ROADS AS ECOLOGICAL CORRIDORS

Dr. A. Zaragoza
Spanish Road Association, Madrid, Spain
azaragoza@aecarretera.com
I. Otero
Polytechnic University, Madrid, Spain
iotero@montes.upm.es
E. de la Peña
Spanish Road Association, Madrid, Spain
edelapena@aecarretera.com

ABSTRACT

The protection of the environment constitutes a key aspect of all countries' policy. The variety of wildlife (animals and plants) of our planet is enormous, so we should not allow that its interaction with road networks could reduce this great natural heritage. Thus, it is essential that all processes of planning of new road networks and management of the existing ones have into account a key concept: the necessity of the environmental integration of roads. An ecological corridor is a linear open space that runs along a natural corridor (for example, a river or a stream in a mountainous area) or along an special route (for example, an old railway line turned to a recreational use) connecting two different areas with a high ecological value. From an environmental integration point of view, would it be possible to consider roads and roadsides as an ecological corridor?. Roads, far from being considered as unsurpassable obstacles, can and should be considered as elements integrated in Nature, even improving the environmental value of the area and increasing the diversity of wildlife. In order to make this real, it is necessary to define the maintenance and protection requirements of roads with high ecological value, so that management could be improved. Previously, an evaluation system should be developed to produce a tool for the estimation of the environmental and landscape value of these areas.

KEYWORDS

ROADSIDES / ENVIRONMENT / ECOLOGICAL CORRIDOR / ECOLOGICAL VALUE, INTEGRATION / DIVERSITY.

1. THE ROAD AS ELEMENT CONNECTING TERRITORY.

Traditionally roads have been considered as an element breaking the territory, by setting up a division line between areas with more or less ecological value and thus, limiting the biological diversity of the environment. Nevertheless, this constitutes a wrong approach in some cases: under certain circumstances, roads not only do not break the ecosystem, but also can behave as an element of connection between areas with different natural resources and diversity.

Undoubtedly, particularities of the environment at roadsides determine its possible behaviour as connection element between habitats: stratus, structure and characteristics of vegetation, slopes, water, mountains, wildlife, erosion, sedimentation,… are some of the aspects to be considered in order to value the environment where the road is integrated.

Roads, far from being considered as unsurpassable obstacles, can and should be considered as elements integrated in Nature, even improving the environmental value of the area and increasing the diversity of wildlife

2. ECOLOGICAL CORRIDORS.

Before analysing the road as element connecting territory it is necessary to define the general concept of “ecological corridor”, in order to considerate roads in this context. Some authors (Little 1990; Smith, 1993) propose the following definitions:

- Opened linear space, corridor made up of natural vegetation or at least more natural than the surroundings.
- Opened linear space going along a natural corridor, as the course of a river, or along an special route, as an old railway line turned to a recreational use.

Corridors have several functions, which could be summarized in the following:

- Protection of the water courses against non-focused pollution and also setting up environmental limitation against weather conditions such as temperature and rain.
- Connection of habitats following biological and geographical criteria, by defining the main characteristics of the areas in terms of weather, plants, geography,… so that a division in sectors could be done.
- Setting up a number of passes for animals, in order to avoid isolation of certain species, changes in habitats, disturbances to animals and deaths. They are also useful for animal migrations and for the in situ investigation of natural world.
- Acting as “green lungs” if they are big enough in the proximity of big cities.

3. ROADS AS ECOLOGICAL CORRIDORS.

Characteristics of the road surroundings is the key concept in its consideration as an ecological corridor. The piece of land to be considered is formed by the road, roadsides and, in a wider approach, the right of way area of the road.

Under certain circumstances, the ecological value and diversity of the road and its surroundings could be even greater than if the road does not exist.

As an example, the results of a survey recently conducted in Canberra can be cited; it has allowed to identify 260 different vegetal species from seeds found inside a car wash tunnel; seeds which in some case had been transported from places 100 kilometres away; it is likely that most of these seeds came from the roadsides, where they will set up and, once they turn into stable vegetal communities, would attract new animal species.

Apart from the importance of the road as a mean of transportation for vegetal species, it is also interesting to consider its aptitudes to make animal movements easier.; wildlife movements will depend basically in the intensity of motorized traffic at roads.

Undoubtedly, not all roads can be considered as potential ecological corridors. Natural value of the road environment will help to define if it is advisable to apply the methodology described, in order to identify a possible ecological corridor and, further, develop guidelines for road management oriented to the improvement of ecological value.

Considering a road as an ecological corridor does not only depend on the ecological value of the road and surroundings, but also on the length of the corridor and characteristics of the two areas connected.

4. EVALUATION METHODOLOGY.

In order to identify the diversity and value of the road and its surroundings it is necessary to develop an evaluation methodology to determine, on the one side, the biological value of wildlife (plants and animals) in the area, once classified and quantified, and, on the other side, maintenance and protection requirements of that area and, consequently, produce a set of recommendations for the improvement of the management process.

This approach constituted the base of an investigation project conducted in the Construction and Rural Ways Department of the Madrid Polytechnic University ordered by the Spanish Road Association. The following work phases were defined:

- ✓ Design of a methodology to determine the environmental value of roadsides.
- ✓ Design of complementary methodology to determine the landscape value of roadsides.
- ✓ Definition of factors determining the environmental and landscape value of roads.

Figure 1 includes the main phases of the approach:

Diagram of the approach

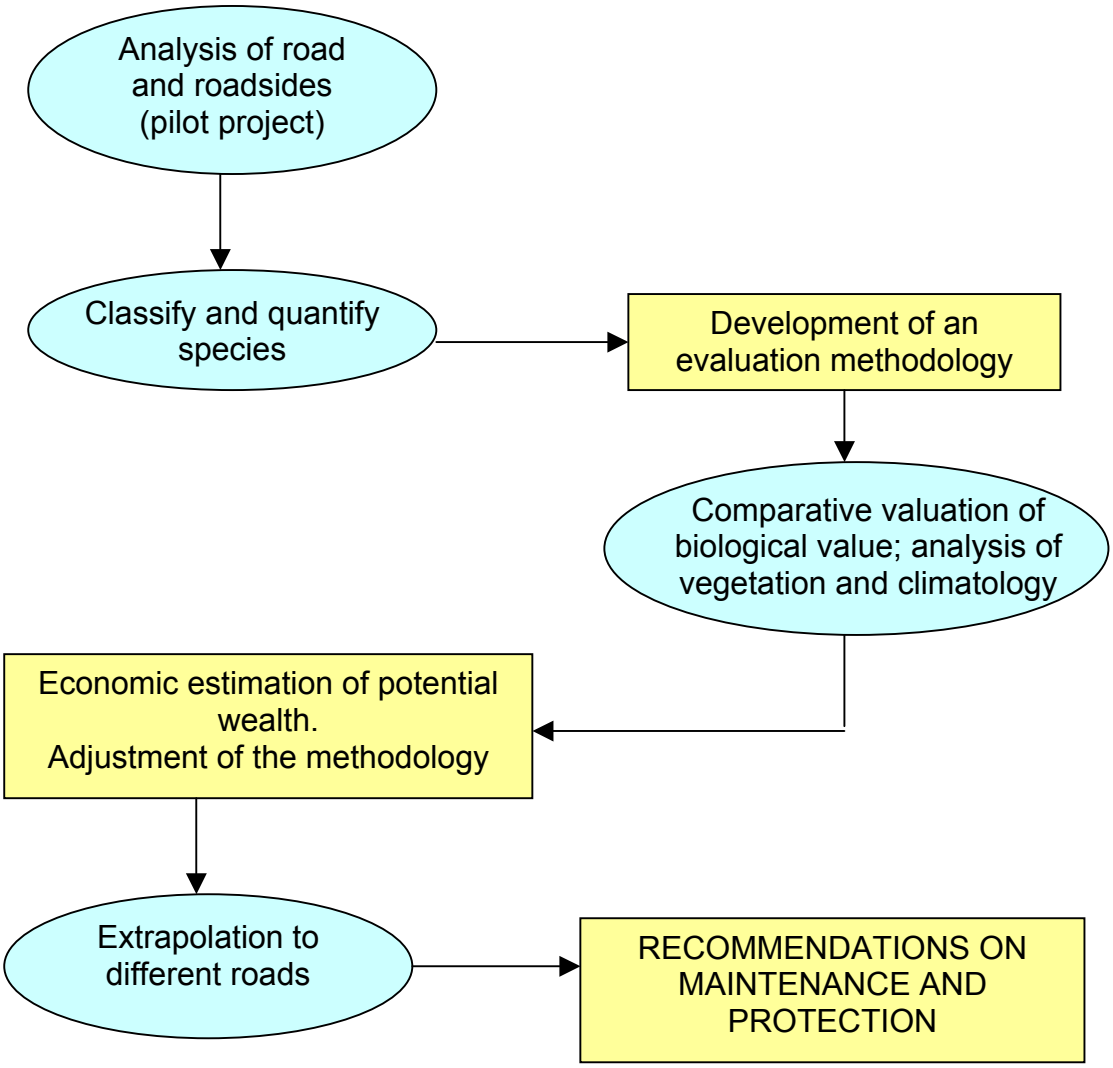

Figure 1 – Diagram of the approach.

Once the evaluation methodology is available it is time to define a set of recommendations on maintenance and protection of roads and roadsides with a high ecological value, so that management processes could be optimised and their character of connection element between areas of high biological diversity could be improved.

4.1. Methodology for the estimation of the environmental value of roadsides.

A field questionnaire to collect the most important biological data on the environmental value of roadsides was developed. Simplicity and easy-understanding criteria were followed. Previously, areas A and B were defined as follows:

- Area A (roadsides): includes right of way area.
- Area B (closest environment): includes right of way area except roadsides.

A checking sheet including the same parameters from a technical point of view was also developed to be filled in by specialized professionals. The objective of this sheet is to check if the data collected by professionals in the sheet is equivalent to the data collected by a non-specialized staff in the field questionnaire.

Following, a pilot test was conducted over two highways in Spain, with a total of 30 sections analysed. Checking sheets were filled in by Forest Engineers, while field questionnaires were filled in by non-specialized staff.

As a result of the pilot test and the comparative analysis of data collected, it was concluded that it is possible to conduct a visual inspection of the environmental quality of a road by non-specialized staff, provided that it is a comparative process developed in situ. Valuation by comparison does not require that the person collecting data has a wide technical knowledge.

Complementary, a second pilot test was conducted to identify parameters in the checking sheet which could be difficult to evaluate, in order to double check the equivalence of the data collected by professionals and by non-specialized staff. As a consequence, some changes were done in the checking sheet to guarantee the equivalence.

Once it has been decided to collect data by using a comparative process, it is necessary to assign a score to each of the parameters considered. Thus, the environmental value of roads will be obtained as a result of the comparison between scores assigned to the roadsides and those assigned to the surrounding area. Score assignment to each parameter has been done by a group of experts.

Roadsides environmental value can be obtained by using the following indexes:

- Index of the natural value of roadsides relative to the surrounding area.
- Index of the natural value gained by roadsides.

Parameters considered within each of the indexes are included in tables 1 and 2; different categories have been defined, each having a different score depending on the natural value or the gained value, so that a total score for area A and B can be obtained.

Index of the natural value of roadsides relative to the surrounding area.

1: Soil uses.	AREA A	AREA B	Results
To be valued in terms of the existing vegetation (close to the river, conifers,…)			$V_1=\sum A-\sum B$ $F_1=2/5V_1$
2: Structure of plants.	AREA A	AREA B	Results
To be valued in terms of vegetation characteristics (trees, bushes, grass,...)			$V_1=\sum A-\sum B$ $F_1=1/6V_1$
3: Cover level.	AREA A	AREA B	Results
To be valued in terms of vegetation characteristics (trees, bushes, grass,...)			$V_1=\sum A-\sum B$ $F_1=2/21V_1$
4: Present situation of plant cover	AREA A	AREA B	Results
Very strong, web maintained, weak, stamped,…			$V_1=\sum A-\sum B$ $F_1=1/3V_1$

Table 1 – Factors included in the Index of the natural value of roadsides relative to the surrounding area.
(Own sources)

The index can be calculated with the following expression:

$$I_{VN}=(F_1+F_2+F_3+F_4)/n \qquad (-2\leq I_{VN}\leq 2)$$

Where n is the number of factors which could be measured.

Index of the natural value gained by roadsides.

1: Slopes.	AREA A	AREA B	Results
Strong, medium, flat,...			$W_1=\sum A-\sum B$ $G_1=-2\|W_1\|+2$
2: Arrastre.	AREA A	AREA B	Results
Severe erosion, medium erosion, light erosion,…			$W_2=\sum A-\sum B$ $G_2=1/2W_2$
3: Other material over the ground	AREA A		Results
Lots, medium, few,...			$G_3=\sum A$
4: Crushed ground.	AREA A		Results
Severe, medium, light,...			$G_4=\sum A$
5: Maintenance-restoration works	Exist (1)	Do not exist and are necessary (2)	Exist but it is deteriorated (3)
Ground levelling, sowing,			

drainage, retaining walls,…	$W_2=\sum 1+\sum 2+\sum 3$ $G_2=2$ if do not exist and are necessary $G_2=-2$ si $\sum 2<-3$ $G_2=-2$ si $\sum 2\geq -3$ y $\sum 3<-3$ $G_2=2/3W_2$ si $\sum 1\geq 3$, $\sum 2\geq -3$, $\sum 3\geq -3$ $G_2=2/3W_2$ si $\sum 1\leq 3$, $\sum 2\geq -3$, $\sum 3\geq -3$

Table 2 – Factors included in the Index of the natural value gained by roadsides. (Own sources)

The index can be calculated with the following expression:

$$I_{VA}=(G_1+2G_2+G_3+G_4+2G_5)/(n+1) \qquad (-2\leq I_{VA}\leq 2)$$

Where n is the number of factors which could be measured.

4.2. Methodology for the estimation of the landscape value of road surroundings..

The field card developed for the estimation of the landscape value puts together the quality of the landscape which can be seen from the road with the visual impact produced for the presence of the road.

Landscape value of the road surroundings can be obtained by using the following indexes:

- Index of the quality of the landscape.
- Index of the impact of the road in the landscape.

Parameters considered within each of the indexes are included in tables 3 and 4.

Index of the quality of the landscape.

Ground shape	High differences of height, high mountains, cliffs, valleys,…
Vegetation	Great diversity, some diversity, poor contrast,...
Water	Clear and clean water, water in motion, lack of water,...
Color	Rich combination of colors, some variety of colors, small variety of colors,...
Background	Improves visual quality, small influence,...
Rarity	Extraordinary, really strange, common,...
Cultural modifications	Free of undesired impacts, strong visual impact, visual quality minimized,...
Results	X=∑scores

Table 3 – Index of the quality of the landscape. (Source: Bureau of Land Mananagement, US Forest Service).

The index can be calculated with the following expression:

$$I_{CP}=(4/33)X+1 \qquad (1\leq I_{CP}\leq 5)$$

Index of the impact of the road in the landscape.

Number of observers	High (cities, highways,…), medium (villages, roadways,…), low
Traffic (ADT)	High, medium, low
Interest	High (high interest tourist area), medium (regional tourist area), low (pedestrians, not tourists)
Road location	Very high, high, sea level
Observers location	Important (schools, motorways,...), normal (highways,...), low (industrial areas, farming areas)
Results	Y=∑scores

Table 4 - Index of the impact of the road in the landscape.
(Own sources).

The index can be calculated with the following expression:

$$I_{IP}=(2/3)Y+1 \qquad (1\leq I_{IP}\leq 5)$$

4.3. Factors defining the environmental and landscape value of roadsides.

Natural and gained value at roadsides are joined in order to estimate the environmental value; a reference matrix included in table 5 is used; the highest the natural and gained values are, the better is the environmental value.

Similarly, landscape value can be obtained by using a reference matrix included in table 6, where quality of landscape and impact of road in the landscape are the inputs.

Reference environmental value matrix

		Natural value				
		-2	-1	0	1	2
Gained value	-2	Very bad	Very bad	Medium	Good	Good
	-1	Very bad	Bad	Medium	Good	Good
	0	Very bad	Medium	Good	Very good	Very good
	1	Bad	Medium	Good	Very good	Very good
	2	Bad	Medium	Good	Very good	Very good

Table 5 – Reference environmental value matrix
(Own sources)

Reference landscape value matrix

		Quality of landscape				
		1	2	3	4	5
Impact	1	Very bad	Very bad	Bad	Medium	Good
	2	Very bad	Very bad	Bad	Medium	Good

	3	Very bad	Bad	Medium	Good	Good
	4	Very bad	Bad	Medium	Good	Very good
		Bad	Medium	Good	Very good	Very good

Table 6 – Reference landscape value matrix
(Own sources)

A road section showing an environmental value and a landscape value of “good” or “very good” could be considered as an ecological corridor. An example is included in figure 2 .

Example of a road which could be considered as an ecological corridor

Figure 2 – Example of a road which could be considered as an ecological corridor

5. RECOMMENDATIONS.

Once the evaluation tool is available it is possible to know the environmental and landscape value of a road and its surroundings. Thus, it is necessary to develop a set of recommendations for the maintenance and protection of these areas, which would constitute the next stage of the project. Some of the work lines could be:

- Installation of specific signing at roads with high ecologic value, so that drivers are concerned in the necessity of driving carefully because of possible presence of animals and also the importance of taking care of plants.
- Implementation of measures to avoid accidents with animals, by improving conditions in habitats in order to avoid long movements of animals, construction of specific crossing facilities for animals, do not using salt for winter maintenance,…
- Limitation of traffic volume and reduction of speed in high value areas, so that the negative impact in wildlife could be reduced.
- Development of maps of ecological corridors and roads, so that drivers could be informed about the ecological value of the roads they use.

Complementary, this tool could be also used to monitor the development and evolution of ecological corridors, considering animals and plants.

Lastly, the methodology showed could be used to value the effectiveness of different road management policies (adaptation of specific crossing facilities for animals, effectiveness of replant activities, protection of habitats,…)

6. CONCLUSSIONS.

Roads should not be considered as elements breaking the territory; on the contrary, under certain circumstances, roads not only do not break the ecosystem, but also can behave as an element of connection between areas with different natural resources and diversity, resulting in a diversity even greater.

It is possible to state that, within the appropriate context, a road and its surroundings could have even a higher natural diversity than if the road does not exist.

A methodology for the evaluation of the environmental and landscape value of the road surroundings has been developed, based on the collection of data at field. This tool can be used as an element to value the effectiveness of different road management policies and to set up a set recommendations for the maintenance of roads with a high ecological value.

Following stages of the project will allow to value the possibility of application of this methodology over a whole road network.

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