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THE INFLUENCE OF NATURAL AND ECONOMIC FACTORS ON THE QUALITY OF GAME HABITATS

UTJECAJ PRIRODNIH I GOSPODARKIH ČIMBENIKA NA KAKVOĆU STANIŠTA DIVLJAČI

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Determining economic potentials of hunting activities is a very important operation in the realistic planning of game management. Since game management and game are affected by a variety of natural and economic factors, it is necessary to analyse them and determine their conditions in the field. Methods used in data collecting are costly and time-consuming, and the final results are dependent on their quality. It is advisable to use two data collecting methods: a) sample plots, and b) linear area estimation, depending on the size of the area under study. Data can generally be divided into three broad groups: food, water, and peace in the hunting ground. The collected data are processed, and realistic conditions for game management in an area are calculated mathematically. The graphic models based on several samples are intended to give the final results on the habitat quality for individual game species.

Key words: hunting area, game, natural factors, economic factors, hunting-economic potentials, evaluating site quality, hunting ground cadaster

INTRODUCTION
UVOD

Determining economic potentials of hunting activities has for many years been in the focus of interest of scientists, experts and hunting professionals. To establish realistic game management and hunting potentials is a very complex procedure, because game and their habitats are influenced by many factors.

Game husbandry is not influenced only by natural factors. In recent times, it has been man with his activities who has played a crucial role in exerting both direct and indirect influences on game habitats and game itself. In discussing the economic potentials of hunting activities in an area, two groups of factors determining the future of game management should be borne in mind. These are: *natural factors / economic factors.*

Natural factors are all those concerning habitat elements, natural phenomena, and natural features such as the relief, climate, vegetation and animal world (flora and fauna), and relationships between and within species.

Economic factors comprise influences resulting from man's activities. These activities can have a positive or a negative effect on wildlife and on game management. Each effect is either directly or indirectly reflected on game management.

Nature undergoes permanent dynamic processes which cause changes in habitats. As these are often initiated and accelerated by man, it is necessary to keep constant watch on and to analyse the existing state of natural factors and the degree of anthropogenic influences.

The level of hunting potentials and the possibility of their utilisation depend on natural and economic factors: therefore, it is of primary importance to determine the factual state in the field and to evaluate it properly.

Despite numerous methods which have been used or are being used to determine the economic hunting potentials of an area, very little space and time have been allocated to gathering field data, the starting point for all further calculations.

THE AIM OF THE RESEARCH
CILJ RADA

The problem of finding the best solutions or models for game planning has not yet been satisfactorily solved either in the world or in Croatia. Difficulties arising from each attempt to address the questions of optimal game management are caused by a large number of interacting, complementing or excluding factors which influence both habitats and game. With the added problems of the conflicting wishes and interests of those wanting to obtain goals other than game management in a hunting ground, the matter is made even more complex.

Highly diverse geographical features in Croatia are responsible for very specific game management methods. It is difficult, and often undesirable, to make general rules about which management operations to use in all regions. In Croatia, luckily, a larger area is usually composed of smaller tracts covered with varied vegetation which provide diverse food and shelter. Human settlements are usually surrounded with farmland forming a specific, heterogeneous vegetative belt. Each vegetation, whether natural or artificially grown, represents a different food source.

The condition of a site and its potentials for game management and for breeding certain game species are obtained from the careful study of details, and measurements and analyses of the factors acting integrally on game.

In order to rank all the different factors influencing game management in different-sized areas called hunting grounds, it is necessary to measure as many elements as possible. After each individual factor is measured, comparisons are made, that is, the empiric equation is drawn, and the suitability of breeding individual game species is established. The aim of this research is to draw a measuring scale for individual site factors, to observe their influence on the game, and in this way to provide a model for evaluating the economic potentials of a hunting site.

Since forestry and hunting share a number of elements, one of the most important being that both activities overlap in space, game management planning should follow the principles of forestry planning, which takes into account a large number of measurable elements.

Today, planning in game management in the Republic of Croatia is based on two data sources:

1. A cadaster of a hunting ground obtained from a competent cadastral-surveying office, outlining the boundaries of a hunting ground and a total surface area under different cultures.
2. Data on the number of game obtained from a game count.

However, these data, and specially the one concerning the size, cannot give us an accurate picture of an area. We cannot see whether the area is evenly covered with one kind of vegetation, or whether it consists of smaller units under different vegetation.

By comparing the method of drawing up a basis for forestry management with one for game management, we see that the former relies on data which are directly measured and established in the field, such as:

* compartments and sections
* surface area of each unit
* number of trees per surface unit
* basal area
* tree heights
* wood mass (with experimental plots or with total dbh measurements)
* increment
* site quality

The basis of game management was drawn up virtually without any field measurements and collected data, so that, theoretically speaking, it was drawn up without knowing the terrain and the situation in hunting grounds.

Apart from the fact that a basis for game management both small and large hunting areas, there is also a need to draw up a global game management plan for larger areas located within the present administrative district boundaries.

The reason for this lies in the vegetation composition, relief, climate, and distribution of different kinds of game. All these factors call for large areas to be divided into smaller ones, while on the other hand, it is necessary to standardise game management within a habitat range of a certain species.

Different guidelines and management goals in several smaller adjacent hunting grounds with practically identical game populations have frequently had negative impacts on these populations. The result has been the decline of trophy structure, a inbalance in sex and age structure, and a decrease in parent stock. Examples of this are large game such as deer, wild boar and bear.

Game management depends primarily on natural conditions (site), but also on a variety of economic factors. Therefore, it is difficult to find a simple solution or a universal formula for such a complex problem. The goal of this research is to find a method for establishing, measuring and recording elements in the field (in a hunting ground) which will serve as a basis for a quantitative and qualitative comparison, and for evaluating the suitability of of a hunting area for breeding certain game species. Determining a method of collecting data from a site and recording a degree of economic influence may provide a new approach to planning in hunting and to game management practices.

RESEARCH SO FAR
DOSADAŠNJA ISTRAŽIVANJA

Hunting is one of man's oldest activities. A pre-historic caveman is believed to have fed mostly on plants (180,000 - 150,000 years B.C.). Later, when his mental faculties advanced sufficiently to make tools, he started hunting animals around him both for food and for their fur, which he used as clothes, cover and bed. The period of the primeval hunter goes back to the distant past, to some 140,000 - 100,000 years before Christ.

Later on, when man started cultivating land, hunting gradually lost its original importance, but continued to be a valuable source of food.

Ancient Greeks and Romans put high value on hunting and hunting skills. With the beginning of the new age, that is, with the abolition of serfdom, hunting slowly took on the elements of economic activity (Čeović, 1953).

In the feudal system, lords allowed local people a limited use of timber from their forests, but hunting remained their exclusive prerogative. Forests were managed in such as way as to accommodate the needs of game and hunting. Feudal lords went so far as to establish new forests, and cut rides and ditches in order to increase their pleasure and success in hunting. The first drawn maps were intended to facilitate orientation in forests and to serve as a basis for hunting arrangements. The first maps made for the purpose of hunting date back to 1716 in France (Panić, 1965).

The turn of the 20th century saw a more significant development of game management in Europe, and an almost simultaneous one in Croatia, since it was a constituent part of European culture. The paper "Viestnik" (News) - published by the First General Croatian Hunting and Fishing Society" first appeared in 1892. It was the third of its kind in Europe. The first hunting manual in the Croatian language was published as early as 1896 (Kesterčanek, 1896). Hunting and game management were gaining importance, and hunting associations were founded, regulations written, and game numbers and bags recorded.

The results brought about by this enthusiasm for hunting and game management were being published, and the economic importance of hunting and its contribution to the overall economic development highlighted (Marinović, 1930).

Game management activities were particularly successful in promoting elite hunting tourism, because it was noticed that a tourist - as a hunter spent on average about 10 times more per day than an ordinary foreign tourist (Car, 1964, Žukina, 1965).

The possibility of game farming in accordance with natural conditions was examined, as well as the negative impacts on game by numerous factors stemming from technical and technological progress (Car, Rohr, 1967).

Many scientists dealing with environmental issues are very concerned about the changes in the ecosystems, of which some have turned into full-scale ecological disasters. Needless to say, some changes have had highly negative effects on the fauna, and on the animal species of special interest to us, game (Seattle 1854, Turina 1991, Gec 1991, Matas et al. 1992, Getz 1995, Springer, Prpić 1994, Komlenović 1995).

Another present-day problem with a very negative effect on animals is the modern road network crisscrossing almost all ecosystems, and disrupting normal communication and contacts among animals.

There are numerous studies on the problem of game passage and contacts between two or more isolated parts of an ecosystem (Georgii 1985, Wittkamp 1985, Wolfel 1995, Kovačić 1993).

Undoubtedly, problems occurring in the forest - game relationship have been the subject of study by a number of renowned scientists. In the middle of this century, some of the most eminent Croatian experts gave their contribution to solving the issue of priorities in the management of areas of common interest to forestry, hunting, and even agriculture (Čeović 1950, Car 1961, 1964).

Despite this, debates on the place and number of game in a unit area continued. Almost in parallel, there were very conflicting claims: one urging a reduction in the number of large game (Hanzi, 1964), and the other claiming that the numbers of all game should be considerably increased (Dragišić, 1965).

Recently, there have been numerous studies on the influence of game on stand regeneration (Viličić 1992, Liović 1993). These studies and debates are permanently concerned with the problem of site quality and the capacity of a site to support individual game species.

Research concerning the products of agriculture which can be used as food for game was carried out by experts in this field (Maceljski 1985, Šoštarić - Pisačić 1968, 1974, Wurttenberg 1956/60, Štafa 1993, 1994). Their findings were used to determine the quality of individual products in feeding or raising game.

The quantity and quality of the green mass in forest associations, and their potential as food for the game living there were also studied (Katreniak 1992, Medvedović 1994).

A key element in assessing the quality of a site for individual game comes with the insights into site conditions, and the suitability of some elements to support certain game species. In order to carry out the task, it is essential to know the biology and ecology of the species in question, that is, its demands on the habitat.

In practice, the potential of a site is usually expressed as a combination of two elements: *sitequality* and the *capacity* of a hunting area. These two terms have been in use since the 1960s.

Capacity is defined as the number of game per productive hunting ground unit of a certain class, although there are discordant opinions as to the actual number of animals per surface unit (Andrašić 1982, Ueckermann, 1956).

The term *site quality* is far more controversial.

One group of experts believes that site quality relates to a certain type of hunting ground. In this way, an association of sites with the same life conditions is formed (Petrov 1963, Danilov *et al.* 1966).

Another group bases the method of evaluating site quality on evaluating life conditions for individual game species in a defined area (Ueckermann 1960, Car 1961).

Apart from these two widely applied methods which determine the site quality analytically, that is, by evaluating certain conditions, there are other, so-called synthetic methods, in which site quality is assessed indirectly (Malinovski 1964, Krasni 1963, Rykovski 1964, Jović 1968, Jurgenson 1963).

One of the most frequently used methods of evaluating site quality is based on measuring the body weight of game (mostly roedeer and deer), and to relate this with several previously selected site factors. In this way certain site quality categories were obtained (Ueckermann 1956, 1957, 1960). The method was later expanded and updated.

This method provided the foundations for developing site evaluation in Croatian hunting grounds (Srdić *et al.* 1955, Car 1961, Novaković 1987). It has been complemented and adapted to suit present-day needs.

Very detailed guidelines on planning in game management and evaluating site conditions were presented in a hunting manual published in 1967, in which the chapter "Management of a hunting ground" was written by the then eminent game management experts Dr Zvonko Car and Dr Otto Rohr.

The quality of site for small game was assessed by adhering to the same principle for all game species included in the group. The method involved grading the most important factors in a hunting area from 1 to 5, depending on the quality of individual factors in relation to the demands of the game species in question (Car and Rohr 1967).

Site quality for large game was determined following a different principle. Site quality was established for each individual game species, and a point scale was made for each individual factor in the hunting area. In the case of large game, there are only five basic factors: food and water, vegetation, soil quality, peace in the hunting area, and the general suitability of the area.

There have been attempts to develop and apply other methods of determining site classes and planning in game management. One of the research tasks undertaken by the experts at the Forestry Institute in Jastrebarsko involves the application of the results of research on the forest types in game management (Bezak *et al*, 1988).

The latest directions and guidelines used in drawing up the basis of game management have been made by the Ministry of Agriculture and Forestry. They are based on the choice of the best working methods, which have been tested in practice and have proved to be the most efficient.

STUDY AREA
PODRUČJE ISTRAŽIVANJA

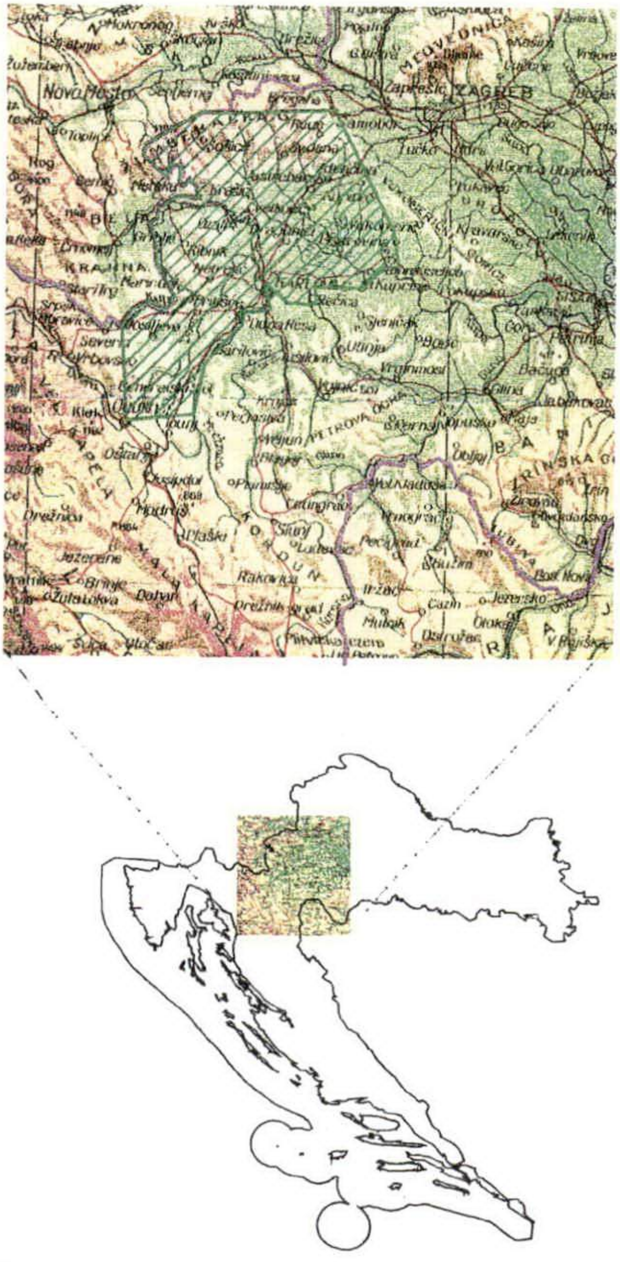
The area where the research was conducted belongs to north-west Croatia (Map 1). The selected area is managed by the Forest Office of Karlovac. The field data were collected from the autumn of 1994 to the spring of 1995.

The observed area is a link between lowland (the Pannonian Plain) and montane Croatia. The town of Karlovac is situated on the edge of lowland Croatia. The northernmost part of the area is taken by Žumberačka gora, stretching between the valley of the river Kupa on the Croatian side and the valley of the river Krka on the Slovenian side. The Žumberačka gora follows the south-west - north-east direction to a length of 40 km. The relief of the mountain abounds in ditches, valleys and conspicuous tops. The dominant tops are Sveta Gera, 1181 m Pleš, 981 m, Ječmenište, 979 m, and Japetić, 871 m above sea level.

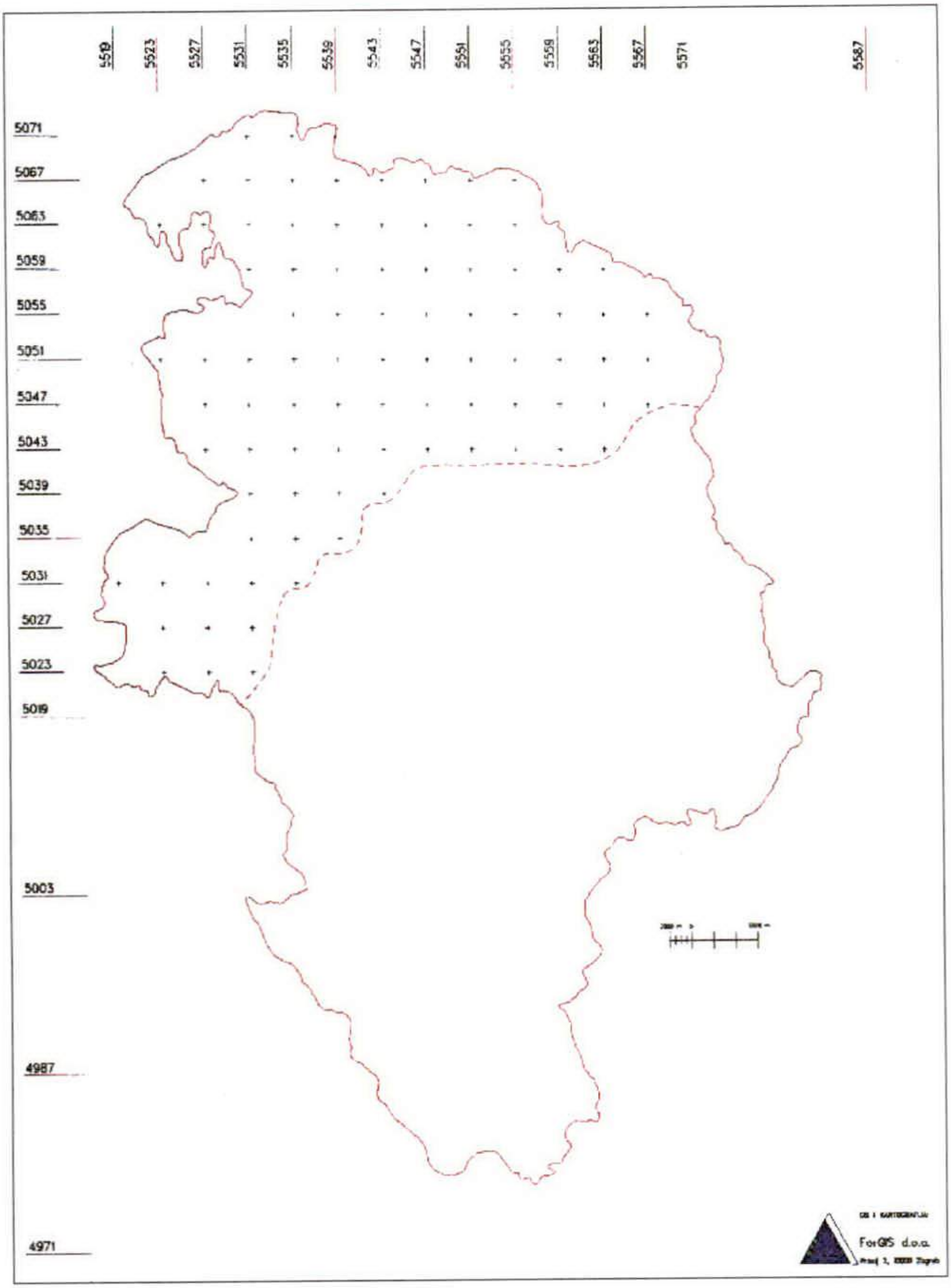
West of the river Kupa which borders the Žumberačko gorje there is a characteristic region of potholes and less well-defined tops. This is a typical karst terrain on a limestone base.

The Pokupsko basin is a specific region, being the westernmost part of the Pannonian Plain, the former Pannonian Sea. The acti onof the river Kupa and its tributaries running down the slopes of Žumberačko gorje and Plješivica has formed a specific geological, pedological and vegetation oasis.

Map 1. Geographical position of the studied area
Karta 1. Zemljopisni položaj istraživanog područja



Map 2.: Area managed by forest office of Karlovac
Karta 2.: Prikaz područja U. Š. Karlovac



The soils developed in the observed area are conditioned primarily by the parent base, climate, relief and anthropogenic influences. A combined action over longer or shorter periods has influenced the formation of the following pedosystematic units, or soils types in the area:

1. Limestone-dolomite humus (Calcomelanosol)
2. Rendzina
3. Brown soil on limestone and dolomites (Calcocambisol)
4. Dystric brown or acid brown soil (Dystric Cambisol)
5. Luvisol or illimerized soil (Luvisol)
6. Colluvial (Diluvial) soils (Colluvium)
7. Pseudogley
8. Swampy-gley soil (Eugley)

The most important hydrographic feature of the observed area is the river Kupa, whose larger part borders the area and a smaller one intersects it. Other important rivers are the Dobra, the Mrežnica (proclaimed the Nature Park), the Dobra tributary of the Globornica, and the Kupčina. The whole observed area also abounds in permanent or temporary water sources of different sizes, and in numerous streams with clean drinking water.

The data from the meteorological stations in Karlovac (112 m) and Jastrebarsko (138 m) present the climatic picture of the area.

Monthly air temperatures were taken in the station over a ten-year period between 1983 and 1992. The recorded data per month and their mean values for the observed period are given.

Table 1. Climatic data for meteorological station Karlovac for the period 1983-1992
Tablica 1. Klimatski podaci za meteorološku stanicu Karlovac za razdoblje 1983 - 1992

Month - *Mjesec*	Ts	SM	Sm	AM	Am	O	V
I	0.3	4.0	-2.8	18.1	-24.6	64.1	88
II	1.6	6.3	-2.3	22.6	-20.6	68.5	84
III	6.8	11.2	2.0	27.2	-10.9	74.4	78
IV	11.6	17.3	6.2	29.0	-3.7	70.7	75
V	16.2	22.0	10.5	32.1	0.5	85.1	76
VI	18.9	24.8	13.3	33.9	4.6	105.0	76
VII	21.9	28.2	15.8	37.0	6.5	79.3	75
VIII	21.2	27.8	15.4	37.0	7.1	78.6	77
IX	17.0	23.6	11.5	34.8	3.7	87.2	81
X	11.1	16.7	6.8	29.6	-3.3	101.5	85
XI	4.9	8.7	1.7	21.6	-14.2	98.9	88
XII	1.4	4.7	-1.2	23.4	-13.5	51.6	88
Anually - *Godišnje*	11.1	16.4	6.4	37	-24.6	964.7	81

Table 2. Climatic data for meteorological station Jastrebarsko for the period 1983-1992
Tablica 2. Klimatski podaci za meteorološku stanicu Jastrebarsko za razdoblje 1983-1992

Month - *Mjesec*	Ts	SM	Sm	AM	Am	O	V
I	-0.4	3.5	-3.9	17.2	-25.5	60.3	92
II	0.6	5.6	-3.5	21.0	-24.0	61.7	87
III	5.7	11.5	0.9	26.0	-13.0	68.2	79
IV	105.0	16.5	5.1	27.0	-4.5	59.1	75
V	15.1	21.0	9.5	30.0	0.0	76.5	76
VI	17.8	23.6	12.3	32.5	3.5	109.7	78
VII	20.5	27.0	14.6	35.5	5.5	74.5	77
VIII	19.9	26.9	14.2	35.5	6.0	82.5	77
IX	15.6	22.7	10.2	33.5	1.8	87.1	82
X	10.2	16.0	5.8	28.0	-4.0	86.3	86
XI	4.2	8.3	0.8	20.0	-14.5	86.8	90
XII	0.8	4.3	-2.1	22.5	-15.4	47.5	91
Anually- *Godišnje*	10	15.6	5.3	35.5	-25.5	900.3	82

Tm (Ts) - mean monthly and annual air temperature
MMax (SM) - mean monthly and annual maximal air temperature
MMin (Sm) - mean monthly and annual minimal air temperature
AM - absolute maximal air temperature over the observed period
Am - absolute minimal air temperature over the observed period
P (O) - average monthly and annual precipitation
H (V) - average monthly and annual relative humidity

The average precipitation and temperature values for the observed area, that is, for the meteorological stations, were used to compute the Lang rain factor (Rf = annual precipitation/mean annual temperature) and to determine the climatic region.

The Lang rain factor (Rf) is:
- Karlovac 86.9
- Jastrebarsko 90.0

According to Koppen's classification, the region belongs to the temperate rainy climate zone of the C type, or more precisely, of the "Cfwbx" type.

Both of these stations are located in the plain and thus record the features of the lowlands. Unfortunately, there are no meteorological data for higher areas; the only indicator of certain climatic changes and particularities is the composition of the vegetation.

Snow is a common winter occurrence in this region. As snow is an important climatic factor, especially as regards hunting and game management, it is necessary to record the date of its beginning and end, its duration on the soil, and its height.

On average, the first snow falls in Karlovac on 20 November, and the last on 18th March. The mean duration of snow cover is 119 days.

In Jastrebarsko, the average date of the first snowfall is 27 November, and of the last is 12 March, while the mean duration of snow cover is 106 days.

Maximal height of snow ranges between 58 and 65 cm.

On average, strong winds occur 1.3 - 3.8 days in a year, while hurricane winds appear in Jastrebarsko on average 0.4 days in a year, while in Karlovac they were not recorded.

Generally, the vegetation cover can be divided into the following groups:

- Forests
- Pastures
- Meadows
- Plouland and other arable land

Forests are spread throughout the studied area, and a forest type, or a plant association growing in individual parts, is determined by the climate, relief and soil type.

Pastures are a well-represented land and vegetation category, ranging from mountain pastures occurring on the topmost parts of the Žumberak and Plješivica mountain, bracken and heather in the hilly parts, to flooded pastures in the Pokupsko basin.

Meadows take up a considerable share of the total studied area, but they are mostly former ploughland turned into hay-producing grassland. Some of these hay meadows have gradually been turned into pastures, and even forests.

Different-sized ploughland are usually placed around inhabited places. The cultures can be classified as follows: maize is grown on as much as 70% of all arable land, and the rest is taken up by wheat, potatoes and other crops. Clover and other grass cultures are sown in smaller areas for the purpose of culture rotation, nitrogen soil enrichment, or respite for the soil.

ANIMAL WORLD
ŽIVOTINJSKI SVIJET

Of animal species (mammals and birds) classified as game under the Hunting Act, the studied area is permanently or temporarily inhabited by 13 kinds of hair-covered animals and 14 kinds of fowl.

The area abounds in a variety of protected mammals and birds not classified as game by law. Still, they are very important because they serve as indicators of ecosystem stability, and enhance the beauty of hunting areas.

SETTLEMENTS
NASELJA

The town of Karlovac is the largest urban centre of the studied area, and has also recently become the district seat.

The observed area covers most parts of the former communes of Duga Resa, Jastrebarsko, Karlovac and Ozalj. Under the new political-territorial administration, there are two towns (Karlovac and Duga Resa), and 11 communes (Bosiljevo, Draganići, Generalski Stol, Netretić, Ozalj, Žakanje, Jastrebarsko, Klinča Selo, Pisarovina, Sošice and Žumberak), of which 6 belong to Karlovac district and 5 to Zagreb district.

According to statistics (The 1993 Annual Statistics) for the 4 former communes, the 1991 census showed that there were 159,013 inhabitants in the total area of 210,800 ha.

ROADS AND RAILWAYS
PROMETNICE

On the whole, the observed area is relatively densely covered with roads and other transport networks. Karlovac, the largest town, is located at the crossroads of important roads and railways. Within the studied area there are 25 km of the Zagreb -Karlovac motorway, then the old Zagreb - Karlovac mein road, the roads Karlovac - Ozalj - Jurovski Brod, Karlovac - Netretić - Jurovski Brod, Karlovac -Rijeka, Karlovac - Senj, and a number of regional and local roads connecting small settlements. Apart from the roads, the area is also crossed by the main railway lines Zagreb - Karlovac - Rijeka, and Karlovac - Ozalj - Metlika.

We should also mention an ever-expanding network of lanes and tracks, which serve for the needs of agriculture and forestry.

From a vegetational and relief point of view, the area encompasses several important and interesting belts ranging from the lowland part of the Pokupsko basin 100 m above sea level to the tops of Plješivica and Žumberak, with the highest points of Japetić, 880 m, and Sveta Gera, 1178 m above sea level. All types of hunting grounds are included in the spectrum; the lowlands, hills, and mountains.

METHODS OF WORK
METODE RADA

WORKING PLAN
PLAN RADA

In order to conduct research on and study natural units, in our areas of study covering one or more hunting grounds, it was necessary to obtain concrete field data. This was done by recording conditions in the field.

One of the ideas on how to set up plots, which was later adopted, involved the use of a point grid (network). This kind of network is currently being used in the ongoing project "Decline of forests", started in 1986.

Every method has its advantages and disadvantages, so another variant was proposed. The aim was to obtain a linear picture of the terrain and determine the position and density of sample lines which would give the most realistic picture of the state in the field.

DATA COLLECTING METHODS
METODE PRIKUPLJANJA PODATAKA

Sample plots
Pokusne plohe

A method of collecting data in sample plots involves the use of coordinates set up for the observation of forest health. These are placed horizontally and vertically at a distance of 4 kilometres from each other. Each of the plots covers 16 km^2, or 1,600 ha.

The distance between the points makes the size of a sample plot rather too large for use in game management.

The smallest surface unit used in game management is the hunting unit (HU), which is 100 ha or 1 km^2. Therefore, the size of a sample plot should be identical to the size of a hunting unit.

The plots arranged in this way more or less cover the area of a district or a large hunting ground, and provide numerous concrete data, while at the same time they do not obstruct the work in terms of time, workforce, or finance.

This is where smaller-sized hunting grounds, which are in fact the most common in Croatia, are at a disadvantage.

As each 100 ha plot in fact represents an area of 1,600 ha, (that is, the experiment covers 6.25% of the total area), it means that our average hunting grounds of 3,000 to 4,000 ha would only be represented by 2 - 3 plots.

This is the reason that, at the initial planning stage, another working method based on a different concept was decided on. This method would yield sufficient data and give a realistic picture of smaller-sized areas.

The method in question was the method of so-called linear surface estimation.

Linear surface estimation
Linearna taksacijska površina

This method has been used successfully in practice. Between 1923 and 1929, the linear estimation method was used to make the national forest inventory of Sweden (Tomašegović 1961, 1972).

Planning and game management also makes use of the data obtained from aerial or satellite photographs. The ability to draw maps of nutrition potentials, and to determine habitats for individual species has been a subject of study especially in Western Europe and America (Ormsby and Lunetta 1987, Anon 1987, Kalafadi_ and Kušan 1993, Lampek and Kušan 1994). The same data can also be collected with any terrestrial measurement methods, but aerial photographs take less time, cover a larger area, and are less costly. In our work we limited ourselves to terrestrial measurements, because our aim was to establish models for evaluating site conditions.

PREPARATIONS FOR FIELD WORK
PRIPREMA ZA RAD NA TERENU

After deciding to set up a 1x1 km plot every 4 kilometres, a field form was drawn up for each plot listing all the most important factors used in game management.

The form took account of numerous site conditions vital for the game, and direct or indirect, harmful or useful anthropogenic influences, so that it included the following elements:

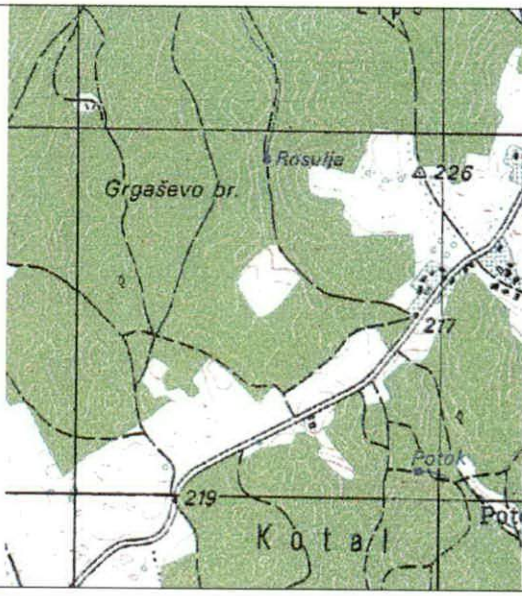
- administrative district
- place name (locality)
- plot coordinates x, y, z
- lowest and highest altitude
- exposure
- inclination
- vegetation composition (cadaster)
- settlement per category
- thoroughfares per category and length
- water per category
- chart giving a rough site estimate for individual game
- date of recording

The form was a component part of the map of the area.

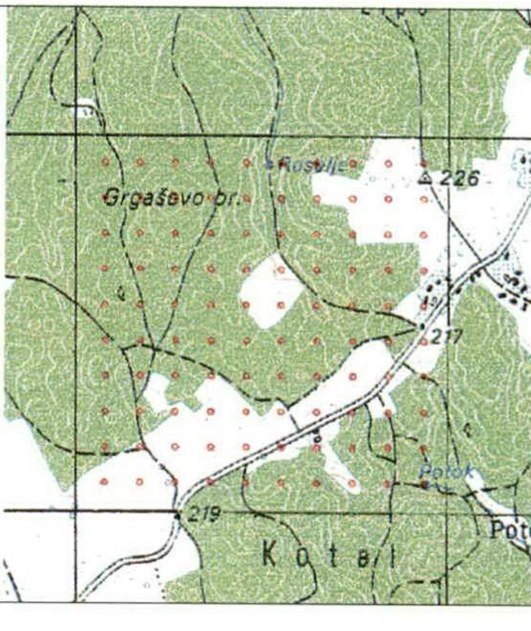
To begin with, the starting points and boundaries of a plot were marked on the map. Since the plot coordinates had been determined earlier, and the plots were 1x1 km in size, the best maps to be used in field work were those at a scale of 1 : 25,000, better known as "special maps". It was also agreed that the point with determined coordinates would represent the bottom left corner of the square, or the plot.

The preparations for the second method of collecting field data, that is, for linear estimation, were similar to the first one. For this method it was necessary to obtain large-scale maps with clearly marked plots so that a concrete situation in the field, that is, the situation at the moment of recording, could be determined more easily and accurately. Some of the collected data were written or drawn into the field maps. The maps were complemented with a form giving additional data. The following data were filled in on the form:

Map 3. A detail of a map with a sample plot
Karta 3. Detalj karte s primjernom plohom



Map 3a. Determining a share of cultures in sample plots using a dot grid
Karta 3a. Utvrđivanje zastupljenosti kultura zemljišta na primjernim plohama pomoću mreže točaka



- hunting ground
- area
- line of recording
- total length of recording line
- line altitude, its lowest and highest point
- inclination
- exposure
- thoroughfares per category
- settlements per category
- water per category
- land structure, size and distribution of plots

Just before starting with the actual field work, a recording plan was made. In other words, lines were drawn in to facilitate the recording and to present the actual state in the field. In order to make optimal recording lines, the lines were drawn in the following manner: after studying the appearance and the shape of the outer boundary of each hunting ground, the two furthest points were identified and joined with a line. In this way we obtained the longest line, a sort of diagonal line through the hunting ground. The next step was to place perpendicular lines on the horizontal one, and to join points two by two on the hunting ground boundary. The lines, set vertically on the horizontal axis, were parallel.

The density of the lines vertical to the horizontal one was defined by the homogeneity of the area under research, and the desired reliability of the collected data.

In our case, the perpendicular lines were set at one kilometre each, and the first one was placed 500 m from the starting point of the diagonal line. In order to get the sample intensity needed for the desired degree of reliability, additional perpendicular lines were later placed on the diagonal line every 500 m between the already existing lines.

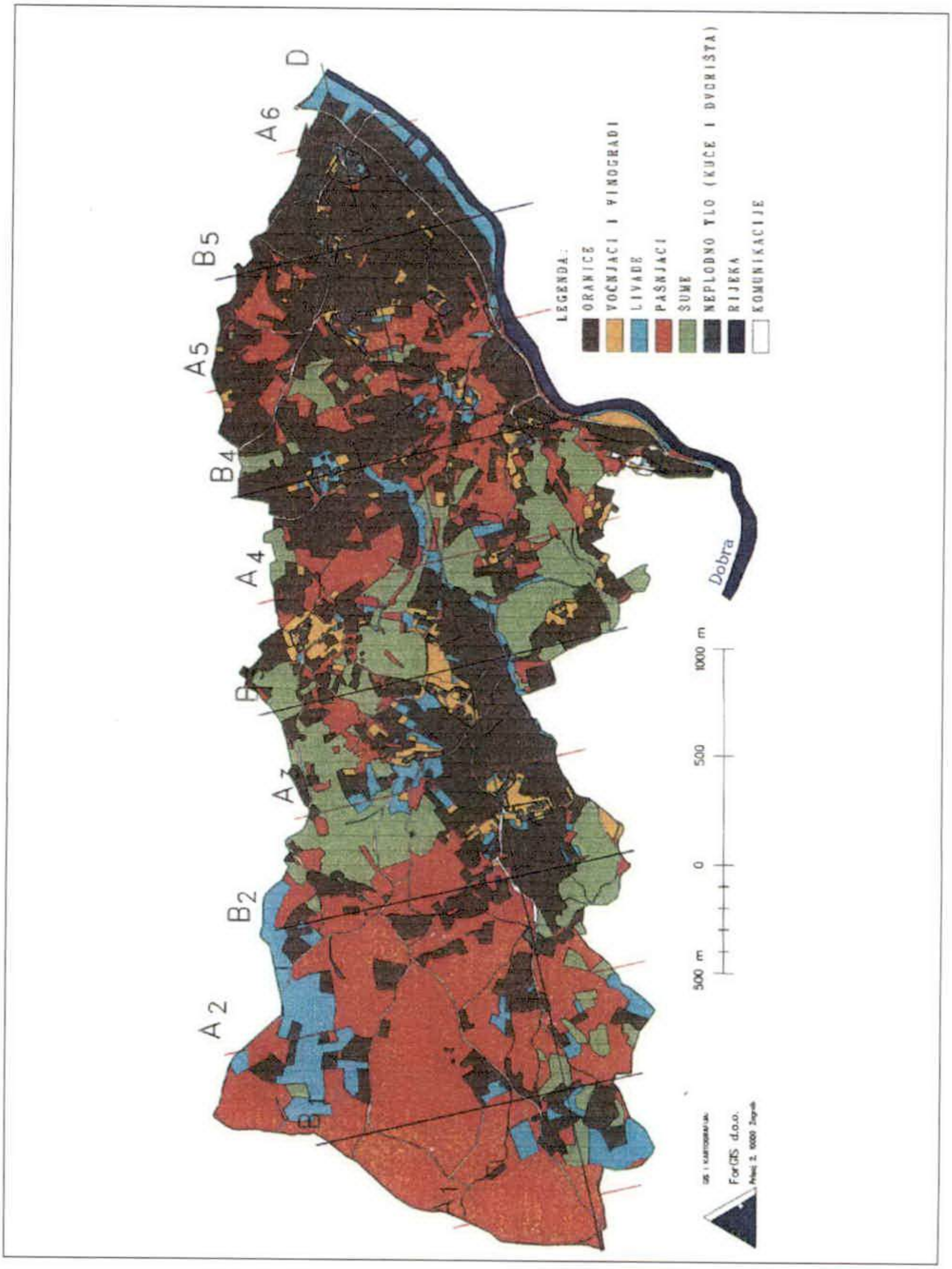
Apart from field maps and forms, other equipment needed for field work included a compass, a measuring tape, and a set of binoculars to facilitate the estimation of the soil and vegetation in adjacent areas.

RECORDINGS MADE IN SAMPLE PLOTS
TERENSKA SNIMANJA NA PRIMJERNIM PLOHAMA

After establishing the number of sample plots and marking their position on the working map, the sample plots were then inspected and their state recorded. The basic data for each plot were filled in on apropriate forms, which were later processed.

The coordinates of each point were marked on the map following the Gauss-Kruger system for easier computer processing and storing.

Map 4. The position of surveying lines in linear land measurement
Katra 4. Položaj linija snimanja kod linijske taksacije površina



It is easier to manipulate x and y coordinates in a computer data bank than place names. Apart from x and y coordinates, the altitude of the identifying point (the bottom left point in the plot under study) was also filled in.

This z-coordinate helps to place the plot and the area it represents into its appropriate altitudinal zone, which is of prime importance in game management.

The lowest and highest points (altitude) inside the plots were also recorded on the form. All these data are easily read from the 1:25,000 scale military-topographic maps which we used in our work. Altitudinal values obtained with instruments placed at certain elevations were tested and possibly corrected with direct field measurements. The elevations are given on the working map, and therefore it is advisable to use topographical maps.

The dominant exposure is established with a compass. The inclination is measured with a clinometer and is expressed in degrees. It is best to record data at the highest inclination. The average inclination can be arrived at by using the difference in altitudes within a plot.

Establishing the composition of vegetation in a plot and outlining the cadaster are the most difficult tasks, because the situation in an area should match the one in official cadastral records.

The following categories are recorded:

- ploughlend
- meadows
- pastures
- forests
- orchards and vineyards
- areas under water
- rocky ground
- unfarmed land (settlements, roads and others)

In the course of filling in the forms and using the 1:25,000 scale maps we came across a problem - how to determine with accuracy the share of each culture in a sample plot. The tast would have been easier if we had had a cadastral map with marked lots. However, that was not the case with our small-scale maps. Luckily, the size of each plot is 100 ha, so the composition of the vegetation or the percentage of individual cultures could be expressed in hectares or in relative (percentage) amounts. After the first plots were thoroughly inspected and the factual state recorded, a sketch was made of each culture and the share of individual cultures in the total plot area was estimated. This procedure yielded relatively good results, but they were not absolutely accurate.

As we have already pointed out in the planning section, as many elements should be measured as possible. The following solution was found: 4 x 4 cm squares were copied on a transparent plastic sheet (the number corresponded to that in a sample plot on a 1:25,000 scale map), within which 100 dots were evenly arranged (10x10). After the state in the field was recorded and marked on the field map, the corresponding square was covered with the dotted sheet, and the percentage or the hectares of each land category was accurately determined.

If there were fully or partially inhabited places in a studied plot, they were recorded by their size, but also by the influence they had on game management. The following code was used:

Category	Factor/Code
Town	1
Village	2
Hamlet	3
Individual houses	4
Uninhabited	5

When the data are processed, certain attributes can be assigned to each category reflecting its suitability for game management. As uninhabited areas are the most suitable, they are marked with value factor 5. On the other hand, towns and their populations have very negative impacts on the remaining natural sites, so their influence is marked with factor 1, which means that this area is excluded from game management.

Thoroughfares are placed into 5 categories, and their share per plot or per 1 km^2 is marked.

Areas under water are marked on the following 7-category basis: spring, stream, river, canal, fishpond, lake, and swamp.

As each of these categories plays a role in game management, it was deemed necessary to mark them individually, and even express them numerically. Since some plots contain several springs and streams, they are particularly valuable for the animal world and the game of the area.

Method of linear estimation
Metode linijske taksacije

A method giving a more detailed picture of a certain area in all its parts, that is, a method of continuous observation of the field and its details, involves observing and recording elements linearly along the very line of movement, but also recording essential details in a wider area along the observation line.

The composition of the vegetation, that is, the land cadaster, is recorded in the following manner: each lot, or a group of lots (depending on the homogeneity of the vegetation cover) is marked with its corresponding culture, that is, land category.

As in the previous method, the following land categories are marked:
- ploughlend
- meadows
- pastures

- forests
- vineyards and orchards
- areas under water
- rocky ground
- unfarmed (settlements, roads and others)

There are two ways in which corresponding cultures in a cadastral unit can be recorded: one is to write a shortened form or the first letter of a land category, and the other is to colour each category with a different colour. Field practice has shown that it is best to write in symbols of land categories, and later to colour them in the office, in the course of computer processing.

The share of each land category is not established during field work, but is arrived at later during the data processing stage. Originally, the plan was to measure the length of each individual lot, or the share of cultures in the field, but this proved impractical for two reasons.

The first is that tape measuring in the field requires at least two persons, with the additional job of recording land categories and their corresponding lengths, unlike marking on the map, which can be done by only one person. The second is that measuring in the field, and especially on sloping areas, requires making corrections due to inclination, which may lead to mistakes. In contrast, on a map all the lengths are already represented on a plane surface.

Additional data should be kept for each individual line in order to receive as many data as possible and have a more complete picture of the state in the field, especially if more than one person does the recordings.

The form for additional data in the linear estimation method includes the following data:

- hunting ground
- area
- recording line
- total length
- altitude
- inclination
- exposure
- thoroughfares
- settlements
- water
- land structure

DATA PROCESSING AND RESULTS
OBRADA PODATAKA I REZULTATI RADA

PROCESSING OF DATA COLLECTED IN SAMPLE PLOTS
OBRADA PODATAKA DOBIVENIH NA PRIMJERNIM PLOHAMA

The choice of a method of data processing depends on the desired goal. If the goal is to present the site and its potentials for game management in accordance with the economic base of the area, then the area is treated as a whole, but if the goal is to highlight individual parts of an area, then the corresponding plots are singled out and studied for the required data.

In order to obtain a clearer picture of a specific feature of some plot or hunting ground, a map of the study area was made using the GIS technology, and each plot was assigned a series of data which could later be displayed or recorded using any one of a number of computer graphics display and storage devices.

Altitude
Nadmorska visina

Values obtained in plots can be used to determine the lowest and highest points of the studied area, but the data will be more accurate if we support them with field maps. As the distance between plots is 4x4 km (and rarely less), sometimes a plot does not cover the extreme points in the field; however, other plots with these values will point to a place where the two extremes should be looked for. Using average altitudes, we can then classify the area into one of the altitudinal types (Map 5).

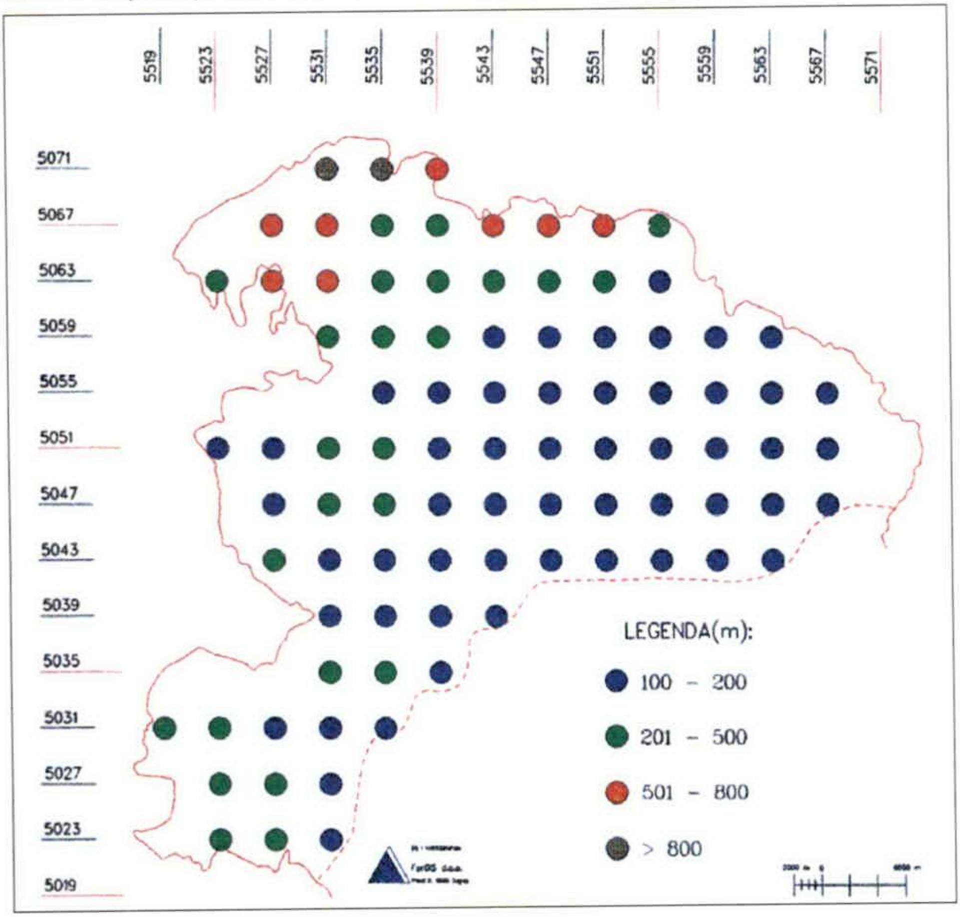
Both directly and indirectly, altitude is responsible for numerous details of importance for game and game management: climatic conditions, approximate vegetation composition, a possible natural distribution of certain animal species, and many others. It is important to establish altitudinal zones as this facilitates game management.

Exposure
Ekspozicija

A collection of data on plot exposures is used to calculate the dominant exposure, that is, the percentage of individual exposures. This type of data gives us indirect information on the possibilities of sheltering game in adverse meteorological conditions and seasons. In higher regions, this data may serve as an indicator of the floral composition in the overall site. The studied area consists of the following structure of plot exposures:

Exposure	Number of cases	Percentage
Flat	26	29.2%
Northern	12	13.5%
Eastern	8	9.0%
Southern	34.2	38.8%
Western	8.5	9.5%

Map 5. Distribution of sample plots at different altitudes
Karta 5. Raspored pokusnih ploha prema nadmorskim visinama



Inclination
Inklinacija

Terrain inclination is especially important in hilly and montane regions for reasons of passableness. Therefore, it is expressed separately for each plot.

We can calculate the mean inclination in the observed area, but it is far more important to highlight the extreme values and the frequency of very steep and craggy parts. The mean inclination of the observed area is 13.4 degrees. In the area of Žumberak and Plješivica, and in a narrow part of the Kupa canyon there are very few extremely steep and craggy points.

Land register /cadaster/
Katastar zemljišta

One of the chief aims of this work is to determine the real state of vegetation cover, that is, the distribution of different land cultures on the terrain itself. The situation recorded in sample plots should give an average land culture in the area.

It is clear that a single plot cannot represent a wider area, or provide a realistic average situation on the terrain. Since this method is intended to describe the conditions in a larger area, it is reasonable to expect that a larger number of plots will give a more realistic average state on the terrain.

Using data processing, we will abtain a mean percentage of each land category in the entire area, or in a smaller, limited area.

Average composition of land cultures in the studied area:

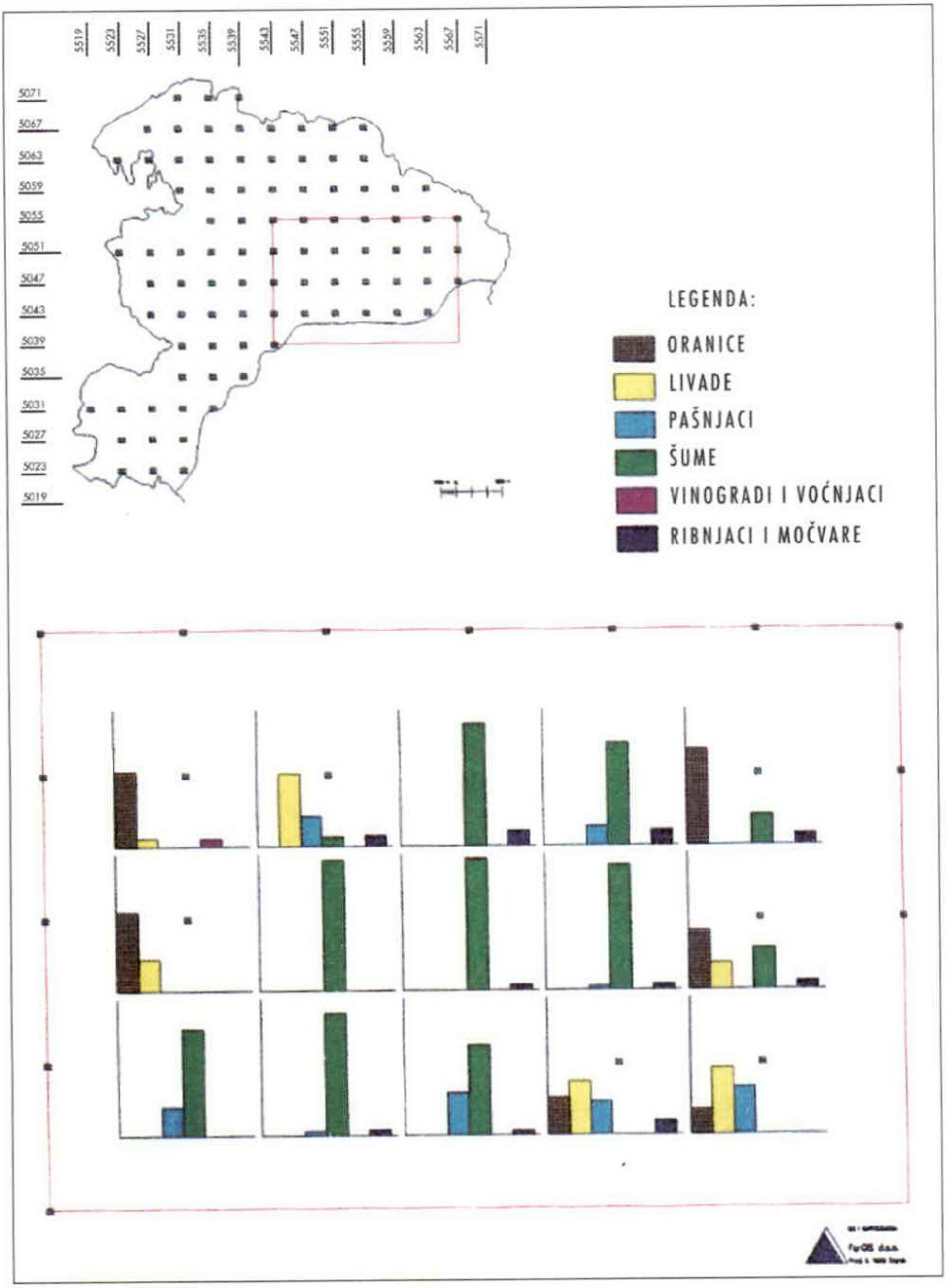
Land culture	Percentage
Ploughland	14.8%
Meadows	11.9%
Pastures	12.4%
Forests	47.5%
Orchards and vineyards	4.1%
Fishponds, canals and marshes	1.4%
Lakes, rivers and streams	0.5%
Rocky ground	0.1%
Others (settlements, roads ...)	7.3%
TOTAL	100.0%

By unifying some parts of the studied area on the basis of their vegetation composition, a foundation and a prerequisite for the formation of one or more hunting grounds was made.

A cadaster is a legally prescribed "identity card" of each hunting ground. It is a very important document because the entire task of planning in game management is based on it. A record of the real state of a land cadaster should be an integral part in making a basis for game manageme, because realistic planning can only be made with realistic data (Map 6).

Intensive cultivation of agricultural areas (ploughland, meadows, pastures) can significantly increase nutritional potentials for game, and thus indirectly influence the number of game and their physical, trophy and reproductive quality. This is why the economic aspect has a very important role in game management. In

Map 6. Soil structure in sample plots of the Pokupsko basin
Karta 6. Struktura zemljišta na pokusnim plohama pokupskog bazena



the studied area, pastures offer particularly good potentials for the improvement of game management improvement. At the moment, very small quantities of game food are produced in relatively short periods. By increasing the rate of cultivation and game food production by only 1 - 2 %, the number of game could be considerably increased, while at the same time other surrounding areas would not be threatened with game-incurred damage.

Settlements
Naselja

Any type of settlement within the area of the studied plot was registered. The settlements are categorised according to their size. The size also determines their influence on the environment and on the game, and game management.

The following categories were found in the observed area:

Type of settlement	Recorded in sample plots
Town	2
Village	19
Hamlet	25
Individual houses	8
Uninhabited	35

Settlement categories provide important information on peace in a certain area.

The distribution and size of settlements have a profound influence on the prospects of game management. Their display on the map gives an overall picture of the extend to which certain observed areas are "covered" with settlements.

Thoroughfares
Prometnice

Thoroughfares, or transport communications, are very important factors in game management owing to their numerous direct and indirect impacts on the game. They are often a limiting factor in the process of recording certain elements of game management, for example, game migration. Their most serious impact is reflected in the portion of game killed on the roads.

The processed data showed the following average structure of thoroughfares in the studied area:

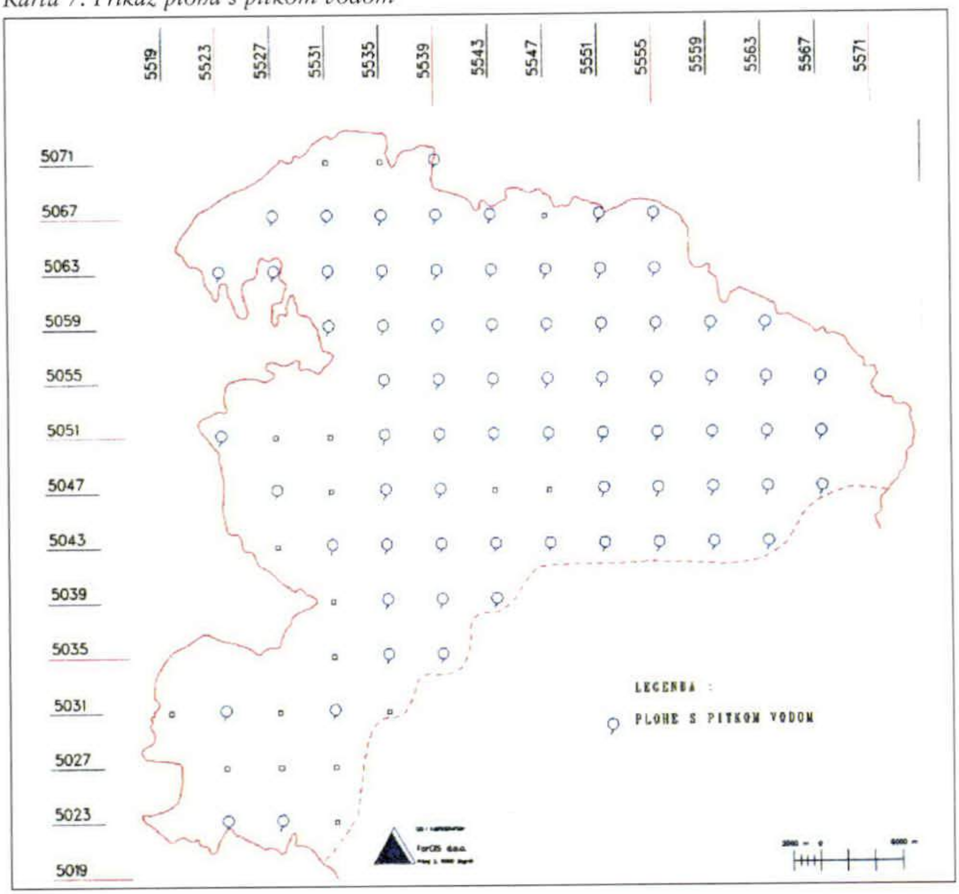
Thoroughfare category	Total factor	Degree in 100 ha
Motorway	5	0.056
Main roads	25	0.280
Regional local roads	126	1.415
Main forest and field roads	131	1.472
Side forest and field roads	227	2.550

Water
Vode

The distribution of water-covered areas and springs of accessible drinking water is a very important element in each hunting ground. Each accessible water source is a positive element. Apart from their numbers, another important factor is their spatial distribution. Evenly distributed water sources are much more important for the game than their number, or the quantity of drinking water in a small area. The distribution and number of drinking water sources are directly responsible for game staying in a certain area and their daily migration.

All water categories, except water springs and streams, (which are negligible) we01re recorded in the land register of an area during field observation activities.

Map 7. Plots with drinking water
Karta 7. Prikaz ploha s pitkom vodom



The following numbers and categories of water sources were recorded in the studied area:

Water category	Number per plots
Spring	1
Stream	140
River	11
Canal	25
Lake	1
Fishpond	1
Swamp	6

Evaluation of conditions for individual game species
Ocjena uvjeta za pojedinu divljač

Field work requires that all elements, both in studied plots and in their wider surroundings, should be taken into account. The state of the terrain, site conditions, traces of game, and all previous data on game management and game will provide a basis for determining which kinds of game actually live, or could possibly live, an the natural conditions of a given area. If conditions exist for a game species listed in the form, then realistic estimates should be made for each individual species, and their suitability graded (bad, good or very good). The concrete state will be obtained later, in the course of determining the site quality of a more narrow area for the purpose of drawing up a basis for game management. If the area provides conditions for any other more important game species apart from the 8 listed, the game should be added to the list and the conditions for their survival estimated. This refers primarily to the mouflon, chamois, capercaillie, mallard, and similar types.

PROCESSING DATA OBTAINED FROM LINEAR AREA ESTIMATION
OBRADA PODATAKA DOBIVENIH LINIJSKOM TAKSACIJOM POVRŠINA

After reading, recording and adding up the data per line, all the data are added, that is, all the lines representing one territorial unit or a hunting ground, are totalled.

After recording data from all the lines, they are totalled per cultures and in total. This provides a basis for estimating the absolute share of each individual culture. Finally, since the total surface area of the hunting ground is known, the absolute surface total of individual land cultures within the studied area is calculated using relative sums obtained from recording the states on lines.

To test the reliability of the proposed method of collecting field data, recordings in the field were done in three ways.

After the relative share of individual cultures in the observed area was established in three ways (diagonally, and with perpendiculars to the diagonal in two variants), the data were processed. First, each of the basic variants was studied separately, and then all the possible combinations of the three variants were made. In the end, we had 8 variants:

cadaster - data from official cadaster giving the real situation in a terrain
diagonal - data obtained from recording the state along the diagonal line
perpendicular A - data obtained from the lines vertical to the diagonal axis, at a distance of 1 km
perpendicular B - data obtained from the lines vertical to the diagonal between the lines in Variant A
DA - data obtained by adding diagonal and perpendicular A
DB - data obtained by adding diagonal and perpendicular B
AB - data obtained by adding perpendicular a and perpendicular B
DAB - data obtained by adding diagonal, perpendicular A and perpendicular B

Data from two KO (Maletić and Vinski vrh) were collected following the same principle. After they were processed, the percentage share of a land category was calculated for each variant.

The data were processed using the computer programme "Statistics", giving correlation values among all the variants.

Table 3. Percentages of land cultures obtained with different sample intensity
Tablica 3. Postotak zastupljenosti pojedinih kultura zemljišta dobivenih različitim intenzitetom uzoraka

Culture *Kultura*	Method *Metoda*							
	cadaster *katastar*	diagonal line *dijagonala*	vertical line A *okomica A*	vertical line B *okomica B*	*DA*	*DB*	*AB*	*DAB*
Plough-fields *oranice*	38.33	45.77	31.55	44.59	38.34	45.09	38.29	40.38
Vineyards and orchavds *vinogradi i voćnjaci*	3.07	2.07	1.52	2.84	1.79	2.51	2.20	2.17
Meadows *livade*	7.92	4.95	8.47	3.86	6.99	4.33	6.08	5.77
Pastures *pašnjaci*	33.06	24.23	39.72	33.15	33.22	29.33	36.33	32.95
Forests *šume*	13.31	13.88	15.77	10.96	15.11	12.21	13.29	13.45
Unfarmed *neplodno*	4.31	9.10	2.97	4.60	5.77	6.53	3.81	5.29

Table 4. Percentages of land cultures obtained with different sample intensity
Tablica 4. Postotak zastupljenosti pojedinih kultura zemljišta dobivenih različitim intenzitetom uzoraka

Culture *Kultura*	Method *Metoda*							
	cadaster *katastar*	diogonal line *dijagonala*	vertical line A *okomica A*	vertical line B *okomica B*	*DA*	*DB*	*AB*	*DAB*
Plough-fields *oranice*	32.95	24.06	36.55	36.79	32.97	33.07	36.67	34.55
Vineyards and orchavds *vinogradi i voćnjaci*	4.21	6.39	6.02	3.56	6.12	4.39	4.82	5.08
Meadows *livade*	7.08	3.99	11.47	3.67	9.35	3.76	7.67	7.05
Pastures *pašnjaci*	26.17	24.00	24.88	23.48	24.63	23.63	24.20	24.16
Forests *šume*	26.08	37.63	16.70	29.18	22.61	31.70	22.82	25.31
Unfarmed *neplodno*	3.51	3.93	4.38	3.23	4.26	3.51	3.82	3.84

Table 5. Correlation among methods in KO Maletić correlations significantly different from $p < 0.05$ are marked with*
*Tablica 5. Korelacija između metoda KO Maletić koleracije signigikantno različite od $p < 0.005$ su označene sa**

Metods *Metode*	Cadaster *Katastar*	Diagonal *Dijagonal*	Vert. A *Okom A*	Vert. B *Okom. B*	D_A	D_B	A_B	D_A_B
Cadaster *Katastar*	1.000 p = ---							
Diagonal *Dijagonal*	.9348* p = .006*	1.000 p = ---						
Vert. A *Okom A*	.9585* p=.003*	.8065 p=.053	1.000 p = ---					
Vert. B *Okom. B*	.9894* p=.000*	.9656* p=.002*	.9141* p=.011*	1.000 p = ---				
D_A	.9968* p=.000*	.9404* p=.005*	.9595* p=.002*	.9859* p=.000*	1.000 p = ---			
D_B	.9754* p=.001*	.9878* p=.011*	.8777* p=.022*	.9943* p=.000*	.9756* p=.001*	1.000 p = ---		
A_B	.9968* p=.000*	.9132* p=.011*	.9739* p=.001*	.9822* p=.000*	.9954* p=.000*	.9623* p=.002*	1.000 p = ---	
D_A_B	.9971* p=.000*	.9540* p=.003*	.9441* p=.005*	.9951* p=.000*	.9976* p=.000*	.9866* p=.000*	.9934* p=.000*	1.000 p = ---

Table 6. Corelation among methods in KO Vinski vrh Correlations significantly different from $p < 0.05$ are marked with*
*Tablica 6. Korelacija između metoda u KO Vinski vrh Korelacije, signifikantno različite od $p < 0.05$ su označene sa **

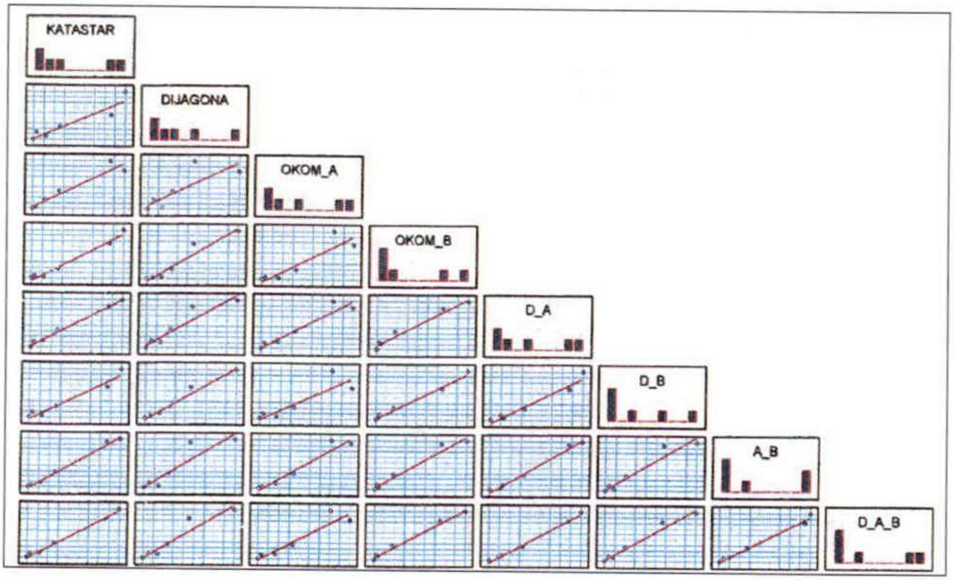
Metods *Metode*	Cadaster *Katastar*	Diagonal *Dijagonal*	Vert. A *Okom A*	Vert. B *Okom. B*	D_A	D_B	A_B	D_A_B
Cadaster *Katastar*	1.000 p = ---							
Diagonal *Dijagonal*	.8758* p = .022*	1.000 p = ---						
Vert. A *Okom A*	.9243* p=.008*	.6290 p=.181	1.000 p = ---					
Vert. B *Okom. B*	.9868* p=.000*	.8873* p=.018*	.8980* p=.015*	1.000 p = ---				
D_A	.9914* p=.000*	.8113* p=.050*	.9648* p=.002*	.9754* p=.001*	1.000 p = ---			
D_B	.9780* p=.001*	.9403* p=.005*	.8417* p=.036*	.9913* p=.000*	.9511* p=.004 *	1.000 p = ---		
A_B	.9833* p=.000*	.7887* p=.062*	.9698* p=.001*	.9782* p=.001*	.9961* p=.000 *	.9468* p=.004 *	1.000 p = ---	
D_A_B	.9954* p=.000*	.8522* p=.031*	.9392* p=.005*	.9931* p=.000*	.9945* p=.000 *	.9760* p=.001 *	.9938* p=.000 *	1.000 p = ---

The test showed that to obtain reliable results, one diagonal line per area is not sufficient. Two variants of setting perpendiculars to the diagonal, viewed separately, gave good results, but perpendiculars A in the KO Maletić displayed considerable aberrations in some cases.

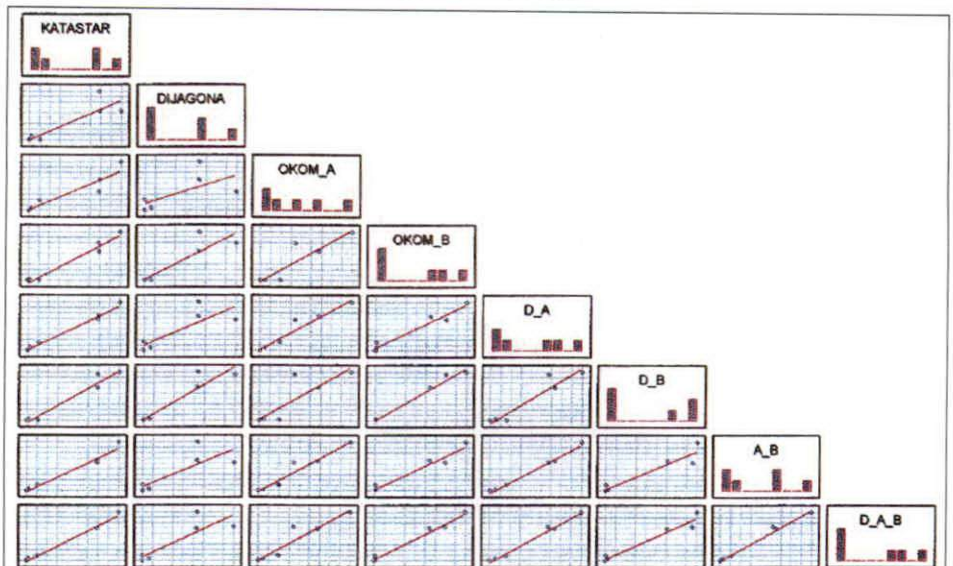
The choice of method is influenced by several factors: the size of the work to be done, costs, and data reliability. With all this in mind, we should always look for a compromise. In our case, the best results were achieved with the DAB variant, as was expected since this variant provides for the most intensive sample taking.

Variant DA (diagonal plus perpendiculars placed every kilometre) called for a much smaller intensity of sample taking, but still yielded a very high reliability coefficient. Compared to the actual state, the values obtained with this method were within 1%, which is acceptable by all statistical standards.

Graph 1. Corelation among methods in KO Maletić
Grafikon 1. Korelacija između metoda u KO Maletić



Graph 2. Corelation among methods in KO Vinski Vrh
Grafikon 2. Korelacija između metoda u KO Vinski Vrh



USING THE COLLECTED DATA MATHEMATICALLY
MATEMATIČKO KORIŠTENJE PRIKUPLJENIH PODATAKA

The evaluation of game management potentials cannot be made using only individual data. Therefore, a series of data was grouped into categories depending on its importance for, and impact on, the game. Cadastral data were placed among the factors concerned with site quality, since they are used in evaluating nutritional potentials, shelter, and overall site quality, and in deciding the suitability of the recorded vegetation elements for certain game species.

Peace is a very important factor in any hunting ground. In fact, some experts rank this factor above all others, and view it as a limiting element.

Peace in a hunting ground is basically determined by two elements - human settlements and thoroughfares. Types of settlements and their distribution have a direct and indirect impact on the game. The direct one is reflected in the fact that the area of and around a settlement directly reduces the living area of the existing game. On the other hand, man also directly influences game habitats, especially by disturbing the animals.

Man's indirect influence is seen through the activities which, among other things, reduce animals' living space, alter natural conditions, and force the game to compete for food and space with domestically-bred animals.

Thoroughfares are one of the most serious problems faced by game management today. Our way of life is unthinkable without a modern communication network; human settlements must be linked with local roads; and economic utilisation of agricultural and forest land is impossible without a good network of forest roads. All this has resulted in a significant decrease in productive areas and in the disturbance of game. Moreover, large numbers of game are run over by vehicles on modern roads, which constitutes one of the most important causes of game loss.

The following equation incorporates all the elements - factors in game management - which have a role in determining what game species to raise and in which number in a certain area.

A formula for calculating the site quality scale

$$Sq = Sc + Sw + Ss + St$$

Sq – site quality scale
Sc – points for a recorded land (culture) cadaster
Sw – points for accessibility of drinking water
Ss – points for the number and structure of settlements
St – points for a thoroughfare network

$$Ss + St = Sp$$

Sp – points determining peace in a hunting ground. They are arrived at by adding up points for settlements and points for thoroughfares. Settlements can bring a maximum of 70 points (for uninhabited areas). Any type of settlement reduces the peace factor, that is, the number of points for peace in a hunting ground. Depending on size, settlements have a constant value which serves as a ponder in estimating a settlement category and its influence on the game.

Calculating points on the basis of the land cadaster (culture):

$$Sc = 100 \frac{Sf}{St} + 30 \frac{Sp}{St} + 30 \frac{Sm}{St} + 40 \frac{Spl}{St}$$

St – total surface area of a hunting ground
Sf – forest surface area
Sp – pasture surface area
Sm – meadow surface area
Spf – plough land surface area

Calculating points for accessible drinking water

$$Sw = 10 \text{ ns} + 10 \text{ nw} - \frac{\text{sgn0 (ns nw - 5) + 1}}{2} \text{(ns + nw - 5) } 10$$

ns – number of drinking water springs in 1,000 ha
nw – number of waterflows with drinking water in 1,000 ha (streams, rivers, canals) function signum 0 is conditioned by:
sgn0(x) – 1, if x is more than 0; -1, if x is less or equal to 0

Calculating points on the basis of number and structure of settlements

$$Ss = 70 - (2 \text{ ni} + 4 \text{ nh} + 8 \text{ nv} + 16 \text{ nt})$$

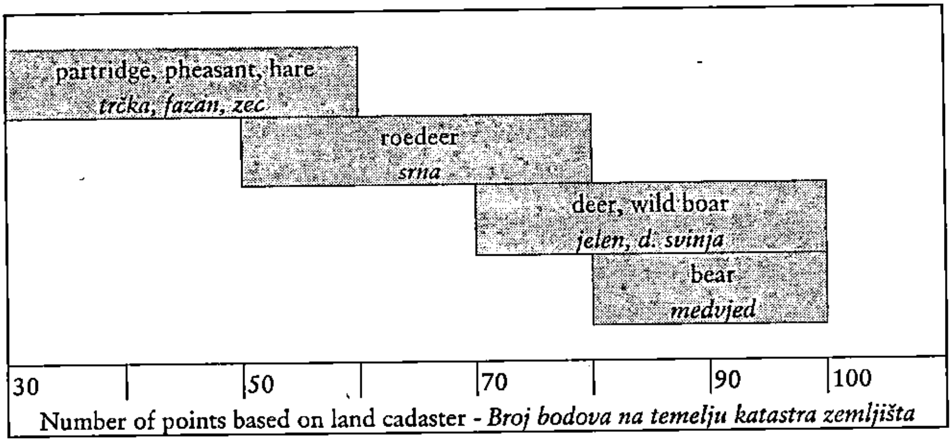
ni – number of individual houses in 1,000 ha
nh – number of hamlets in 1,000 ha
nv – number of villages in 1,000 ha
nt – number of towns in 1,000 ha

Calculating points on the basis of thoroughfare network

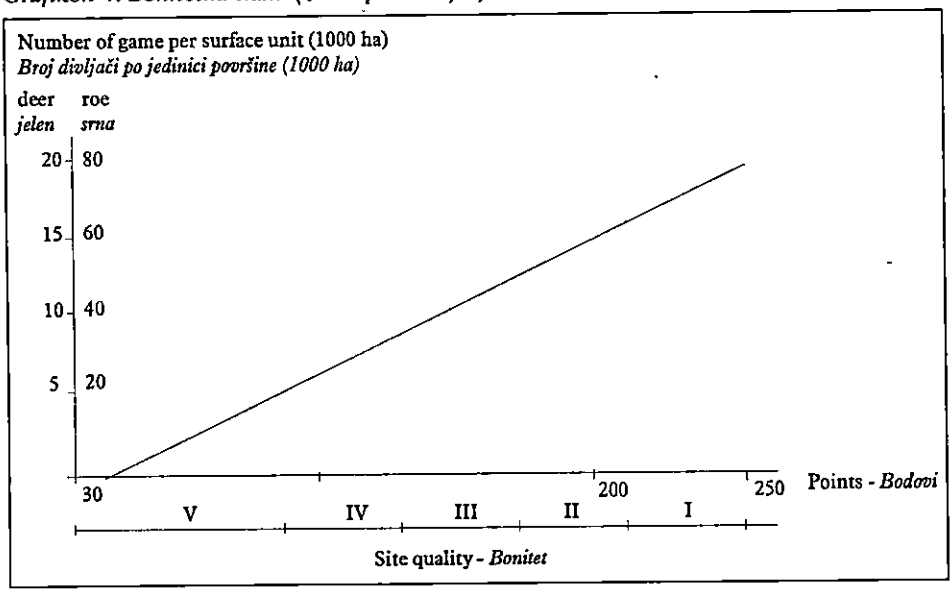
$$St = 30 \times \frac{(30 - 2 \text{ nf}) \text{ ex nf} + (24 - 2 \text{ nr}) \text{ ex nr} + (22 - 4 \text{ np}) \text{ ex np} + (25 - 5 \text{ nm}) \text{ ex nm}}{30 (\text{ex nf} + \text{ex nr} + \text{ex np} + \text{ex nm})}$$

nf – number (share) of main forest and field roads
nr – number (share) of regional roads
np – number (share) of principal roads
nm – number (share) of motorways
ex – existing

Graph 3. Optimal conditions for individual game species
Grafikon 3. Optimalni uvjeti za pojedinu vrstu divljači ovisno o katastru zemljišta



Graph 4. Site quality scale (For big game)
Grafikon 4. Bonitetna skala (za krupnu divljač)



DISCUSSION
RASPRAVA

This paper is primarily concerned with attempts to introduce as many measurable elements as possible into game management planning, and thus provide a basis for performing calculations for short or long-term game management.

Croatia has excellent potentials for game management. There are also good possibilities for developing hunting, increasing game numbers, and expanding the overall tourist offer and general economy with hunting tourism.

In order to meet the demands of both domestic and foreign tourist - hunters, the Croatian hunting grounds should offer a range of possibilities, in the first place their natural potentials, and an optimal number and structure of game. It is possible to increase the number of game with certain management practices, but economically speaking, the results may not bring the expected profit. The best solution is to apply the "wise use" principle to our natural potentials.

Our knowledge, experience and working methods used so far, combined with the detailed analysis of individual factors or groups of identical factors acting on the game management and game population growth, show that it is virtually impossible to single out one factor and its impact on game. The reason for this is that all factors are mutually involved in a cause-effect relationship and act integrally. It is well known that climate, soil, relief and vegetation are closely connected and interdependent. An expert in these relationships can accurately define the main features of all these factors by relying on the information on only one of them.

All the factors and elements, with their causes and consequences, create the need to keep a constant watch on the situation in the field, and to record any changes and reactions of the game.

The basic factors influencing game management and the stability of game populations are divided into natural and economic ones. Natural factors are those which have been here since time immemorial and which are a constituent part of the habitat. Economic ones are related to man's activities. In order to give a clearer picture of some factors and their influence on game management, all the important factors have been classified into three groups:

- Land cadaster (composition of land categories)
- Water (composition of areas under water and springs of accessible drinking water)
- Peace (population density and road and rail network as peace-affecting elements)

Each of these groups, and each individual element, is partially determined by nature, but unfortunately, also by man. Man's activity, especially in the 20th century, has had a profound effect on the landscape, climate, water regime, vegetation composition, and the natural pace of daily and seasonal game migrations.

Another important issue to be addressed is the question of living space, shelter and the reproduction area for animals. It goes without saying that the composition of a land category itself provides basic conditions for the support of a corresponding game species. On the other hand, game find its own living space, shelter and space for reproduction, provided the chosen areas offer peace.

The first problem we had to solve before starting our work was the choice of a method of recording the three mentioned groups of factors. Clearly, the best results are obtained by making rounds of the terrain, and by recording and mapping the whole area. However, the final goal would not justify the length of work involved and the costs. Therefore, we studied the working method based on representative samples in order to satisfy the set goal and at the same time avoid excessive cost.

Only a combination of balanced management measures and a normal number of game everywhere can guarantee successful game management in all hunting grounds. Game follows the laws of diffusion, and moves to less densely populated parts.

Our task was to determine elements of game management in a smaller area, such as a hunting ground, and a larger area, such as a district, region, or the area of the natural distribution of a game species. For this purpose it was necessary to work out the recording methods which would shit the area under observation.

The method involving 1x1 km sample plots arranged 4 km from each other was used in larger areas (larger hunting grounds, districts, areas of distribution for certain game species).

The second method, used in smaller areas (hunting grounds), was based on collecting data by means of linear area estimation. Data were recorded along the drawn line, but also in a wider "zone of responsibility".

The aim of both working methods was, first, to collect data on the concrete field conditions by means of samples, and second, to process the collected data in order to evaluate individual factors and their importance for certain game species, or for game management as a whole.

Both methods of data collecting with terrestrial measurements in the field can be done by one person only, which makes the job simpler and the costs lower.

The essential tools in field work for both methods are geographical maps of the areas under study. The most suitable are maps with a scale of 1:25,000. On these maps, each square kilometre is presented as one square, which makes it easy to define the selected plot and record the factual state.

Cadastral maps with a larger scale are more suitable for the method of linear land estimation. The cadastral lots contain signs for easier and better orientation, which allov for a more accurate estimation of land category compositions (land cadaster).

What is the advantage of the proposed method of determining natural and economic factors in game management?

It would be an illusion to expect that one pice of work will bring about revolutionary changes in game management and in methods of determining its potentials. However, even a relatively small contribution will eventually result in progress. An increase in the use of management potentials by only 1% would definitely justify the use of the new working methods in future management.

As has already been said, nature is constantly changing. In recent years, Croatia has also been going through dynamic processes.

The starting point for planning in game management so far has been the data on land categories, which were provided by a competent institution - a cadastral office, and the data on the number of game, which was obtained by a count. Both of these data are subject to errors; for example, some cadastral data may be 30 years old, and may not have taken account of the changes in the composition and structure of land categories. Establishing the number of game with a count may also be unreliable, as it depends on the time and method of counting. Errors occur mostly when counting big game; since they inhabit larger areas, the same animals can be counted several times over in different hunting grounds.

The next question is: although we had at our disposal a detailed analysis of the situation in the field, why did we classify all the factors and their categories into only three groups?

The answer is: game needs food, water and peace. All the elements recorded in the field are included in precisely these three categories.

Land structures, or land registers, were used to present basic elements for food, shelter and breeding space for a certain game species. Naturally, it is necessary to know the biology and ecology, as well as the way of life of each individual game. In the "water" section, there are 7 different water categories, so they can also be categorised according to how suitable they are for each game species.

Peace in a hunting ground, considered by many authors as the most important factor in game management, deals with two of the most significant groups of disturbers - human settlements and transport communications. The fewer settlements and roads there are, the more peace and security the animals enjoy. Predators, being a component part of the ecosystem, were not considered as sources of disturbance.

Notwithstanding the region in which a hunting ground is located, or the game living there now or possibly in the future, or the intensity of game management at present and in the future, it is necessary to carry out a detailed analysis of the habitat and establish its potentials. The collected data should be reliable, and should be stored in a database for the purpose of comparison with some future data, because each ecosystem is subjected to dynamic processes which have to be permanently monitored. Each major change sets off a series of chain reactions which eventually affect the game.

We have presented one of the proposals which involves collecting, processing and using data for a concrete goal today, and storing them for future comparison with some data collected at a later time.

The vast field of game management leaves room for additional research and detailed analyses of individual segments. Special attention should be paid to the economic moments intended to improve game management, increase food production for thè game, and advance the entire complex technology of game farming in natural conditions. Naturally, we should continue to take account of site capacity, inter and intra-species competition, and sociological behaviour of certain economic game species.

By using the new working method, several advantages can be achieved, some of the most important being: the analysis of site conditions, the database enabling calculations of realistic potentials in game management, to be made maps providing a visual analysis of available potentials, stored data to be used for comparison in subsequent analyses, and the possibility to monitor changes in an area.

CONCLUSIONS
ZAKLJUČCI

The basic aim of the work is to study and justify the new approach to recording, establishing and evaluating site elements which directly influence game and game management.

The following conclusions can be drawn:

1. Hunting and game management developed with increasing radidity at the turn of the century, while the directives and norms have been more strictly adhered to since the middle of this century.
2. Until now, the focus of attention was put on the study of site capacity, that is, game population density per surface unit, while the basic issue of the available space and its quality for game survival was addressed less frequently.
   Most research on game habitats involved forested areas, mainly for two reasons: a) forests are the home of most game species, and b), the problems concerning the forestgame relationship are most frequent there.
3. Apart from forested areas, game also makes partial or full use of agricultural land, which is a significant source of food, living space and shelter (especially for small game). It should also be adequately evaluated and used more specifically for game management.
4. The data used to describe the area and land categories in a hunting ground have so far been provided by a competent cadastral office. The real situation in the field has not actually been established, and the dynamic changes in habitats have not been adequately followed.
   On the whole, very few data have been used in drawing up a basis for game management. The data, such as the mentioned land registers and game counts, have been. In contrast, forest management uses ten measured elements as a base for future calculations and management regulations.

5. In this work we used two new methods of collecting data on the natural and economic factors influencing the quality of game habitats. The two proposed methods are - sample plots and linear land estimation.
   Both methods are intended to depict the state and structure of land categories, the distribution of drinking water springs, the arrangement and size of settlements, and the features and density of road and rail networks.
6. The research showed that the method of sample plots is more suitable for the analysis of larger areas (regions, districts), while the linear land estimation method is better adapted to smaller areas, such as hunting grounds.
7. By testing the collected field data, it was found that to establish the factual state in the field with a statistically allowed aberration ($p=0.01$), it sufficed to draw a diagonal line across the observed area (hunting ground), and perpendicular lines at a distance of 1 km from each other, and then to do the measurements of the concrete state.
8. The collected and processed data are visually presented in topographic maps, where, together with statistically processed and displayed results, they give a graphic picture of the state of each individual factor. Factors such as the land cadaster, drinking water springs, settlements and transport links are presented in such a way.
9. All the recorded data are built into a mathematical formula, which represents yet another way of obtaining the values which indicate the potentials for game management in a certain area (scale of site class, site capacity).
10. Using field data, a point scale is calculated mathematically giving an objective picture of the game management potentials of a site.
11. The new organisational hunting and game management scheme in Croatia, and the application of the new Hunting Act, require the drawing up of game management basis of an area. The aim is to standardize management guidelines in larger areas, or in several hunting grounds with similar site conditions. This is particularly important for big game, because their populations inhabit areas which go over the boundaries of the present hunting grounds. The method of sample plots and the mathematical models presented in this work are proposed for this task.
12. The research conducted so far has stressed the need to collect far more data directly in the field, and to use only factual and concrete data in calculations and planning of future game management. The present fast-changing ecosystems require constant observation and monitoring of individual factors in a hunting ground. Consequently, in the future, prior to drawing up a basis for game management, it is advisable to carry out field inventories, and to record all factors affecting the site and game at least every ten years.

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UTJECAJ PRIRODNIH I GOSPODARKIH ČIMBENIKA NA KAKVOĆU STANIŠTA DIVLJAČI

SAŽETAK

Lovstvo je kroz povijest pratilo razvoj čovjeka i ljudskoga roda te mu je u danim trenucima služilo u određene svrhe, od pračovjeka koji je lovom pribavljao hranu (meso), odjeću i prostirku za ležaj (kožu i krzno), preko srednjovjekovnoga lovca koji je lovom stjecao ratničke vještine, pa sve do današnjega lovca kojemu lov služi za sport i rekreaciju. Danas je pojedincima lov sport. Da bi se njihovim, sve brojnijim zahtjevima moglo udovoljiti, postalo je lovstvo ujedno gospodarska grana.

Od kraja 19. stoljeća, a posebno u ovom stoljeću, lovno se gospodarenje ubrzano razvijalo. Istražuju se i primjenjuju brojne metode uvrđivanja lovnogospodarskih mogućnosti staništa za život pojedinih vrsta divljači. Istraživanja su većinom tekla u smjeru utvrđivanja optimalnoga broja divljači po jedinici površine u određenim ekosustavima. Podaci o zastupljenosti pojedinih kultura na određenom zemljištu uzimani su uglavnom od službenoga katastra površina te su na osnovi njih rađeni daljnji proračuni.

U ovom je radu cilj bio istražiti metode prikupljanja terenskih podataka o čimbenicima koji utječu na lovno gospodarenje, te na osnovi konkretnih podataka izračunati kakvoću staništa za pojedine vrste divljači koje žive ili imaju uvjeta za život na promatranom prostoru. Za postizavanje zacrtanoga cilja predložene su dvije metode prikupljanja terenskih podataka o nizu čimbenika o kojima ovisi lovno gospodarenje.

Za veće površine predviđeno je postavljanje primjernih ploha na razmaku od 4 km. Svaka ploha obuhvaća 1 km^2, odnosno 100 ha. Na toj se plohi bilježi postotni odnos pojedinih kultura zemljišta, izvorišta dostupne pitke vode, broj i veličina naselja i mreža prometnica. Naselja i prometnice čimbenici su koji utječu na mir u lovištu.

Na manjim površinama, poput pojedinih lovišta, predviđa se linijska taksacija površina. Na planski postavljenim linijama, koje se postavljaju ovisno o obliku lovišta, u dijagonali i okomicama na dijagonalu, različite gustoće, na što utječe homogenost snimanoga prostora, utvrđuju se isti čimbenici kao i na primjernim plohama.

Područje istraživanja obuhvatilo je sjeverni i sjeverozapadni dio Uprave šuma Karlovac, te dvije katastarske općine koje se nalaze u sklopu cjelovitog istraživanog prostora i koje su uvjetno bile lovišta. Na većem prostoru podaci su prikupljani na primjernim plohama, dok je na manjim površinama, kao što su katastarske općine, istraživana primjenjivost i pouzdanost linijske taksacije površina.

Na osnovi prikupljenih podataka o čimbenicima koji su bitni za lovno gospodarenje, poput katastra površina, broja i strukture izvorišta pitke vode, broja i strukture naselja te zastupljenosti pojedinih kategorija prometnica uz pomoć

prikladnih formula, dobiju se određeni bodovi za svaki pojedini čimbenik. Zbrajanjem bodova svih čimbenika dobije se ukupan broj bodova, odnosno skala bonitetnih razreda, čiji je raspon od 30 do 250 bodova. Unutar te skale nalazimo pet bonitetnih razreda.

Podaci o katastru zemljišta, odnosno bodovi dobiveni na osnovi tih podataka uvrštenih u formulu mogu nam načelno dati poziciju na grafikonu iz kojega se vidi za koju bi vrstu divljači promatrani prostor najviše odgovarao, tj. koja bi divljač trebala biti glavna gospodarska vrsta u određenom lovištu.

Ključne riječi: lovište, divljač, prirodni čimbenici, gospodarski čimbenici, lovnogospodarski potencijali, bonitiranje lovišta, katastar lovišta