Signal Field Theory in Ecological Semiotics

Elina Vladimirova, John Mozgovoy
Department of Zoology
Samara State University
Academkika Pavlova St, Samara
Russia 443011
elvlad@newmail.ru

Abstract

The theory that we are about to illustrate furnishes an explanation of the animals" inter population and among species communication phenomena. We shall deal with small predator mammals that live naturally near the city of Samara (Russia, the Volga Region), such as the red fox, the pine marten, the ermine (short-tailed weasel) and the least weasel. Latin names are *Vulpes vulpes (L.), Martes martes (L.), Mustela erminea (L.)* and *Mustela nivalis (L.).* Studies of information transfer in populations make it possible to come to some conclusions about the mechanisms of sign processes for the above-mentioned animals. We have researched some integration processes in small predatory solitary living mammals.

We have been interested in the nature of animal communication based on information received by them through their habitat characteristics without any direct visual contacts with their kind. To formulate these theoretical statements we have conducted many field observations and applied some original author"s techniques.

There are a number of works devoted to animal sign interaction nowadays in biosemiotics, sociobiology, and ethology. This interaction in the situation of spontaneous contact may be represented by a dialogue or some directed information translation. Additionally, many animal species that lead solitary lives live and interact through their information environment. While directly contacting, animals transfer some significant information about their own state, their environment, they may establish a contact with their partners deliberately and expect their response. More often in nature we witness a situation when some information exchange among the individuals inhabiting the same or adjacent territories takes place without any communicative intention of the information sender. An animal in the course of its natural life activity changes its habitat. Later on an addressee who, in its turn, is changing the environment in some way and leaving his life activity information for the visitors to come "reads" this information. So the outer environment accumulates the information of animals" life activity and can

store the information for a long time; the information is perceived by other animals as their habitat characteristics and as some communicative knowledge. Our field research has demonstrated that the same species life activity signs, left in their common environment are more important for the animals than some abiotic information.

While working with the technique offered below, an animal sign interaction researcher is not dealing with the "objective habitat environment" but with a "signal information field". In the course of the movements of a recipient animal in its own or in group signal field, sign information is simultaneously being read and created for those individuals that are expected to come to the territory later. The signal field technique allows us to split up the continuous information flow into quanta in which signifiers correlate with signified meanings. Now it"s possible to take into consideration not only the subject but also the quantity of some sign information, to measure any sign behavior, which allows us to process observation results mathematically, to model automatic regulation processes, based on individuals" sign interaction. While using our signal field techniques you can formulate the real variability of the elements composing some information continuum. Moreover the formalization takes place, as far as it is possible, on the basis of environment perception by sign information natural users.

Jackob von Uexküll used the concept "Umwelt" to describe "the autonomous existence" of animals We support this idea, which refers to the ecological niche of information, as it appears to and is experienced by, that animal. We have attempted to carry out animal subjectivity investigation by means of calculations. The individual inner world subjectivity determines individual signal field characteristics. The signal fields possess parameters that can be measured. Signal field indices depend on both the habitat environment state and the given animal"s reference to some species. The informative processes will result in a population integration effect, and then in an ecological structure adjustment regulation.

The theory and the technique corresponding to it have been tested on ecological empirical material. We believe that practical significance of the signal field theory has passed beyond ecology limits. The theory makes it possible to take into consideration both the subjectivity and the quantity of sign information in semiotic systems, which are organized respectively according to the hierarchy principle.

1 THE MAMMALS BIOLOGICAL SIGNAL FIELD CONSTRUCTION PRINCIPLE AS AN ECOLOGICAL MODEL

The biological signal field is "a total sum of mammals influence on the environment, changing its structure" (Naumov 1977: 339). The authors of the corresponding technique denote the field as "a spatial temporal continuum which determines ecosystem functioning and which is simultaneously formed by this system in its activity process" (Mozgovoy & Rosenberg 1992: 8-9). The field function is to direct animals to the condition of the environment, as well as to the state of the ecological system population. A biological signal field represents the informative-communicative process of mammals" interaction

and the environment where they live, and the process is studied from the sign information recipient"s point of view. There are several signal fields: the signal field of individuals, that of populations, that of population groups (e.g. according to their age or sex), the field of co-adaptable close species complex and the bioceonosis signal field.

To develop the biological signal field theory, Mozgovoy has been, since 1961, collecting field material on the ecology and mammal behavior during the winter. The winter footprint tracking method is known in animal ecology as the "Formozov and Nasimovich technique", it makes it possible to study the material-energetic aspects of mammal"s life activity in winter periods (Nasimovitch 1955; Formozov 1959; Oshmarin, Pikunov 1990). However, the method fails to use a very important informational aspect of the ecosystem function. This drawback may be eliminated by unifying the animals" footprints tracking method on the fixation basis applied to elementary motion acts as a response to signal field object perception and inner stimuli, determining the dominant motivation. But it"s not enough to be able "to read" animal footprints, we also need to have an articulated task and some behavior structures choice. We need to develop a conceptual basis to study animal"s behavior in the wild. The mammals biological signal field theory may be such a basis (Mozgovoy & Rosenberg 1992: 30-31).

When we use such a method, the main difficulty is connected with some reinforcement of the objective approach to the investigation subject matter – mammalian activity in the environment as it is subjectively significant for them. We mustn"t allow animal outer world perception to be substituted by that of a zoologist who carries on the observation. The objective animal activity interpretation deals with two methodological problems: first, the calibration of the environment signals that cause animal reaction, i.e., with the determination of signal equivalence or non-equivalence for animals, motivated in a certain way, which could make it possible to carry out some measurements, and second, with permissible "quantum" or microscopic level reaction, taking place as a response to signal perception.

When collecting field material the researcher follows the animal footprint path and registers all the outer environment objects the animals orient themselves by and respond to by a movement. Using footprints on snow to define species, age, sex, motivation and functional state, requires, as well as the footprint path "freshness", an extensive experience of field observations. Animals possess certain species behaviour stereotypes; that is why an experienced researcher is able to define what kind of an outer environment signal and what sort of the animal"s behavior motivation guide the animal movement activity in

each specific case. Wild predator mammals are very "thrifty" – they respond by a movement or by some activity to the environmental signals that are most meaningful for them. Animal ecology knowledge is a necessary condition that makes an investigation in signal field technique possible. A researcher, who has limited field observation experience, is practically unable to solve the problem.

According to the signal field theory animal behavior may be divided into discrete movement responses, determined in the following ways. On the one hand, by an individual"s species affiliation, inborn receptor delivering abilities and the animal"s genetic memory, its specific characteristics (life experience, its nervous system type, as well as its sex and age affiliation), specific motivation and in the long run, on the whole, by its behavior at a certain moment context. On the other hand, by outer environment objects, perceived by the animal, including some signals which indicate the population state. For the collection and analysis, the researcher chooses "an elementary" movement response, i.e., a complete movement fact, indivisible further without any quality loss, which may be defined by footprints. A number of examples will be given later.

The animal movement action in the wild may seem unguided by any visible landmarks. In this case its footprint path, as a rule, is twisting. Often the footprints are guided by some environment objects or events: micro relief elements, shrubs, a grass bunch, ice-covered soil patches, other animal footprint paths, a snow burrow, feeding or "comfort" animal"s behavior signs, ski-tracks, birds" "roaming" and so on. The animal makes its way directly to this object. The moving activity disposition at each object that directs the animal"s movement may differ. Let"s take, for example, four responses of fox to rodent smell or noise under snow. They are: a stoppage or pricking up of their ears, stalking, jumping and catching. Each of these elementary movement responses includes some smaller motion elements, but they have noting to do with our aim, while the elementary movement responses are stereotyped enough for the animals of the given species in similar situations. Their movements may be confidently correlated to some outer environment events.

We leave out of our account a set of things signified without any definite conformity, such as snow trace prints. It is a drawback of our method. We compare the information interaction with the environment among individuals, their age and sex groups. Therefore we believe, that we can neglect those animal perception quanta which have not made a movement print.

It"s a rather complicated task to master animal snow footprint tracking for city or town dwellers who have no experience with winter realities. Science is sometimes understood to be a prerogative of those people who live in the city and who in their majority have a rather vague idea of animal life in the wild, especially, in winter. The polluting effects of cities, including sled usage in suburban zones makes our work more complicated when we use signal field technique. All the above-enumerated facts have resulted in scarce application of this most interesting animal ecology research method — signal field technique. Besides, it"s not an easy task for an ecologist, as a rule, to further master the semiotic analytic method. Nevertheless, our experience has proved that this task may be solved.

Species, sex, age and motivation of an animal may be identified by the corresponding techniques of nature research. Such identification is based on good research observation skills. When animal motivation, sex and age characteristics cannot be determined for certain, some extra observation may be used to provide additional facts for making a choice between alternative assumptions. Formozov"s footprint tracking method has become a part of winter animal ecology study zoological practice. The method is a sensitive one, and with some due care it furnishes accurate quantitative information data.

We may easily combine all elementary movement reactions into three groups, connected with the environment objects, their meaning and value for an animal:

1) Environment events and objects orientation (code);
2) Certain events and object types search or their avoidance (meaning);
3) Movement activity connected with objects; it may be expressed by the number of elementary movement responses or by the number of drives (value).

These steady and objectively discrete elementary behavior acts are suggested as the main parameters of the mammals" biological signal field. Movement elements, behavioral reactions of similar motivation and parameters of the signal field, which represents an animal signal-information environment, may have some numerical expression and can be calculated depending on the research tasks. We should say here, that the individual itself serves as "an instrument", or a device to define the field parameters, and at the same time, it is the individual itself whose signal-information outer connections are studied. We consider that it is possible to investigate not only individual but also population-species and biocoenosis levels of sign-information organization in animals and environment interaction.

There are two methods to organize the field material collected by the animal footprint tracking method:

1) Formalization of an individual as the object of interaction with the environment, with an emphasis on the environmental objects that caused the movement reaction;
2) Formalization of elementary movement acts and the environment objects, with an emphasis on the individual behavioral type motivation affiliation.

In the first case, an individual"s behavior is reduced to some elementary movement response, and the researcher"s main attention is focused on the environmental objects as physical bearers of signals which have caused these movement reactions, as well as on the quantitative assessment of these movement responses.

The field parameters are stated, according to this approach, not in the form of physical-chemical space-time states (not in the form of reality detached from an animal perceiving outer environment objects), but in the form of typical information space and the living system time. Signal field parameters characterize its structure, i.e., the inner form of field organization as a signal-information system. This structure is revealed on the basis of interrelations between environment objects - signal bearers- and animals that perceive those signals in the process of movement activity. In the second case elementary movement responses are grouped in classes according to a form of their behavior (orienting, search-investigating, comfortable, defensive and other types). We get data, which characterize animal behavior in response to signals in the process of their movement activity (Mozgovoy and Rosenberg 1992: 27-28).

Formalization of a space-time information continuum, making up the field, presupposes a composite consideration of five parameters: the magnitude, the anisotropy, the intensity of the signal field, the equivalent distance, and the signal object value. Signal field structure, its functioning and main dynamic laws may be defined by the following characteristics:

1) *Field magnitude* is the outer environment events and objects complex, revealed through their participation in the recipient"s activity, taking into consideration the recipient"s responses in the course of perceiving the environment. The exponent of the "subjective" meaningful environment part characterizes the outer environment perception value, as well as the degree of correspondence of the outer environment to the animal"s motivated expectations;
2) *Field anisotropy* is the parameter revealed by considering repeated movement responses to similar nature events and objects. The criterion that makes it possible to define different environment events and objects as signs that possess an identical meaning for the recipient, is the same behavioral motivation. This is a selectivity index of the interaction of animals and their habitat;
3) *Field intensity* is the parameter characterized by the intensity of the movement responses in the perception of an environmental object. A certain object status index for the recipient;

4) *Equivalent distance* is measured in meters; when covering this distance the target object makes 100 elementary movement responses (100 drives). This parameter makes it possible to take into account the contribution of an individual or a group of animals to changing their habitat, it also makes possible the quantitative expression of the "information expansion" of the target object. If we reduce the field parameters and the equivalent distance, we can get comparable quantitative field parameters for animals with different body sizes and different life process tempos;
5) *Signal object* value is the quantity of elementary movement reactions in response to any signal object perception.

All studied mammals signal field parameters depend on both internal and external environment factors. But under other equal conditions, the signal field magnitude characterizes, first of all, the enrichment degree of the environment in terms of objects and events that are interesting or new for the representatives of the given species. In other words, these parameters define the form of the received information. Signal field anisotropy, first of all, characterizes animal motivation, or the information significance. Anisotropy shows the most preferable objects and events of the natural subjective sign landscape. Signal field intensity, first of all, characterizes an individual"s reactive ability to the perceived environmental objects and events. In other words, we deal with the received information value. The equivalent distance is connected with an individual or group species reference. The equivalent distance also depends on calendar time perception rate as the measure of environment changes.

Biosemiotics interprets an organism and its environmental interrelations as a meaning of the lowest sign degree (Stepanov 1971: 28). The ability to perceive environmental objects depends directly on how often and how regularly an organism and a certain object interact. Signs, which are the most regular and meaningful for the life cycle support, develop in those interrelations,.

In reality both environmental objects and events differ, though in the human language, in the language of the interpreter of mammalian sign interactions, they may be called by one and the same word. How can we establish object and event equivalence when we define the signal field magnitude? When there is some difference between the objects, the problem of equivalence definition is solved through an organism and its environmental relations equivalence.

The common property we use to unite the meanings of different environment objects will be similar object and organism interaction, which may be defined by rather stereotyped behavior responses, characteristic of a certain animal species. The objects the per-

ception of which causes the same behavior response with the similar motivation will have the equivalent significance for animals. It"s important that parameters of magnitude, intensity and anisotropy of the signal field may be calculated in two different ways: 1) the field parameters are given in accordance with the footprint path duration, expressed in meters. Studying fox behavior, for example, it is normative to carry out the field parameter calculations for a thousand meters of a footprints path; 2) the second way of calculating the signal field parameters should be used to compare different animals species behavior or to calculate signal field parameters of a group. Here we should calculate the signal field magnitude and anisotropy per the equivalent route distance. The field intensity per an equivalent route is always equal to a hundred drives, but the equivalent route length, expressed in meters, proves to be different. The most convenient technique of the statistical calculation of the information field parameters is dispersion analysis.

Figures 1 and 2 illustrate the technique of the field material collection that takes into consideration signal field parameters. The red fox *(Vulpes vulpes)* footprints are shown in Figure 1. The footprints are left during its food-search activity. The animal is moving from the left to the right. Its footprints path was oriented by the following objects: 1) a ski-track; 2) a tree; 3) again a ski-track; 4) again a tree; 5) a ski-track; 6) an elk"s footprint; 7) an elk"s footprint on the ski-track; 8) a stub; 9) a bush; 10) a stub. There are six different objects (the field magnitude): 1) a ski-track; 2) a tree; 3) an elk"s footprint; 4) an elk"s footprint on the ski-track; 5) a stub; 6) a bush. The total number of objects, actualized by the information recipient movement activity on a certain plot, i.e. field anisotropy is ten. Elementary movement reactions number or field intensity on the certain part of the footprints path is equal to twelve: a ski-track is one response (1); plus a tree is one response (1); plus a ski-track (1); plus a tree (1); plus a ski-track (1); plus an elk"s footprint (1), plus an elk"s footprint on the ski-track (1); plus responses, connected with a stub (an approach, a territory marking, a reorientation – the beast turned round and paused) (3), plus one movement response in the directions of the bushes (1); plus a response to a stub (1); then the animal moves on. Should we consider a ski-track, an elk"s footprint and the elk"s footprint on the ski-track to be different orientation objects or maybe in the third case the object is not a new one and it is only a sum of the objects met earlier? The answer to such questions may be given only by the animals" preliminary observation practice. Our observation experience shows that an elk"s footprint on the ski-track provides quite different information from that of a ski-track and an elk"s footprint taken separately. Animals cross "dangerous" plots, connected with man"s activity, following other animals, imitating them. The figure shows that the fox follows the elk"s footprints pre-

cisely, "step by step", crosses the ski-track, but then it notices a stub and moves to the stub. Animals often follow other animal footprints or their own which were left as an earlier footprint path.

During field material collection a researcher chooses some prearranged metric extent of a footprint path, taken as a standard meter, to get some comparable exponents of the signal field for different animals. The fox"s signal field parameters calculation was made on the animal"s 1000-meter path. This magnitude is provisional, it is defined experimentally. The thing is, that having covered about 1000 meters the fox responds practically to the whole variety of objects within its life interest sphere. If we take the footprints path longer than 1000 meters, new objects rarely appear. Besides, this distance is convenient for making the calculations, it"s comparable with the red fox"s day and night hunting plot size, and it is good for the researcher because he is able to collect some essential field material covering the distance in an hour.

Figure 2 shows the pine marten"s *(Martes martes)* track. The magnitude of the signal field is equal to four, there are four movement orienting objects: 1) a tree hash; 2) a bush; 3) a grass stem; 4) a stub. The marten field anisotropy on the footprints path plot, i. e. the total number of the objects is also equal to four, as all the objects were different. How did we define that a large forked tree in the beginning of the footprints path and a stub with a branch sticking are different objects for the marten, different "signal-words" of this creature"s thesaurus? Based on long-term field experience we conclude that there are stereotyped sets of responses to different "words" in the semiotic thesaurus of different species of animals. The marten almost always jumps on low stubs if they occur in its path as it searches for small rodents, and will as a rule, climb trees if it sees fox footprints often and for a long period of time. We may suppose that the fox footprints produce some stress influence on them. The marten signal field intensity in the situation, shown in Figure 2, is equal to ten, which is the number of "elementary movement responses", connected with the four outer environment objects, which orient its movements. As for the tree hash, there are two responses here: its approach and its gaining foothold of the tree hash (two reactions). Then the pine marten changed its "two-set" movement for short steps without any dependence on an object (one response), one response to a bush, then grass (one response), a stub (three responses – the marten approached it, jumped on it and then jumped off the stub), pace change without an object (one response), all in all: ten elementary movement reactions. The animal crossed a hollow without any response, that"s why this micro relief element was not taken into consideration when we calculated the field magnitude, but we have marked it in our notes, since this object might be meaningful for

the marten under different circumstances. Thus, this object is of different significance for the fox and for the marten, since the fox, having its short rest while hunting, sometimes lies down on a sunlit slope protected from the wind. And the fox "does it so as to be heated by direct sun rays on the one side and by the rays reflected from a snow wall or a tree stub on another side" (Formozov 1959: 22).

Motivation provides the context of the message received from the environment. The motivation is based within an animal"s physiological needs such as hunger, thirst, comfort and reproductive behaviors, such as its need for a rest, its need for reproduction, etc. The animal"s emotional state adds to its motivation. The behavioral context includes an automatic stimulation effect because the behavioral action itself prolongs the duration of such activity. The environmental signals that determine another type of activity are understood as habitual, and thus, weak and average in their intensity, and therefore can"t cause any dominant behavior displacement. But such sideline signals can result in a new type of behavior, as an addition to the basic behavioral type. The new behavior represents a subdominant type. The activation of one continuous behavior type produces nervous system tension. Since the animal"s attention is very mobile, this fact reveals itself in periodic dominant and subordinate type activity alteration.

Since we register animal movement reactions, our method could seem behavioristic. This is not so. The research is focused on the signified or what is meaningful to the animal, and there is no way to access this interpretant other than through its signifier. It is the main difficulty in zoosemiotic research. Behaviorists deny the content plane. The basic problem here is the perception continuum subdivision, according to the animal"s properties, but not to those of the researcher conducting the observation. In other words, the problem remains semiotic – the problem of attributing the signifier to their hypothetical signified, proceeding from their "language" or semiotic system as well as from the peculiar features of animals treated as the objects of observation.

One of the main aims of signal field theory is to make possible the measurement and comparison of the information contribution of different species and animal life rates to their mutual habitat alteration. Field magnitude, anisotropy and intensity estimates enable us to formalize communicative processes in populations and co-adaptable close mammal species complexes in order to acquire the possibility to compare adaptive behavior responses of different individuals, populations, species and representatives of different intra–population groups of one and the same species (e.g. age and sex) (Mozgovoy 1989: 138-150).

Signal field theory substantiates the necessary set of parameters which - if taken into consideration – enable us to make a model of population dynamics of small predator mammals living near Samara (Mozgovoy 1983: 105-107). According to the population self-regulation hypothesis (Shwarts 1980: 126, 164-166; Gilyarov 1990: 105) mammalian populations are able to support their number at a level adequate to their habitat environment conditions. Apart from genetic mechanisms that ensure the dominance of more fertile genotypes depending on the number of individuals in the population, the population dynamics is based on stress mechanism or "shock disease" that changes the behavioral responses of mammals as well as the size of their ecological niche (Dajoz 1975: 245; Giller 1988: 32). The hypothesis of the behavior regulation of predator mammals number suggests that social behavior depends on the population density at a certain moment of time; endocrine predator responses to a higher density change, first of all, territory; and reproductive behavior responses through the increase of "individuals" aggression" (Rosenberg, Mozgovoy & Gelashvilly 1999: 213.)

A number of specific ecological problems had been solved with the help of signal field theory and field observation technique. For example, we compared responses of organisms and above-organism systems, living under different anthropogenic pressing factors. In Table 1 we show fox *(Vulpes vulpes),* marten *(Martes martes)*, ermine *(Mustela erminea)* and weasel *(Mustela nivalis)* signal field parameters. The field magnitude is calculated according to these animal"s equivalent footprint distance. The field magnitude is determined by the variety of the environment objects and events to which the animal reacted. For the fox one hundred elementary movement reactions fall on about 900 meters of its path, for the marten the same number of drives occurs (in the average) on 343 meters of the footprints path, the ermine produces one hundred drives covering about 220 meters distance, and the weasel has the same if it runs 145-meter distance. The field intensity, while some equivalent distance is covered, is equal to 100 elementary movements. The field"s anisotropy is determined by the overall number of objects and events, to which the animal reacted while covering a route of some fixed length. Anisotropy may be also determined per its equivalent distance. But in the example given in Table 1, anisotropy and intensity are calculated for 1000 m of the animal"s footprints path. It was made to demonstrate different animal species tempo of their motion activity. The research was carried out in the Samara region flood-lands woods in 1978-1982.

We may see that there is a different degree of discreteness of the environment perception in different species, this fact is likely to reflect the width of their connections with the environment and the ability to adapt to the changes; it is expressed by the reflected

environment objects number. The fox, possessing a larger signal field magnitude, has the maximum environment reflection abilities, assimilation and transformation, unlike other ecologically related species. We may consider it to be the dominant species of this co-adaptable complex, inhabiting the floodland woods of the Samara region. In compared species we mark different signal field intensity: the fox"s one is minimal, the weasel"s intensity is maximal, we should say, for example, that the marten"s field intensity is 2.5 - 3.0 times higher than the fox"s. One-way analysis of variance (ANOVA) has shown that individual variations of this parameter are not higher than their interspecies differences, though those of the marten are twice as large. Their interspecies variations and interspecies differences of the signal field anisotropy are similar.

Let"s examine signal field parameters within the fox species, within the different variables of sex and age affiliation as well as in their behavior type. The degree of influence of those three factors on the parameters of the signal field was calculated with the help of the dispersion analysis (analysis of variance). The reliability of the influence of this factor on the sign was determined with the help of Fisher"s criterion. The data taken from J.P.Mozgovoy"s and I.V.Yudina"s work (1995) are shown in Table 2.

The accumulated material is divided into four parts characterizing the dominant motivation form. Such division is necessary, since the field parameters depend on the dominant form of behavior in the process of day and night activity. It"s easy to differentiate the dominant behavior forms, they are, as a rule, revealed in the complete investigation of an animal"s day and night activity. All parameters of the signal field increase according to the change of activity from the comfortable or "at-ease" behavior to the hunting behavior through appropriate stages.

In Table 3 we show the marten and the fox activity tempo changes with age. The same animals were observed during four winter periods in the city of Samara environs. All the animals were engaged in their food-searching activity. We may see that the individual"s activity tempo slows down with age. Scientific sources of information assume that this phenomenon is connected with the slowing down of the activity rhythms of metabolism. Research of the same character conducted during field seasons of 1993 – 2000 confirmed this regularity.

As an example of signal field technique application to animal ecology studies let"s follow some signal interrelations among the fox, the marten, the ermine and the weasel. The signal ties among the different species of this complex differ. In Table 4 you may see some signal relations hierarchy that shows in different species information dependence.

The data analysis enables us to conclude that for the weasel the information value of the same species activity footprints is much higher than the information value of the signals left by the individuals of other species. Analyzing the obtained data, it is possible to make the following conclusions. The animals belonging to close species inhabiting the same region make up one common co-adaptable complex. The species of the same co-adaptable complex have identical natural "signscapes". Their sign fields are similar in magnitude and consist of similar elements. The animals react to animal"s footprints paths more actively than to elements of a landscape. The intensity of intraspecific contacts is higher than the intensity of interspecific contacts. Males react to unusual signs of the natural environment and to anthropogenous signals more actively then females. A similar research task was set in 1993 – 2000. The conclusions drawn on the basis of the material of the previous years were once again confirmed.

The following example illustrates a comparative analysis of signal fields of the animals living in similar natural conditions, which only differ in some anthropogenic influence level. The work was carried out in the winter period in 1978-1985. These data are shown in Table 5. We examined signal fields of 12 adult pine martens *(Martes martes)* inhabiting the Volga flood-lands not far from the city of Samara, in Krasnosamarskoye forestry of the Samara region and in Bashkirsky Preserve. The anthropogenic factor influence on the animals" habitat increases from the Bashkirsky Preserve, through the Krasnosamarskoye forestry, toward the environs of the city of Samara. The field intensity calculations were carried out on 1000m animal footprint paths. The intensity gives movement activity tempo characteristics and is measured by the common number of movement responses on the distance unit.

So you can see that the pine marten"s activity is higher in the anthropogenic condition than when such influence is weaker. In anthropogenous natural signscapes parameters of the anisotropy and the intensity are higher, than in those without anthropogenous effect. The females" field intensity in the anthropogenic environment is higher than that of the males. The increase of the anisotropy and the intensity in natural signscapes testifies to the animals" stressful state.

2 PECULIARITIES OF MAMMALS SIGNAL FIELD ORGANISATION AS A SIGN SYSTEM

Signal field theory studies mammals living in the wild. Animals, as populations and as a close species co-adaptable complex, and using signs in their information interaction proc-

ess with the environment, may be characterised by the following properties: 1) their information exchange with the environment ensures more effective adaptation of populations and of the close species co-adaptable complex; 2) individuals taking part in the sign processes possess their peculiar group and genetically fixed memory, therefore, memory of some past experience is always present in a sign, producing connotations. A sign is a reference to another significant situation in the past, therefore it becomes fixed as a part of some individual experience (either in the form of a movement response or its blocking).

Mammalian behavior in their signal field is a process during which the animals successively "read" reports without any address that deal with environmental objects and events and inform them of the environmental state. Those environmental objects that produce a result within the mammalian signal field theory are defined as signal objects or mammals sign denotations. It is not an easy task to differentiate separate signals, expressed in a movement, a pose, a sound or some other things, and, hence, it is impossible to divide "the interaction text" into its components. In an indirect interaction, by means of the environment signals in the long-term fixed text, the animal-recipient responds to every signal by its movement activity, forming the way of its behavior. This behavior may be divided into separate units – or response "words" to "the text" signal (Mozgovoy, Rosenberg, Vladimirova, 1998: 17). We should mention here that the environment objects themselves are not signs, they become such having gone through an animal-recipient perception.

One of the founders of zoosemiotics, CharlesMorris, in his work *Foundations of the Theory of Signs* noted that "not only people, but also animals respond to some things taking them as signs of something else" (Morris 1983a: 37; translation from Russian). Then he continued, "sign functioning is, in general, a way when some phenomena take into their consideration other ones by means of the third class indirect phenomena" (Morris 1983a: 43; translation from Russian). In his other work *Signification and Significance: A Study of the Relations of Signs and Values,* he introduced basic semiotic terms in the following way: "semiosis (or a sign process) is a fine element ratio of *V, W, X, Y, Z*, where *V* arouses in *W* some predisposition to a definite response *(X)* to a definite object appearance *(Y)* (which, therefore, does not act as a stimulus) under certain conditions *(Z).* In the cases where we have this ratio, *V* is a sign, *W* is an interpreter, *X* is a thing interpreted, *Y* is a meaning (signification), and *Z* is a context where this sign exists" (Morris 1983b: 119; translation from Russian). Morris outlines his basic semiotic terms with the reservation that he is doing it "for the present work only". We support Morris" point of view

completely, and we should mention the fact that he does not insist on his definitions being "objective" ones for "a sign", he "considers them to be the requirements for the recognition of signs as such" (Morris 1983b: 118-119).

It may seem that Morris" animal sign behavior notions differ from the ideas offered by the authors of mammalian biological signal field theory, but a more profound examination of the problem has shown that the differences are due to what kind of analysis - static or dynamic - is the basis of sign phenomena modelling. In the static approach, what is called a "predisposition to a definite response" (Morris 1983b: 119), is, in the dynamic approach, called "elementary movement responses to the environment objects and events" (Mozgovoy & Rosenberg 1992: 15) or "the thing interpretated" in Morris"s terms. This predisposition "may be interpreted taking into consideration the probability notion as a certain response probability under some definite conditions when a certain sign appears" (Morris 1983b: 120; translation from Russian). "Or, as we shall see further, the thing interpreted may be considered to be an intermediate variable quantity which is postulated in theoretical aims and is controlled by circumstantial empirical data" (Morris 1983b: 120; translation from Russian).

We shall now refer to the notions of "semiosis" and "sign", which, we believe, correspond to our understanding of information-sign processes in the mammalian signal field theory. Reflection over these definitions leads to a better comprehension of the peculiar approach of biological signal field theory to problems within ecology-ethology.

Zoosemiotics is a process, an energy phenomenon, and a means of adaptation, that ensures the interaction of an individual or any other bigger living system with their outer environment. The function of the notion "sign" in this approach is to denote the relative character of the signified and its environmental interrelation, and the signifier and its inner environmental relation, and, if it is possible, to bear in mind their unity in specific research. Additionally, "semiosis" is understood as some real energy phenomena, and "sign" is understood as the model of this phenomenon, oriented, first of all, to its outer environment. Von Uexküll"s "Umwelt", meaning "the semiotic world of an organism" and including "all the meaningful aspects of the world for a particular organism" (Kull 1998: 302) is used in the semoisis model, stressing the features of semiosis as a process of translation (Kull 1988: 300), as well as the "individual"s limited abilities to the outer environment perception" (Dewsbury 1981: 21), and its "dependence on its motivation and an already formed search image" (Hinde 1975: 135-136).

Sign perception as "a model, generalising the functional properties of some given object or phenomena", but not of "a real object or some reality or some reality phenomenon" (Leontjev, 1967: 37), in our opinion, does not contradict the ideas described above, since psychical mechanisms construct some adaptive - for a given function level - models including scientific ones. The division into "reality", and "reality modelling" ignores the fact that any scientific discourse implies some reality modelling. This sign interpretation is found within the works of Morris and von Uexküll, of modern biosemioticians, and aslo, of the authors of signal field theory.

"Researchers's dissension boils down to one simple technical question: what sign property should be called "meaning"? (Melnichuk 1968: 43). The field observation method based on mammalian signal field technique implies associating "meaning" first of all, with the field anisotropy. Meaning is used as "an integral sum total re-organisation operator" in Lévi-Strauss's terminology (Lévi-Strauss 1999: 127, 129), and in the signal field theory text 'integrity' is determined by the animal's biological motivation.

If in zoosemiotics we deal with such notions as "sign", "semiosis", "meaning", "sign sense", then we should describe semoisis using biological signal field parameters: an individual sign sum total (a vocabulary); we should connect with "a signal field size", we should compare text meaning for an individual with the text meaning for another individual with the help of the notion of "a signal field anisotropy", sense (value) text peculiarities for different individuals may be measured with the help of the notion of "a signal field tension". Linguistic correlation with signal field theory does not mean any contextual equivalence of these notions. Instead, it gives an opportunity to accentuate various aspects of the less differentiated sign system of animals by this analogy with human natural language. In pragmatically oriented signal field theory "field magnitude" plays the part of "a syntax information component", field intensity characterizes "pragmatic" information component, field anisotropy enables us to take into consideration the "semantic" information component (Rosenberg, Mozgovoy & Gelashvilly 1999: 115). We should again point out that these associations only emphasize some aspects within the whole mammalian semiosic process.

Wardool writes, "in the information theory any information quantity is studied irrespective of its essence. In Linguistics (wider - in Semiotics) information subjectivity is studied irrespective of its quantity" (Wardool 1967: 9). Signal field method investigations allow a researcher, we believe, to take into consideration both the quantity and essence of any sign information.

Thus, in Zoosemiotics the following definitions of the "sign" are possible:

1) a sign is a thing that stands for something;

2) a sign is a thing referring its user to something which differs from the sign itself;

3) a sign is a thing creating a perception of something which differs from its perceived form;

4) a sign is a thing causing a movement response, if the signified is correlated with the addressee"s dominating motivation;

5) a sign is a movement from the perceived form (signifier) to some contents (signified) of the sign user's species or individual experience;

6) a sign is a thing inspiring some activity, corresponding to the user's dominating motivation (intention) with less than 100% probability. If "a sign" simply causes an activity, we deal with a causal-consequential interaction but not with a sign one.

An elementary movement act (a drive) in the signal field theory corresponds to an animal movement division unit, which is denoted by some correlation between the signified and the signifier. A possibility of the division of expression plane and contents plane into units is preserved. The units have no correlation in their opposite planes and such division of the individual animal's movement process will be wrong. For an animal, the signified denoted objectively is their life experience element, partially corresponding to a search image.

The signal field signs equivalence problem finds its correlation in linguistics. The reduction of infinite various realisations of signs to a finite number of invariants is based on Karl Bühler's principle of "abstract relevance" (Bühler 2000: 34). "In accordance with this principle not all substantial sign characteristics are taken into consideration but only those ones, which are abstracted from the whole and carry out the semasiological function and could be defined by some system opposition since we speak of sign systems" (Buligina 1967: 8-9).

Pierce writes: "A sign or "a representamen" is something that stands for anything for somebody in certain relation and quality. It is addressed to somebody, that is, it creates an equivalent sign in this man"s mind, or maybe a more advanced sign. The sign, which he creates, is called the interpreter of the first sign. The sign substitutes something –and namely, its object. It substitutes this object not in all its manifestations but only in reference to some idea which is sometimes called "the representment ground"" (Pierce 2000:

48). This definition seems to be suitable enough for using it as the subject in mammals biological signal field research, that is in a metalanguage description of the animal sign systems peculiarities.

Since outer world objects and phenomena may or may not correspond to the expectations of motivated animals, the sign interaction of individuals with their outer environment serves as a structured system of meanings, and the scientific discourse including this interaction character description by a researcher is a social phenomenon which depends on its own structural change and reconstruction.

Let's produce some evidence in favour of an information recipient semiotics in comparison with an information sender semiotics for ecosemiotic modelling.

Sign systems study from a recipient's point of view is more adequate for ecological research aims, because in this approach a sign is always vital as something "grasped" by an individual's attention in the outer - as this individual is concerned - environment. The attention may differ only in its degree of intensity. On the one hand, the sign is required by the recipient's motivation, conditioned by its individual and species experience; on the other hand, the sign is generated by some outer - as far as the recipient is concerned - reality, if it is adequate to the recipient's intentions and its perceiving apparatus.

What will be 'marked' by an individual in its adaptive behavior as a sign? How can we define the environment or the individual functional state roles in the semiosis process? Everything may seem to become a sign in semiotics, oriented to the sign information recipient. Gestalt psychologists point to a figure and its background existence in perception: figures, in their opinion, differ from their background in their details and some definite structure. Since an actual semiosis is always less in its volume than a potential one, then in the real world that surrounds the individual, there are always objects and events not included into an individual subjective world. The outer environmental influence on an individual surpasses its abilities to perceive. Since we have no other way to penetrate into the animal inner world but our observation of them, to get some comparable objective results we should mark only such outer environmental objects that cause animal movement response.

Thus, mammalian signal field theory appeals to the recipient's semiotics much more than to the sender's semiotics. In zoosemiotics and in semiotics on the whole the opposite idea finds its supporters. Actually animals often give a signal and wait for a response. We believe that in individual ecology the opposite approach may prove to be more productive

than that of the signal field theory authors, depending on the tasks set. It goes without saying that the mammalian sign field theory authors do not ignore the studies of mammalian species evolutionary experience. The other point of view must exist, it deals, first of all, with some communicative intention in animal sign activity.

Semiotics, oriented to a sign message sender makes it possible, first of all, to stress those sides of the sign function which were called "a symptom" by Karl Bühler (Bühler 2000: 34-38). In Table 7 the comparative characteristics of different sign functions is given.

The mammals signal field theory concepts resemble neo-behavioral ideas, the basic difference here is that the signal field theory, created to solve some concrete ecological problems, deals with individuals and over-organism systems as its investigation objects. Besides, unlike neo-behaviorist suppositions, mammalian signal field theory treats a whole 'text' rather than a single stimulus.

The investigation of mammalian communication using mammalian signal field technique makes it possible to find particularities of basic language activities – selection and combination. Thus, surpassing the threshold level of one species sign capacity leads to individual activity to promote type changes. The two ways of mammalian signal field organization, in an analogy with textual structure – paradigmatic and syntagmatic - correlate, first of all, with a behavior self-stimulating effect, that is "behavior stimulation by means of some similar behavior that prolongs the given behavior act" and with the displacement of the dominant behavior type; we also witness "subdominant activity" appearance according to the time division principle (Mozgovoy, Rosenberg & Vladimirova 1998: 7).

The communication instrument of animals is their own behavior, perceived through immediate contacts between individuals or through the environment changed by their adapting behavior. The main problem of solitary living animal zoosemiotics is the clarification of a non-intentional, non-directed message structure "written" in the environment objects and events and organized as a "text" read in consecutive order in the course of the animals moving activity. Moving activity of animals in their own or group information sign field actualises this message. The task of a researcher is to organise the process of sign message reception in such a way as to reflect as minutely as possible the structure and organisation of the sign message received by animals.

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Table 1. Red fox (*Vulpes vulpes)*, pine marten *(Martes martes)*, ermine (short-tailed weasel) *(Mustela erminea)* and least weasel (*Mustela nivalis)* signal field parameters. Field magnitude is calculated according to the equivalent distance. Field intensity and anisotropy are calculated for 1000 m animal"s footprints path. The river Volga flood-lands woods, vicinities of the city of Samara, 1978-1982. (Mozgovoy and Rosenberg, 1992)

	Fox	Marten	Ermine	Weasel
The number of individuals under the observation	7	14	2	3
The studied footprints path length, in meters	37823	82162	1325	1000
The average value of the field magnitude	23,4	18,5	17,0	11,0
The utmost value of the field magnitude	18-33	12-32	15-18	5-17
The anisotropy average value	44	107	234	197
The anisotropy utmost value	42-67	99-200	-	-
The intensity average value	111	289	468	695
The intensity utmost value	97-150	240-456	-	-

Table 2. The signal field parameters of different red fox *(Vulpes vulpes)* individuals with different behavior types. The field magnitude, its anisotropy and intensity calculations were calculated for a 1000-meter footprints path. Forests in the vicinitiy of Samara, 1994. (Mozgovoy and Yudina, 1995)

Type of behavior	The animal"s sex and age	The studied footprints path length, in meters	The field magnitude	The field anisotropy	The field intensity	The equivalent distance
The withdrawal from danger (passive-defensive behavior)	Adult male	1655	26	48	157	658
	Adult female	1024	26	99	284	1284
	Adult female	1884	11	36	119	397
Food-searching activity (search-food behavior)	Adult female	1588	36	121	354	284
	Adult female	988	32	112	443	226
	Adult female	1705	27	143	439	228
	Adult female	1443	34	149	334	275
Transition to the other feed plot (territory	Adult male	2584	36	88	242	413
	Adult male	2295	24	61	203	493

behavior)	Adult male	1094	35	63	233	429
	Adult male	1874	15	67	176	568
	Young male	2358	21	47	98	1020
	Young male	957	18	73	180	556
	Young male	1060	21	53	174	575
	Adult female	1478	23	76	254	394
An individual plot round (territory behavior)	Adult female	1114	42	89	408	245
	Adult male	1541	46	106	434	230
	Adult male	1549	44	139	373	268
	Young male	1324	30	128	378	265

Table 3. The pine martens *(Martes martes)* and red foxes (*Vulpes vulpes)* age activity tempos decrease in terms of intensity. The calculations are done on a 1000-meter footprints path. The river Volga flood-lands woods, in the vicinity of Samara, 1980-1983. (Mozgovoy and Rosenberg, 1992)

Individual descriptions	Signal field parameters	1980	1981	1982	1983
Adult female marten	Intensity	-	473	407	310
	Magnitude	-	38	34	32
Young male marten	Intensity	540	-	397	-
	Magnitude	41	-	27	-
Adult male fox	Intensity	-	-	276	195
	Magnitude	-	-	38	28

Table 4. Information ties among the species of one and the same co-adaptive complex. The field magnitude is calculated according to the equivalent distance. The observation is being carried out in 1992 in the vicinity of Samara. (Mozgovoy and Rosenberg, 1992)

	Signal field magnitude	The number of elementary motion responses to the activity footprints of the following species representatives:				
		human being	fox	marten	ermine	weasel
Fox	26.4	18.6	31.4	0.8	-	-
Marten	20.5	16.0	4.0	18.8	-	-
Ermine	19.0	6.1	6.1	0.3	21.5	-
Weasel	12.0	4.6	20.2	0.5	-	2.9

Table 5.The tempo of the pine marten (*Martes martes)* movement activity is expressed through the signal field intensity if there are different degrees of anthropogenic influence. The work was being carried out in the river Volga flood-lands woods, in the vicinities of the city of Samara, Krasnosamarskoye forestry of the Samara region and Bashkirsky Preserve, 1978-1985. (Mozgovoy and Rosenberg, 1992)

Type of behavior	Indices	Bashkirsky Preserve and Krasnosamarskoye Forestry		The Volga flood-lands not far from Samara	
		Males	Females	Males	Females
Food-searching activity	Individuals number under the observation	1	3	4	4
	The studied distance length, in meters	7840	7771	13740	16500
	The field intensity	224	291	368	510
The transition to an other feed plot	Individuals number under the observation	1	4	1	3
	The studied distance length, in meters	4860	4960	1722	12494
	The field intensity	134	177	190	347

Table 6. The outcome of the one-way analysis of variance of signal field parameter variability (after Mozgovoy and Rozenberg, 1992). All the animals are engaged in search-food behavior. Field observations were held in flood-lands woods of the river Volga near the city of Samara in 1990. The values of the power of influence of the factor 80% trustworthy are marked with an asterisk, the rest are 95% trustworthy.

Object	Factor	Signal field parameter	Power of factor influence, %	Average quotient by factor gradations	
				X 1	X 2
Fox (on a 500-meter distance)	Sex (adult individuals)			Males	Females
		Magnitude (number of objects)	-	18	19
		Anisotropy	-	36	39
		Intensity	8,7	89	133
Fox (on a 500-meter distance)	Age (males)			Adult	Young
		Magnitude (number of objects)	2,2*	18	20
		Anisotropy	-	36	40
		Intensity	5,4	89	119
Marten (on 26 different objects of the distance)	Age (females)			Adult	Young
		The length of the distance covering 26 different objects	-	440	395
		Anisotropy	-	83	82
		Intensity	2,0*	241	311

Table 7. Human beings and animals sign function comparative characteristic

Sign functions in K.Bühler terms	Mammals communication in nature	Natural human language
Symptom	Characterizes the functional state of the first participant of the interaction process (the sender) Manifests the sender"s condition in elementary movements.	Characterizes the sender mainly extralinguistically. Can indicate the chosen information context significance for a sender, his functional status, some ideology preference, social censorship effect. In a number of cases declares the sender"s self-identification with one or the other social group or his marginal position, his orientation on the mutual understanding with his addressee, the ability to use language code rules: vocabulary volume, dialect, preferable discourse style and so on.
Symbol	Characterizes the animal"s motives and environment phenomena coincidence degree.	Corresponds to the things and situations mentioned in the utterance
Signal	Rules the communication of the second participant (the recipient), its external behavior, and internal state. Releases a movement as a sign perception response.	Brings together the interaction subject, its situation and the recipient"s position. In case the information is significant for the recipient, it influences his behavior.

Subtitles to Figures:

Figure 1. It is the red fox"s (*Vulpes vulpes)* footprints path. The signal field magnitude, i.e. the number of different environment objects (the objects are signal bearers) is equal to six. The signal field anisotropy, i.e. the total number of the environment objects, taken up by the animal into its activity sphere is equal to ten. The signal field intensity, i.e. the number of "elementary" movement reactions is equal to twelve.

Figure 2. It is the pine marten"s (*Martes martes)* footprints path. The signal field magnitude is equal to four, anisotropy is equal to four, and intensity is equal to ten.