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# METHODS OF ECONOMICAL EVALUATION OF GRASSLANDS UNDER EXTREME CLIMATIC CONDITIONS BASED ON PLANT SOCIOLOGICAL SAMPLES

***This work shows the methods used for economical evaluation of grasslands. It indicates the applied parameters of each method. We show 4 evaluation methods through 2 examples on semi-natural and degraded grasslands. The methods produced similar results suitable for evaluation, mainly Balazs's method which deals with quantity and quality factors as well.***

***Keywords:*** *agricultural economics, biodiversity, yield, economic aspects.*

***JEL code:*** *Q15, Q19, Q24.*

**Ласло Васа, Чаба Гюріца, Кароль Пенкша**

# МЕТОДИ ЕКОНОМІЧНОГО ОЦІНЮВАННЯ ЯКОСТІ ПАСОВИЩ В ЕКСТРЕМАЛЬНИХ КЛІМАТИЧНИХ УМОВАХ НА ОСНОВІ РОСЛИННИХ ЗРАЗКІВ

***У статті подано огляд методів, що використовуються для економічного оцінювання якості пасовищ, вказано набір параметрів для кожного методу. Наведено приклади використання 4 методів оцінювання двох пасовищ на напівнатуральних і виснажених землях. Усі методи дали аналогічні результати, придатні для оцінювання, особливо метод Балажа за кількісними і якісними факторами.***

***Ключові слова:*** *економіка сільського господарства, біорізноманітність, урожай, економічні аспекти.*

***Таб. 1. Фор. 6. Літ. 39.***

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# МЕТОДЫ ЭКОНОМИЧЕСКОЙ ОЦЕНКИ КАЧЕСТВА ПАСТБИЩ В ЭКСТРЕМАЛЬНЫХ КЛИМАТИЧЕСКИХ УСЛОВИЯХ НА ОСНОВЕ РАСТИТЕЛЬНЫХ ОБРАЗЦОВ

***В статье дан обзор методов, используемых для экономической оценки качества пастбищ, указан набор параметров для каждого метода. Даны примеры использования 4 методов оценки двух пастбищ на полунатуральных и истощенных землях. Все методы дали аналогичные результаты, пригодные для оценки, в особенности метод Балажа по количественным и качественным факторам.***

***Ключевые слова:*** *экономика сельского хозяйства, биоразнообразие, урожай, экономические аспекты.*

**Introduction.** The natural and seminatural grasslands of the world have a great ecosystem supplying ability. Besides conservation of biodiversity, their economic value is also of great importance (Partel et al., 2005; Hopkins and Del Prado, 2007; Szentes et al., 2012). We have to highlight that the economic value of grasslands can be considered constant only under similar conditions (e.g., grasslands or irrigated grass in the same Atlantic climate). Under significantly changing environmental con-

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ditions the yield of grass may greatly vary. It is because the yield of grass is influenced by several environmental (climate, soil, exposure) and biotical (species composition) factors. In European regions with extreme climate - like the Pannon biogeographical region — dry and wet grasslands show extremities (Kiss et al., 2011). We must focus on the situation of dry grasslands, because their productivity is more critical due to the nutrient poor, economically unfavourable sites (Hobbs et al., 2006; Borhidi, 2003). They are very vulnerable to the alien species, whose invasive spreading is harmful to the species composition of dry grasslands and threaten their existence. This is strengthened by the worldwide climatic changes and the more frequent meteorological anomalies (Wittmer et al., 2010). As a result of that tropical and subtropical species tend to appear in the temperate zone. Therefore C4-species may appear and spread (Kalapos and Mojzes, 2008), which decreases the biodiversity of the grasslands (Bartha, 2007; Gabbard and Fowler, 2007; Harlen et al., 1958; Schmidt et al., 2008), and also decreases the economic value of them (Szabo et al., 2008).

The measurement of the productivity of grasslands is important from plant- and animal production and economical respects (Szucs, 1986, 1996; Szucs et al., 1994; Szucs and Liebmann, 1993; Szeman, 1985; Benyovszky and Penksza, 2002; Nagy, 2004), because their value is important for rural producers regarding the effectiveness and profitability of production (Nagy, 2003).

It is important and necessary to deal with the feeding value of grasslands, but it requires certain measuring methods. With our thesis we wanted to provide a review of the grassland evaluating methods and to show their comparison through two examples. The evaluation of grasslands is important to obtain exact data in order to draw the attention of decision makers and rural development experts.

**Material and method.** At first we list the usable methods and show the parameters used in them. We describe 4 methods in details. It is a common ground in the case of all 4 methods, that they are based on the samples of real site sampling areas. The quadrates of the sampling areas give us the quantity and composition of the species. Now we just have to measure the height of the species. Therefore the costs of the methods are low.

We compare the results of the 4 methods through 2 site samples. The site is a 150 ha pasture of a sheep producing farm, which lies in a NW-SE valley. The SW slope is a steep area with poor water management which creates a drier and hotter environment for the vegetation. The vegetation is a typical Pannon steppe (Salvio nemorosae-Festucerum rupicolae). The pasture is grazed by 150 texel ewes and their lambs. The animals are kept on the pasture all year long.

We examined 5 sampling areas in the SW pasture zone at 200-210 m sea level height. We marked 5 sampling areas on the overgrazed, erosion threatened area of the eastern part. Therefore we can compare a seminatural and a heavily degraded dry steppe sample with different methods.

**Evaluation methods (ecological, grassland management, nature conservation) for grassland — Qualification and yield estimation methods of grasslands.** The examination of yield, quality and species composition of grazing grasslands started in the Alps (Stebler and Schroter, 1892). Domestic experts started to classify agriculturally useful grassland associations and to use evaluations and estimations (Balazs, 1943, 1949) after the start of plant-sociological surveys in Hungary (Dorner, 1923; Bittera, 1935; Tolvaly, 1944; Gruber, 1962).

In order to determine the number of animal unit a grassland can support in a given interval and to measure its usefulness regarding animal production first we must declare its feeding value. It is determined by the quality and quantity of the yield. It is important because there is a lineal correspondence between the productivity of the grassland and the quality of the forage (Voisin, 1968). The improvement of these factors increases the agricultural value. The territorial performance of a grassland depends upon its utilization of the horizontal and vertical space, the production zone. The utilization of the surface can be described by the amount of cover (Grant, 1981).

There are several methods for determining the feeding value of species and grasslands. One of the crop estimate methods is based on grass cover and grass height, along with species composition. This method was designed in Germany by Klapp et al. (1953), and with some corrections it is still in use (Briemle, 1997; Briemle and Ellenberg, 1994; Briemle et al., 2002). In Hungary the methods of Balazs (1943, 1949, 1960) were used, which are based on the same principles. It is more difficult to determine the green yield of pastures than of meadows, because grazing animals feed on sprouting grass as well. Therefore, the quality and quantity control of the grazed yield is a difficult task.

The cutting probe is based on the true yield of the grassland (Antal and Huzsvai, 20th07). A few m2 are cut or reaped and the clipping is measured while it is green. We can judge the yield of the pasture by the yield of the measured sample unit. We can judge the quality of grassland by the classification of the species in the sample unit. This method gives an immediate and direct estimation of the yield of grassland. But its disadvantages (different height of cutting, great handwork demand, tool demand, few samples, imprecise sampling due to bending grasses etc.) make it difficult to use (Nagy and Peto, 2001). An updated method is the parcel harvester method which executes cutting and measuring at the same time (Der, 1995).

Klapp's method. In order to determine the feeding value of the species of a grassland Klapp and his colleagues (Klapp et al., 1953) designed the 10-point scale. The most valuable species got 8, the valueless ones or those grazed by animals got 0, while the poisonous species got 1. The aspects of species categorization are as follows:

- protein and mineral content based on chemical analyses,
- savouriness of forage and preference of livestock,
- rate of valuable plant parts (leaf, stalk, flower, fruit),
- period of full value as forage,
- usefulness and harvesting characteristics of species,
- harmful and poisonous characteristics,
- permissible rate in the crop (e.g.. in case of poisonous plants).

If the rate of poisonous and valueless species is high in the crop, than the total value of crop decreases. In order to calculate it Klapp and his colleagues (Klapp et al., 1953) considered the following:

1. Feeding value of poisonous plants up to a 3% cover -1; between 3-10% -2; over 10% -3.

2. We decrease the value number of the hay polluting dicotyledonous species by 1-2 points over a 10 % cover.

3. A different evaluating method applies for the grasses and weeds highly worsening the value of forage.

Balazs's method. Using this method the proper selection of the location of the quadrates is essential. The typical plant associations should be present with more quadrates when we determine the location of the estimation and the number of sampling areas.

Production estimation was made with the following formula, based on Balazs's method (1949):

$$P= ((M-s)*B*b)/100$$

P: prodcution [Kg/ha]

M: grass height [cm]

s: height of cutting [cm]

B: 400 [kg/ha/cm] mass coefficient with 100% total cover

b: cover % [%]

Using the average grass height and the total cover (April-September) we estimated the yearly yield and its distribution in time, and basing on that estimated the livestock-supporting capacity of grasslands. We calculated with 60 kg/day green mass and a 210-day-long grazing season in case of cattle, with 7 kg/day green mass and a 210-day-long grazing season in case of sheep and with 80 kg/day green mass and a 180-day-long grazing season in case of horses.

We can calculate the forage quality of grassland by dividing the sum of the yield of useful species with the total yield of grassland and multiply it by 100.

$$K=(T+/T) *100$$

K: forage quality [ %]

T+: sum of the yield of useful species

T: total yield of grassland

If the result is between 75%-100% the forage is I class, excellent quality;

between 50%-75% — the forage is II class, good quality;

between 50%-25% — the forage is III class, medium quality;

between 0%-25% — the forage is IV class, poor quality.

*Vinczeffy's method.* The examined grasslands are classified by the scale characterised by the 3-figure qualifying number. This method does not count on soil and climatic effects. The constituent species are divided into first-, second-, third-, fourth and fifth-class species. The serial number of species of each quality groups is constant. Serial number 1-19 indicate the first quality group, 21-39 indicate the second quality group, 41-69 indicate the third group quality, 61-79 indicate the fourth group quality, and over 80 indicates the fifth quality group. The number of the dominant species is the second figure of the qualifying number. If the total cover of species of the fifth group remains under 10%, it is not indicated in the qualifying number. But the first figure of the qualifying number decreases by 1 if the total cover is between 10-25%, and by 2 if it is between 25-50. For example, the qualifying number of poa pratensis and its grasslands is 9. It is the first class grassland, so the first 2 figures of the qualifying number are 1 and 9. If the cover of the fifth-class species is between 10-25%, the qualifying number will be 2, 9 and if it is between 25-50%, it will be 3, 9.

The third figure of the qualifying number indicates the yield. The yield based rating of Vinczeffy's (1963) method is the following:

Meadows:
1: 70q/ha or more hay,
2: 52-70 q/ha hay,
3: 35-52 q/ha hay,
4: 17-35 q/ha hay,
5: 17 q/ha or less hay.

Pasture:
1: 155 q/ha or more green grass,
2: 120-155 q/ha green mass,
3: 85-120 q/ha green mass,
4: 50-85 q/ha green mass,
5: 50 q/ha or less green mass.

Continuing the former example, if the cover of the fifth-class species is 8%, the yield is 97 q/ha green grass, the qualifying number of the pasture is: 1,9,3. If we define the yield of the grassland as hay, the green grass value is divided by 3, or the yield is recorded in hay value number. The biological value of the first class pasture and meadow is practically equal. The smaller yield of the pasture is compensated by its savouriness and better digestability. The first and third figures of the qualifying number determines the "grassland value", whose yield can be expressed in hay value.

*Nagy' s agricultural value.* According to Nagy (2003, 2004) the agricultural value (AV) of grasslands can be determined by agronomical characteristics. The following formula is used to calculate the agricultural value of a given species:

$$\text{AV species} = \text{Cover species} \times \text{Productivity species} \times \text{Quality of yield species}$$

The agricultural value of a grassland with arbitrary number of species is calculated by the sum of agricultural species of each species. The following formula is in use:

$$AV = 1/100 \times \sum_{i=1}^{n} Bi \times TKi \times TMi,$$

where B: cover %
TK: productivity factor of species
TM: forage quality factor of species.

There is the 5-point scale for both factors. Productivity is determined subjectively. The categories are the following:
1: poor, very low;
2: low, under average, moderate;
3: average, medium;
4: good, above average, highly productive;
5: excellent, very highly productive.

The scale for forage quality is the following:
1: valueless, livestock dose not eat it;
2: poor, livestock eats it only if necessary;

3: medium, livestock does not want to eat it beyond a certain maturity level;

4: good, livestock gladly eats it;

5: excellent, livestock mainly chooses it.

Using the above mentioned numbers in the formula we can calculate the maximum agricultural value, which is 25. The calculated value can be categorized into 5 quality groups:

| | | |
|---|---|---|
| 0,0 - 5,0 | valueless, low-grade | V. |
| 5,1 - 10,0 | minimal value, poor | IV. |
| 10,1 - 15,0 | average, medium | III. |
| 15,1 - 20,0 | good, above average | II. |
| 20,1 - 25,0 | very good, excellent | I. |

**Determination of grassland yield.** Vinczeffy's method (1959) is not suitable for quantity measurement of grassland yields, but the estimated or measured data used in other methods can be indicated on the 1-5 scale (third number).

Nagy's method (2003) is also inappropriate for the precise estimation of actual yield of a grassland because it does not count with the actual grass height. The 1-5 value number and the cover of species indicate the potential yield of species. But the actual yield can be estimated only roughly.

Klapp's method is one of the most accepted one in European practice. Its improvements (e.g., Briemele, 2002) are also widely used. Its disadvantage is that it uses only 2 spatial dimensions and therefore we cannot determine the quantity of yield.

Besides the value of cover Balazs (1960) also uses the value of grass height. The first step of this method is the calculation of the relative green mass of the species (t) which expresses the quantity of yield of each species in relative value. It is the product of the cover of species ($D_B$) and average height (m).

$$t = DB \times m$$

1 m measures up to 1 cm height. We measure the average height of the leafy shoots and exclude the out hanging grasses.

The quadtrates/relative green mass of species (T) is the sum of the relative green mass of all species (t) ($T = \Sigma t$).

The average grass height (M) is calculated by dividing the sum of yield of the species of the grassland by the total cover of the grassland expressed in $D_B$:

$$M = T / \Sigma D_B$$

M: average grass height [cm],

T: total yield of the grassland which is the sum of yield of the species,

$\Sigma D_B$: total cover of grassland [$D_B$].

With the B numbers the relative yields and the average grass height can be converted into absolute quantities. The $B_M$ number expresses the green mass of the 1cm cut of grassland with 100% cover referred to a hectare. Therefore the $D_B$ value of the samples must be converted into b% when using the B numbers (1DB = 3,125% ).

Balazs (1951) proposes the use of the following values:

$B_M$: grass: 0,400 t ha-1

clover: 0,470 t ha-1

The calculation of yield: the average height of grass (M) is multiplied by $B_M$, and it is multiplied by the real cover (DB).

Since grass yield cannot be fully utilized, the height of cutting (s) must be subtracted from the average height. If we want to convert it into hay-value, than the calculated result must be divided by the drying factor (E) whose value is 2.5-3.5 depending on the climate, species and state of maturity. With optimal exploitation this value is 2.5 in case of dry grasslands and 3 in case of mesophile grasslands.

We can calculate grass yield with the following formula:

$$P=[(M-s)\times BM\times b]/100\times E$$

P: grass yield [kg/ha]

M: grass height [cm]

s: height of cutting [cm]

BM: mass of 1 cm high grass cut with 100% total cover; value number: 0,4 [t/ha]

b: territorial value number [DB]

E: draying factor

We can precisely determine the productivity of grassland if we sum the yield of all production period. To compare the yield of several grasslands, the data of the first increment is appropriate.

**Determination of the quality of yield.** Vinczeffy' (1959) method is based only on the dominant grass species. It is indicated by the secound number. However the author does not provide an alternative for codominance. This method cannot be widespreadly used for it uses only a few numbers. With this method we cannot precisely determine the quantity of the yield because it uses only one scale for the yield of grassland. It focuses on the weeds and harmful species from grassland management aspects. Besides the dominant species only this group is indicated in the indictor number. We must know the numbers belonging to species and also the numbers of categories, which makes the use of this method difficult.

Nagy's method assigns a quantity and quality number to each species. The numbers vary between 1-5. This value is multiplied by the cover of species and finally products are summed. Therefore the forage value of grass with 100% cover is 25 if calculated with quality number 5 and quantity number 5. As a disadvantage of this method the used numbers refer only to grass species and to the most frequent pulses and the precise quantity of the yield cannot be determined.

Klapp's method uses the 1-8 scale based on several aspects. This value is multiplied by the cover of species, and the result is multiplied by the total cover in order to get the forage value of grassland.

It is difficult to determine the forage value of grass yield because it depends on several subjective values, such as accustoming etc. The main objective factors of Balazs's method (1960) are the following: maturity of plant (age), feeding value, fiber- and silica content, digestibility, stinging characteristics, roughness, odour, taste, acid- and poisonous material content etc. The purely chemical examination is not satisfactory for determining the forage value, for livestock do not feed on morphologically disadvantageous plants nonetheless their excellent nutrient contents. The categorization must be made regarding useful and harmful species as well. The latter species must be highlighted, because most methods like Klapp et al. (1953) and Briemle et al. (2002) do not use quality categories for them, although their harmful effects differ from each other.

In Balazs's method (1960) morphology is more important, than in that of Klapp et al. (1953). In his method harmful species are categorized by the -1 - -3 scale. Pulses are of the best quality. They are considered as forage quality, therefore they are ranked into a special category. These are the high-class plants (+6 and +7), e.g., Medicago sativa, Trifolium repens. All the species eaten by livestock without any harmful effects are categorized by the +1-+5 scale. The value number in between neutral species is 0.

*Table 1.* **Shows the comparative data gained by 4 methods.**

| | Dry | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | semi-natural | | | | | | degraded | | | | | |
| number of species | 12 | 11 | 13 | 12 | 13 | 9 | 8 | 7 | 10 | 9 | 8 | 7 |
| total cover | 63 | 64 | 52 | 58 | 58 | 66 | 51 | 56 | 43 | 44 | 58 | 54 |
| Vinczeffy | 7,4 | 7,5 | 7,5 | 7,4 | 7,5 | 7,4 | 1,27,5 | 1,27,5 | 27,5 | 27,5 | 27,5 | 27,5 |
| Nagy | 6,17 | 5,26 | 4,82 | 4,28 | 4,9 | 5,37 | 2,39 | 2,13 | 1,98 | 2,38 | 3,34 | 3,6 |
| Klapp | 1,83 | 1,38 | 1,10 | 1,14 | 1,25 | 1,47 | 0,50 | 0,31 | 0,36 | 0,47 | 0,88 | 0,91 |
| average height | 24,57 | 22,21 | 24,32 | 24,48 | 22,53 | 23,18 | 17,35 | 16,51 | 15,30 | 14,52 | 14,15 | 15,55 |
| Balazs term. | 5,43 | 4,92 | 4,43 | 4,98 | 4,53 | 5,32 | 2,92 | 3,02 | 2,11 | 2,02 | 2,58 | 2,71 |
| Balazs min | 3,45 | 3,49 | 3,53 | 2,84 | 3,34 | 3,57 | 0,14 | -0,79 | 0,17 | 1,04 | 1,80 | 2,10 |
| hay yield | 1,81 | 1,64 | 1,47 | 1,66 | 1,510 | 1,77 | 0,97 | 1,00 | 0,70 | 0,67 | 0,86 | 0,90 |

Without the necesary codes the values obtained by Vinczeffy's method can be hardly interpreted and their information content is low.

With Nagy' s method (2002) we get a 1-25 number, which includes the quantity and quality of yield, but it is suitable for only a rough estimation, although in our example it properly indicated the differences originating from species composition.

The method of Klapp et al. (1953) provides us a better estimation regarding the quality of grassland. The difference of quality between 2 crops is also well indicated. Although we cannot know the quantity of yield.

Balazs's method (1960) provided the greatest differences between the quality of 2 crops. Besides we could calculate the quantity of the yield with this method (t/ha), and we could determine the amount of hay yield.

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