 weeks). At the return in the laboratory, we put the litter bags in the drying at 50ºC and dried until constant weight was reached (4 days). After 4 days we removed gently the contents of each bag and place them on clean paper and weighed.

D. Data processing

Weight values obtained by weighing were entered in an Excel file, for each of the three replicates were calculated the average. Using equation: $\ln (M_0 / M_t) = k * t$, was calculated K values for each interval and mean K values.

Where: M_0 = mass of litter at time 0, M_t = mass of litter at time t, t = time of incubation (usually in weeks), k = decomposition rate constant.

The N and C content were determined using the CHN analysis method. To estimate nutrient acquisition rates by plant were used in parallel two methods (McClaugherty method. and method of stable isotopes of $\sigma\ ^{15}N$ ‰). The results obtained by both methods were similar the nutrient acquisition efficiency was 23%. Also by removal of litter nutrients were used two ways of calculating (litter bags method and method of stable isotopes of N 15). The result was similar.

To estimate the **water balance** we used the general equation: $D + P = Q + ET + \Delta S$

Where: P is precipitation, Q is runoff, ET is evapo-transpiration, Δ S is the charge in storage (in soil or the bedrock), D is groundwater recharge

III. RESULTS AND DISCUSSION

About ¾ of the Glavacioc's basin area is covered with agricultural land (71.5%). Except for agricultural land, most of the land is covered with various constructions, (13%) representing the rural area consists of villages. The forests occupy 12% of the territory, wetland 2%, pasture 1% and rivers and lakes 0.5% (fig. 1).

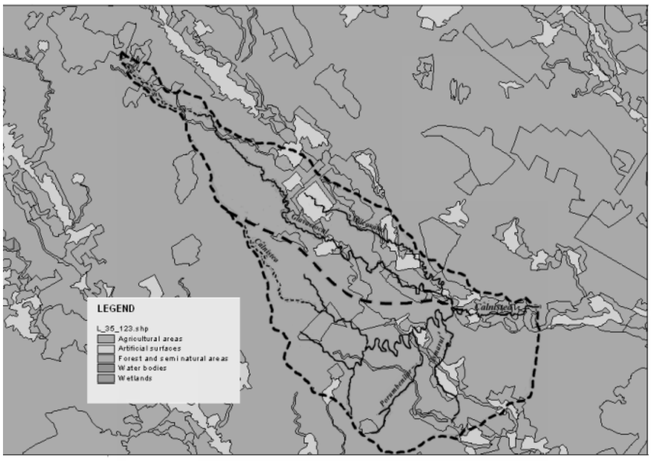

Figure 1 Land use in Glavacioc catchments (CORINE land cover map, 2006)

Water balance

The area is deficient in terms of the moisture, the average annual precipitation values are around 571.5 mm and potential evaporation about 717 mm, reveal a deficit of about 185 mm water (fig. 2). Higher values were recorded in July, August and September. Sometimes, the phenomenon is manifested by frequent droughts, some lasting (eg, one in 1946-1947 or in 2000 and 2003, 2007, 2012). The mean values of periods of drought, as multi-values were calculated for 15 to 19 days and maximum of 50 days. The flow is low because the presence of loess deposits with high infiltration coefficient, interfluves as smooth slope very weak fields, and the existence of semi-endhoreic areas. Much of the water resulting from precipitation, which fails to flow, seeps as runoff and loading the lakes and rivers. The aquifer depth exceeds 20 m, and in land with high slopes and valleys depressions right falls below this value. Although the area is deficient in humidity, the river and groundwater supply and compensate the water losses by evapo-transpiration. The area is cultivated with various crops (corn, wheat, sunflower) which grow, and have not the need for irrigations (fig. 2).

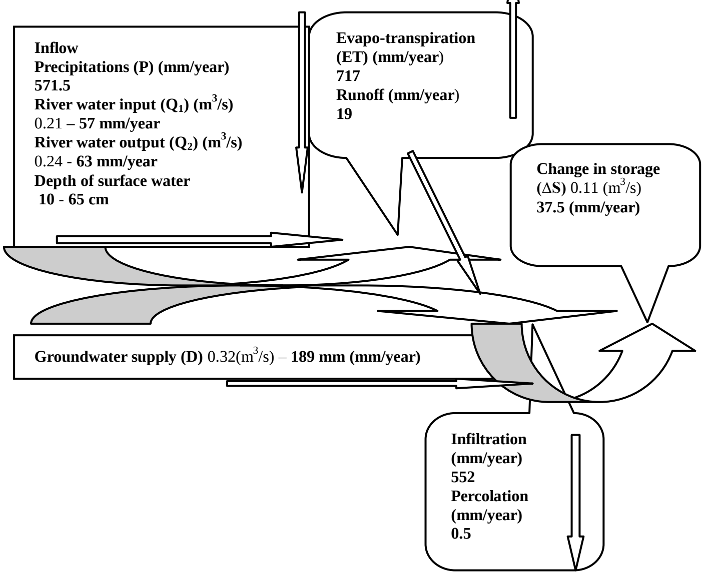

Figure 2 Water balance in Glavacioc's catchments

The green infrastructure in Glavacioc basin is a very heterogeneous, here are present the following types of ecosystems: rivers and lakes, wetland with *Carex sp. Lythrum sp. Scyrpus sp.*, wetland with *Salix sp.* and *Typha sp.*, *Phragmites sp.*, pastures, 9 typologies of forest, 25 type of crops , villages and rural areas. This mosaic provides, on one hand, a high diversity, a source of natural resources (wood, biomass, food) and on the other hand great areas to reduce diffuse pollution from agriculture (riparian areas that function as buffer zones). The number of plant species from the vegetal communities, present at basin level, was 74; and number of ecosystems types was 41, of which the most numerous were the ones semi-natural and anthropogenic (27). In terms of specific composition in all type of vegetation, the species present jointly represents less than 20% (tab. 1).

Table 1. Species composition and dominance in vegetation

Species	Frequency %	Braun-Blanquet index	Dominance
Typha latifolia	2	+	
Stachys palustris	5	1	
Scirpus lacustris	100	5	first dominant
S. sylvaticus	15	2	
Lycopus europaeus	0.5	r	
Phragmites australis	2	+	
Lythrum salicaria	69	4	second dominant
Ranunculus acris	1	+	
Galium palustre	1	+	
Epilobium hirsutum	35	3	
Juncus glomeratus	2	+	
Carex pseudocyperus	56	4	second dominant
Acorus calamus	0.75	r	
Bromus sterilis	5	+	
Buglossoides purpurocaerulea	28	3	
Galium schultesii	34	3	
Glechoma hederacea	67	4	second dominant
Lolium perenne	2	+	
Lysimachia nummularia	14	2	
Plantago major	7	1	
Plantago media	9	1	
Ranunculus acris	38	3	
Taraxacum officinale	11	2	
Erigeron canadensis	78	5	first dominant
Geranium phaeum	4	+	
Asperula glauca	6	1	
Alliaria officinalis	23	2	
Stellaria aquatica	4	+	
Mercurialis perennis	0.75	r	
Anemone nemorosa	17	2	
B. purpurocaerulea	6	1	
Asparagus tenuifolius	3	+	
Corydalis cava	21	2	
Corydalis solida	24	2	
Circaea lutetiana	0.5	R	
Galium mollugo	11	2	
Galium schultesii	9	1	
Geranium phaeum	7	1	
Geranium pratense	4	+	
Geum urbanum	29	3	second dominant
Glechoma hederacea	58	4	first co-dominant
Heracleum sphondylium	1	+	
Lamium album	2	+	
Lysimachia nummularia	14	2	
Plantago major	9	1	
Polygonatum latifolium	3	+	
Potentilla reptans	2	+	
Ranunculus acris	28	3	
Ficaria verna	65	4	first co-dominant
Rumex crispus	0.7	R	
Salvia nemorosa	2	+	
Scilla bifolia	18	2	
Silene vulgaris	12	2	
Veronica chamaedrys	8	1	
Viola odorata	46	3	second dominant
Amaranthus retroflexus	4	+	
Arctium lappa	2	+	
Bromus sterilis	3	+	
Capsella bursa-pastoris	3	+	
Daucus carota	1	+	
Echinochloa crus-galli	3	+	
Erigeron canadensis	11	2	
Erodium cicutarium	0.5	r	
Setaria pumila	0.7	r	
Achillea millefolium	1	+	
Cichorium intybus	2	+	
Galega officinalis	0.5	r	
Hypericum perforatum	1	+	
Lolium perenne	23	2	

Lotus corniculatus	9	1	
Mentha longifolia	3	+	
Plantago major	4	+	
Potentilla reptans	1	+	
Prunella vulgaris	16	2	
Ranunculus acris	2	+	
Senecio jacobaea	3	+	
Taraxacum officinale	5	+	
Trifolium hybridum	7	1	
Trifolium pratense	8	1	
Trifolium repens	11	2	
Dactilis glomerata	4	+	
Elymus repens	76	5	dominant
Vicia cracca	11	1	
Cirsium vulgare	0.4	r	
Inula britanica	1	+	
Ranunculus sardous	1	+	
Sonchus asper	0.7	r	
Triticum aestivum	100	5	dominant
Cirsium vulgare	1	+	
Setaria pumila	0.5	r	
Sonchus asper	1	+	
Bromus sterilis	2	+	
Viola tricolor	0.5	r	
Vicia cracca	6	1	

The largest quantities of biomass are produce by mixed forest (F_1) following by querceta forest (F_2), a significant contribution it has the layer of trees. The herbaceous layer the least productive is the grass present in mixed forest. The most efficient plant layer in C and N uptake is the wheat crop, but the stock is low because the plant stems and grains are removed. For the vegetation with the only herbaceous layer, the largest storage capacity has the wetland followed by agricultural land and pasture (fig. 3).

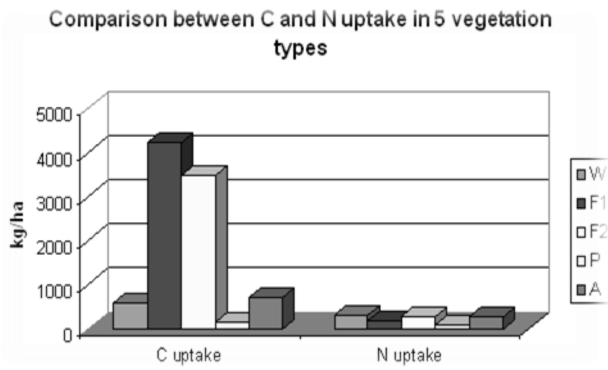

Figure 3 The C, N uptake by vegetation, July 2010

The C stocks represent approximately 50 % of the biomass and the N stock almost 2 %. The litter decomposition in the five areas covered with five different vegetation types followed an exponential decay model. The litter composition from the area that was put in bags was relatively uniform in terms of structure; evidenced by low values of standard deviation of the three replicate values.

The highest value of the constant of decomposition rate (k) was recorded in forest with low slope - F_1; here the decomposition process is most intense. In forest with high slope - F_2 the k value is close to that of F_1. The greater speed of decomposition process, in F_1 is due to a saturated soil in water (here is sufficient water like humidity necessary for bacterial exo-enzymes activity) and the nature of litter (the quantity of lignin and cellulose in the leaves of the trees and shrubs is low compared with the stems of wheat and *Scyrpus* sp). The lower values of k occurred in wetland; plant species present here are adapted of high soil moisture conditions; tissues structure of these plant are impregnated with silica salts that are difficult to break down in small fragments. The wheat straws were also in the structure the tissues impregnated with silica salts; therefore the value of k in agriculture land is low and similarly with wetland. In both agricultural land and in wetland the decomposition process takes place slowly (fig. 4).

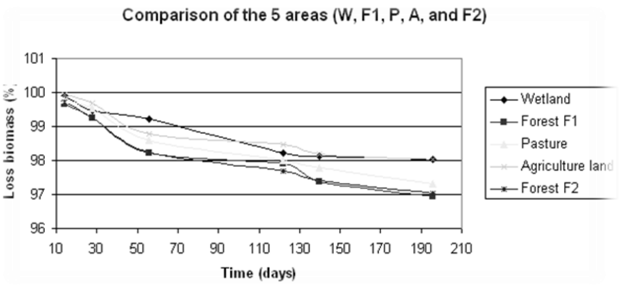

Figure 4 The decomposition rate (loss of biomass) in all five areas

In the rapid process of decomposition, the nitrogen is released this reaching in the soil where it is taken up by plants or denitrification. The carbon is part of the lignin and cellulose substances and is mineralized more slowly; is slowly released into the atmosphere. The litter is an important source of nutrients for the soil; their supply being made slowly; allowing of the plants to take nutrients and only a small portion to be lost by infiltration or denitrification.

Nutrients balance

Since the dynamics of stocks in herbaceous layer is different than the trees layer (the period of the cycle of nutrients in the tree layer is much longer than in the herbaceous layer) nutrient balance was calculated separately for each layer. In wood the amount of nutrients (C, N) stored in the layer of the trees, only in 2011, was 10 times greater than that stored in the leaves. In wood, the amount of nutrients taken as productivity, accumulate from year to year and only the leaves supplies the litter, which decomposes. In the two forest types (F_1 and F_2), 4/5 the amount of litter is decomposed, and 1/5 accumulates at the soil surface and supplies with organic matter the horizon 0 of the soil (fig. 5). This organic matter plays a fundamental role in soil processes; this is an energy source of microorganisms and precursor in soil humic acids. Although part of N is lost in the process of denitrification, like a final stage of decomposition, a large amount of N returned to soil as nutrients from which is taken by plants. The analyses of Figure 5 show that the temperate forests are very important ecosystems in terms of the amount of carbon stored, of storage period and of fertility of the soil.

The most efficiently layer of herbaceous in uptake of nutrients was the wheat crop (A). This agriculture land is the most productive, there registering the highest value of productivity (4.241 g/m^2/year) (fig. 6). Although the most productive is the farmland, the highest value of standing crop is in the wetland, because in agriculture land most of the biomass is removed with threshing. Also the wheat straw is removing by the local population, they use for bedding in stables. The least efficient in uptake and storing the nutrients is herbaceous layer in mixed forest F_1. This layer is very low productivity due to competition for light, space and nutrients.

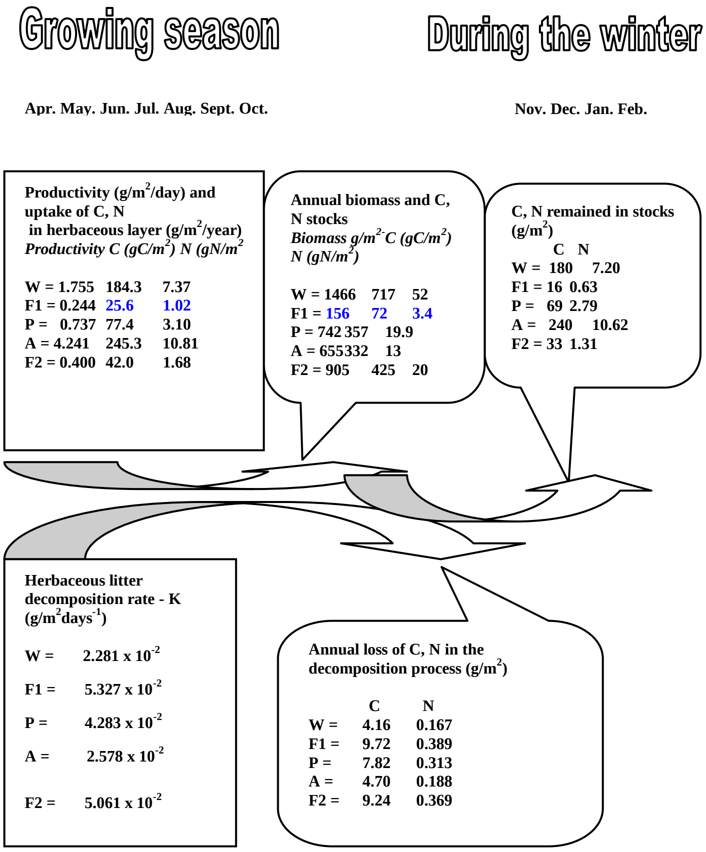

Figure 5 Nutrients balance in herbaceous layer

Also, the pedo- climatic conditions in this forest (high humidity, organic matter in sufficient quantities, good oxygenation conditions) creates optimal conditions for the litter decomposition process, here was recorded the highest rate of decomposition (5.327 x 10^{-2} g/m^{2}days^{-1}) (fig. 6).

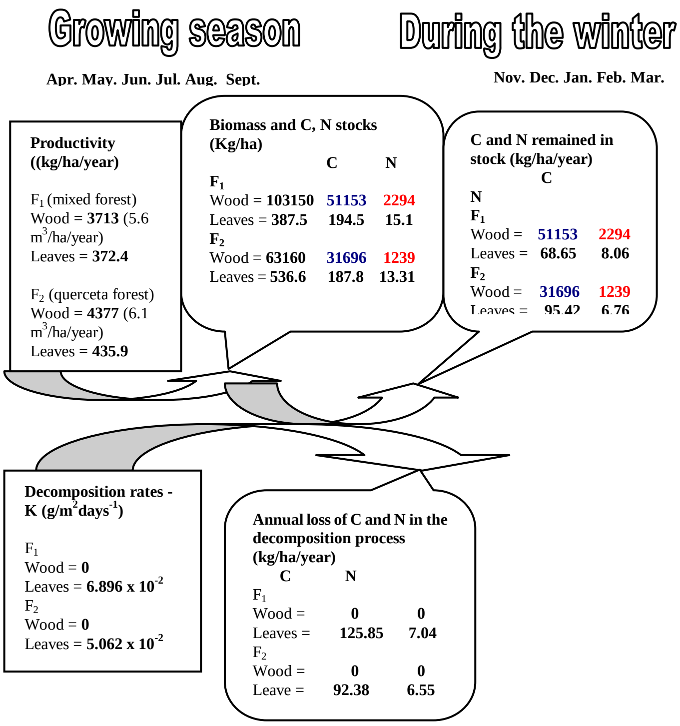

Figure 6 Nutrients balance in trees layer

III. CONCLUSIONS

The forest ecosystem is the most efficient in terms of nutrient acquisition and storage. Albeit the crops have a high productivity; in the layer of herbaceous the uptake rate and period of storage of nutrients is limited comparing with the wood. Making only a unilateral analysis regarding takeover efficiency and nutrient use by plants in crops we assumed the risk to ignore the role of other types of ecosystem in nutrients cycle. A holistic approach, the achievement a simultaneous analysis for all the functions for the different types of ecosystem (reducing pollution, creating local microclimates, etc.) outside the production can give an overview; and help us to take the best decisions in the use of different types of land. Natural and semi-natural ecosystems are the main sources in the production of resources and energy generation and play an important role in reducing of pollution. With as the demand for resources and energy required is greater with both human pressures exerted on ecosystems and biodiversity is higher, which implies the need for preservation of these species and ecosystems. Also the residues arising from the use of resources accentuates the pollution and the anthropogenic pressure on natural capital. Keeping a mosaic structure is an ideal solution to harmonize the development of society with nature conservation. A green infrastructure with lakes and rivers, wetland, different types of forest, pastures, shrubs including different types of crops, represent the ideal structure to meet both goals.

ACKNOWLEDGEMENTS

This work was supported by International Atomic Energy Agency - Soil and Water Management & Crop Nutrition Section, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, in the research program called Investigation of Nitrogen pathways in typical entropic-modified riparian zones of the Arges river catchment's area, Romania, Contract no. 15352. We thank Lee Heng and Sakadevan K. for assistance.

REFERENCES

1. Bradford J.B., Lauenroth W.K., Burke I.C., 2005, The impactof cropping on primary production in the u.s. great plains, Ecology, 86(7), 2005, pp. 1863–1872
2. Houghton, R. A., 1995, Land-use change and the carbon cycle. Global Change Biology 1:275–287.
3. Houghton, R. A., Hackler J. L., and Lawrence K. T.,1999, The U.S. carbon budget: contributions from land-use change. Science, 285:574–578.
4. Richards, J. F., 1990, Land transformations, Pages 163–201 in B. L.
5. Vitousek P.M. and Howarth R.W., 1991, "Nitrogen limitation on land and in the sea: how can it occur?" In: Biogeochemistry 13:87-115.
6. Reich P.B., Grigal D.F., Aber J.D., Gower S.T., 1997, "Nitrogen mineralization and productivity in 50 hardwood and conifer stands on diverse soils", in: Ecology 78:335-347.
7. Likens, G. E., F. H. Bormann, Johnson N. M., Fisher D. W. and Pierce R. S., 1970, Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed ecosystems, in: Ecological Monographs 40:23-47.
8. Melillo J.M., Aber J.D., and Muratore J.F., 1982,Nitrogen and lignin control of hardwood leaf litter decomposition dynamics. Ecology, 63:621-626.
9. Hättenschwiler S. and P.M. Vitousek, 2000, The role of polyphenols in terrestrial ecosystem nutrient cycling. In: Trends in Ecology and Evolution 15: 238-243.

10. Kendall and McDonnell, 1998. Isotope Tracers in Catchment Hydrology. Elsevier
11. de Ridder N. A. and Boonstra J., 1994. Analysis of Water Balances. In: H.P.Ritzema (ed.), Drainage Principles and Applications, Publication 16, p. 601- 634. International Institute for Land Reclamation and Improvement (ILRI), Wageningen, The Netherlands. ISBN 90-70754-33-9.
12. Lal, R., 1991, Current research on crop water balance, and implications for the future, Soil Water Balance in the Sudano-Sahelian Zone (Proceedings of the Niamey Workshop, February 1991). IAHS Publ. no. 199.
13. Turner, W. C. Clark, Kates R. W., Richards J. F., Mathews J. T., and W. B. Meyer, editors. The Earth as transformed by human action. Cambridge University Press, Cambridge, UK.
14. Whittaker, R.H., 1978, The Braun-Blanquet approach. Classification of Plant Communities, Junk, The Hague.
15. Gheorghe I.F. Fitocenologie şi Vegetaţia României, 2008. Ed. Didactică şi Pedagogică