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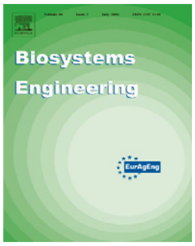

Research Paper: RD—Rural Development

A multicriteria assessment model for evaluating droving route networks

A. Cazorla[a,*], *I. De los Ríos*[a], *J. Merino*[b], *J.L. Alier*[b]

[a]*Planning and Management of Sustainable Rural Development Research Group, Departamento de Proyectos y Planificación Rural, Universidad Politécnica de Madrid, E.T.S.I Agrónomos, Ciudad Universitaria s/n, 28040 Madrid, Spain*
[b]*Departamento de Tecnología Industrial, Universidad Alfonso X El Sabio, Spain*

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A model was developed for the classification and assessment of droving routes of high ecological value, based on the use of scalar methods and the definition of value functions. The model provides a new planning tool for use in decision-making and the sustainable management of these corridor zones. This is the first such model to involve an assessment process requiring (a) the definition of the possible uses of droving routes, (b) their division into sections, (c) the definition and use of assessment indicators, (d) the evaluation of sections with respect to their uses and (e) assessments with regard to each individual use, plus an overall use assessment. The model was validated in a rural area of Spain, a country whose droving routes make up a dense network some 125,000 km in length and which occupy some 442,000 ha. The study area was in the southwest of the Province of Madrid, which has 14 droving routes all catalogued as being of historic-cultural interest. The results showed the advantages of using scalar methods for the assessment of this type of corridor, bearing in mind that, while they act as linear communication networks, these corridors also occupy large areas of land that could be used for different activities. The main novelty of the multicriteria method used in the model lies in the use of indicators and value functions.

1. Introduction

With the first cataloguing of greenways, undertaken in America by Little (1990), '*historical routes of high cultural value*' (e.g., droving routes) appeared in the literature as one of a number of possible types of ecological corridor zones. This author also offered the first definition of the term "greenway": *an open, linear space that connects parks, natural reserves, historic sites, cultural and recreational spaces, with one another and with population nuclei* (Little, 1990). This definition acted as a starting gun for international debate (Forman, 1991; Smith, 1993; Schwarz, 1993; Thorne, 1993; Flink and Searsns, 1993) on the importance of these corridor zones with respect to the landscape and multifunctionality of the land. The origin of greenway planning goes back to the beginning of landscape architecture as a profession in the United States (Fábos, 2004).

Currently, droving routes and the ecological networks of which they are a part of are becoming increasingly important in rural development in Europe. The complex interactions between historic-cultural and natural features result in different ways of managing these networks (Jongman et al., 2004). Droving routes have traditionally been used for the movement of livestock, but are now seeing their ecological and social functions expanded. These changes, along with

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*Corresponding author. Tel.: +341 610 877 699.
E-mail address: adolfo.cazorla@upm.es (A. Cazorla).

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Nomenclature

$A_{(x,\ k)}$	index the official/legal value, of section x and use k
C_x	carrying capacity of the physical environment for a particular section x
C_i	indicator for the carrying capacity for a particular use i
$C_{(x,\ k)}$	index value for the carrying capacity, of section x and use k
c_{ij}	indicator of the connectivity of the section i with area j
I_x	matrix of indicators for a corridor section x
I_{jkx}	indicator j for use k in section x. Possible k indicators are: 1, the carrying capacity for use k in section x of the physical medium; 2, transitability; 3, connectivity of the section; and 4, intensity of current use. The possible uses of k are: 1, the movement of livestock; 2, the movement of vehicles and agricultural machinery; 3, linear plantations; 4, walking and hiking; 5, sporting movement in non-motor vehicles (largely cycling); and 6, riding.
M	number of possible uses of each section of the corridor
N	number of environment variables
O_i	coefficient that defines the importance of the activity in section i
$P_{(x,\ k)}$	index value for the potential use, of section x and use k
$Q_{(x,\ k)}$	index value for connectivity, of section x and use k
r_{ij}	environment variable j that corresponds to use i
S_j	coefficient defining the importance of the activity in area j
$S_{(x,\ k)}$	index value for the social preferences, of section x under use k
$T_{(x,\ k)}$	index value for transitability, of section x and use k
T_{ij}	mean distance separating section i and area j
$TVU_{(x)}$	total value for all uses in each section x
$TVU_{(x,\ k)}$	total value for use k in section x
$U_{(x,\ k)}$	index value matrix of current use of section x and use k
X	coefficient defining the importance of a particular activity with respect to T_{ij}
$v_{(x)}$	value function attributed to a particular current and potential uses of a section x

the new reality of the rural world, have led these corridor zones into a time of profound transformation. However, the absence of specific planning models for these routes has led to the degradation of corridor zones in many parts of Europe (Cazorla, et al. 2004).

Droving routes present a clear example of multifunctionalism since they have ecological, social and productive functions (Conine et al., 2004; Bennet, 1991; Gobster and Westphal, 2004); this has become the main argument for their protection and conservation. In the context of European integration, networks of these corridor zones are becoming increasingly important, both socially and ecologically (Jongman et al., 2004).

The classification and multicriteria assessment of droving route networks can be approached through the use of scalar methods and the definition of value functions that reflect the preferences of an expert or a decision-maker. The use of such methods in environmental and land-use planning has solved problems in the case of undertaking simultaneous activities and the optimisation of land use (Geman and Geman, 1984; Jellet, 1990; Martínez et al., 1995, 1998).

Consideration of the possible relationships between territories and the activities to be undertaken within them led to the identification of two basic regional planning concepts: carrying capacity and impact (Ramos, 1979). Several models have been proposed for the determination of these two concepts. The models have involved the development of scalar (Martínez et al., 1989; Pincus, 1968; Ripley, 1988) and simulation techniques (simulated annealing) (Jellet, 1990; Vidal, 1993; Mitra et al., 1986; Kinderman and Snell, 1980; Collins, 1988; Cerny, 1982). However, no models appear to have been developed for the multicriteria assessment of droving routes and their unique features. The results of such models could be used in their management or in territorial planning. The present work describes a new assessment model for the management of these multifunctional corridor zones, using scalar and simulation methods in a novel way.

2. Methodology. Materials and methods

The use of the proposed model includes the following stages (Fig. 1): (**A**) the definition of the current and **potential uses** of all the droving routes belonging to the network in question; (**B**) their **division** into sections and the determination of variables to be used in their assessment; (**C**) the **design of indicators** for assessing each section; (**D**) the **assessment of the sections** with respect to their uses; and (**E**) **overall assessment** of droving route sections.

2.1. *Definition of the potential uses of a network of droving routes*

The first step is to decide upon the possible uses of the droving routes forming the network, and their classification into categories. This is done by examining the features of the territory through which these corridor zones run. For example, when the model was tested, the possible uses of the studied droving routes were classed into six categories: a main use (i.e. the movement of livestock), two categories of compatible uses (i.e. transport and the movement of agricultural vehicles, and linear plantations) and three categories of complementary uses (i.e. walking and hiking, riding and the sporting use of non-motorised vehicles [largely cycling]). The best results in planning for corridor zones are obtained when

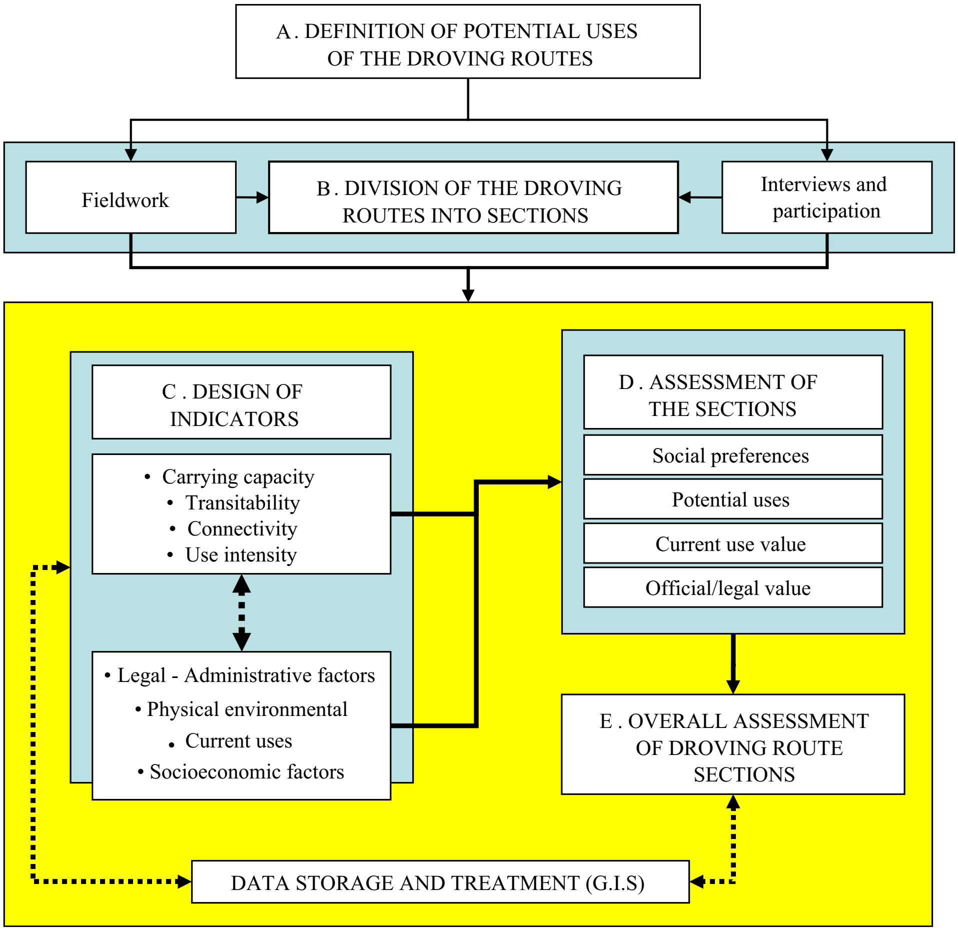

Fig. 1 – Proposed model for assessing networks of droving routes: methodological process.

multiple objectives such as environmental protection, recreation and transport are considered together (Conine et al., 2004; Gobster and Westphal, 2004).

2.2. *Division of the droving routes into sections, and their assessment variables*

The length of droving routes (sometimes hundreds of kilometres long) means their characteristics can change as one travels along them; the characteristics of the territories they cross can also change. Their resulting heterogeneous nature (wide, straight, well conserved and documented in some areas, yet narrow, winding and with degraded pasture in others) means their uses can change (Gómez Sal, 1996). Therefore, for their analysis, it is advisable to divide these routes into homogeneous sections. These form the basic territorial unit for the classification and assessment of droving route networks (Cazorla et al., 2004), and therefore form the territorial basis for the production of an inventory—a relational database holding data such as the physical characteristics of each section, the type of road surface, the state of repair, etc. The division of droving routes into these sections relies on visual information plus details provided by maps, and takes into account significant alterations in their perceivable features. Table 1 shows the features used in the validation of the model discussed in Section 3. The inventories produced during fieldwork are also used to identify the indicators to be used in the assessment of the sections.

2.3. *Design of indicators reflecting the uses of a droving route network*

The construction of any index requires the definition of an integrated value encompassing information on many factors. The use of indicators makes it possible to transform each point or unit of a territory into a vector composed of multiple components. This integration is performed using scalar techniques (Martínez Falero et al., 1995). The division of a corridor into sections, whose possible uses are limited and known *a priori* (Kirpatrick et al., 1982), simplifies the treatment of this information. Stochastic methods (Azzencott, 1987; Azzencott et al., 1992) can be used as an alternative when a great deal of information needs to be analysed (Jellet, 1990). When using scalar methods, the definition of value functions is helpful. Value functions reflect the preference system of a decision-maker stating how beneficial it is for the decision-maker to be in a certain state. The value function $v(x)$ is defined as:

$$\begin{aligned} & v : X \to \Re \\ & f_1(x_1),\ldots,f_n(x_n) \to v[f_1(x_1),\ldots,f_n(x_n)] \equiv v(x) \\ & v(x) \in \Re, \quad \forall x \in X \end{aligned} \qquad (1)$$

Table 1 – Features characterising the sections of a network of droving routes

Key features	Attributes
Physical environment of the section under examination	• Vegetation and land use • Altitude and topography, landscape • Presence of protected natural areas
Current characteristics of the section under examination	• Gradient • Width • Type of surface and state of repair • Vegetation present • Accessibility
Current uses of the section under examination	• Intensity of use • Presence of linear plantations • Instances and types of usurpation, yielding of some part of a corridor for an authorised use
Legal and administrative factors	• Type or category of droving route • Official/legal category • Inclusion within or proximity to protected areas
Socio-economic factors	• Connectivity: capacity to provide access to other points in the territory • Transitability: current ability of sections to facilitate the movement of people, animals or vehicles, and to facilitate the use of sections in the surrounding area (local and area uses)

Fishburn (1970) showed that a finite set of corridor sections has a value function if the assessor has a system of preferences that can be used when making decisions. This value function can be decomposed in different ways (additively, multiplicatively, partially additively or polynomially, etc.) according to the relationships between the objectives of the decision-maker's preference system (Kinderman and Snell, 1980; Alier et al. 1996).

In the case of multifunctional droving routes, the indicators used should provide information on the current status of the sections and on their potential with respect to the different uses considered. For this, and with respect to the information recorded in the inventory, four major indicators are used: the carrying capacity; transitability; connectivity; and intensity of use.

2.3.1. *Carrying capacity of the physical environment*

To determine the carrying capacity, traditional territorial planning methods (Aguiló and Iglesias, 1995; Aguiló et al., 1998) can be used, as well as the tools and indicators of environmental planning (Botequilha and Ahern, 2002). For the integration of values, scalar methods and function values can be used. When determining the carrying capacities for the different uses of a section *x* of a droving route, the relationship between each environmental variable and use can be expressed as:

$$C_x = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix} \qquad (2)$$

where r_{ij} is the environment variable *j* that corresponds to use *i*, *m* is the number of possible uses of each section of the corridor $\Rightarrow i = 1,2\ldots,m$ and *n* is the number of environmental variables under examination $\Rightarrow j = 1,2\ldots,n$.

The rows of this matrix, with n components ($r_i = [r_{1i}, r_{2i}, \ldots, r_{ni}]$), represent the indicators of the carrying capacity for each use of a section. This value function has an additive decomposition (assuming mutual and preferential independence between the objectives defined by the decision-maker). Thus, for a use *i* (C_i), the indicator for the carrying capacity is obtained as follows:

$$C_i = \sum_{j=1}^{n} k_j v_{ij} \qquad (3)$$

where k_j is the weighting coefficient for the environment variable *j*. v_{ij} is the value of the class corresponding to the environment variable *j* in use *i*.

Any appropriate method can be used to determine the weighting coefficients. To determine the carrying capacity of the physical environment, it is helpful to use social research techniques such as the Delphi method; this helps incorporate the opinion of the local population and droving route users.

2.3.2. *Transitability*

The transitability of a corridor section can be defined as the intrinsic nature of the section to facilitate the movement of people, livestock and vehicles. The markers of transitability reflect the current situation and at the same time provide information on the potential of the corridor with respect to its potential uses. Table 2 shows the variables proposed for assessing transitability.

2.3.3. *Connectivity*

An analysis of connectivity is vital since this variable is of great importance in the management of droving route networks (Vilesa and Rosier, 2001). The connectivity of a corridor can be defined as its capacity to allow access to another area of a territory with the aim of permitting an activity in that area. Gravity indices (Echenique, 1975; Aguiló et al., 1998) can be used to define the indicators of connectivity in each section of a corridor. These indices provide information on a group of points in a communications network, and allow the inclusion of environmental and socioeconomic data. The expression describing the connectivity of a section is (Aguiló et al., 1998):

$$c_{ij} = \frac{O_i S_j}{T_{ij}^{x}} \qquad (4)$$

where, for a corridor section *i* and another area *j* of the territory, c_{ij} is the connectivity of the section *i* with area *j*. O_i

Table 2 – Variables for assessing transitability according to the use of a corridor

Selected variables	Use of corridor				
	Movement of animals	Movement of vehicles and agricultural machinery	Walking and hiking	Sporting movement in non-motorised vehicles (largely cycling)	Riding
Types of usurpation perceived along the section	x	x	x	x	x
Useful width of the section	x	x	x	x	x
Type of surface and state of repair	x	x	x	x	x
Width of the road surface			x	x	
Interruptions of the section (type and quantity)	x	x	x	x	x
Intersections with roads	x	x	x	x	x
Gradient of the section	x	x	x	x	x

the coefficient that defines the importance of the activity undertaken in section i. S_j the coefficient defining the importance of the activity undertaken in area j. T_{ij} the mean distance separating section i and area j. and X is the coefficient defining the importance of the activity with respect to T_{ij}.

Social, research techniques can also be used to determine the above coefficients; this allows the opinion of the local population and corridor users to be taken into account.

2.3.4. *Use intensity*

This is determined by assessing the intensity of use on an ordinal scale (high, medium, low or none) during field work. The information that can be gathered *in situ* includes the type of vegetation present, the type of road surface and its state of repair, usurpation of the route, obstacles to passage and the presence of materials left behind by people, animals and vehicles, etc. (Table 3). Territorial analysis of the environment facilitates the calculation of these use intensity variables and better reflects interactions at the area level (Sancho, 1998). This information should be complemented by interviewing the local population.

Once these four main indicators have been examined, each section of the corridor can be represented in a 6 × 4 matrix, the six rows and four columns corresponding, respectively, to the uses and indicators mentioned above. The expression of the matrix for a section x is therefore:

$$I_X = \begin{pmatrix} i^x_{11} & i^x_{12} & i^x_{13} & i^x_{14} \\ i^x_{21} & i^x_{21} & i^x_{21} & i^x_{21} \\ i^x_{31} & i^x_{32} & i^x_{33} & i^x_{34} \\ i^x_{41} & i^x_{42} & i^x_{43} & i^x_{44} \\ i^x_{51} & i^x_{52} & i^x_{53} & i^x_{54} \\ i^x_{61} & i^x_{62} & i^x_{63} & i^x_{64} \end{pmatrix} \tag{5}$$

where I_x is the matrix of indicators for a corridor section x, $i^{x}{}_{j\,k}$ the value of the indicator j for use k in section x. The possible *indicators* j are 1, the carrying capacity of the physical medium; transitability, connectivity of the section, and the intensity of current. The possible uses k are the movement of livestock, the movement of vehicles and agricultural machinery, linear plantations, walking and hiking, sporting movement in non-motor vehicles (largely cycling) and riding.

Some matrix cells will remain vacant since for some uses it is not necessary to take certain indicators into account. For example, with respect to linear plantations the indicators of transitability and connectivity need not be evaluated.

2.4. *Assessment of sections with respect to their uses*

The following stage requires the integration of the four indicators for each corridor section with information regarding social preferences and the official/legal category of the droving route in question (Fig. 2).

2.4.1. *Assessment according to social preferences*

The importance of the social dimension in the management of multifunctional droving routes has recently been reported by several authors (Gobster and Westphal, 2004; Ryan and Hansel Walker, 2004); certainly the population stands to be a major beneficiary of any such planning. Ackoff (1984) indicated that development is a product of learning, not of production. This idea, the roots of which lie in the principles of social learning (Cazorla and Friedmann, 1995; Friedmann, 1993), has been developed and applied in different studies on planning (Cazorla et al 2005; Alier et al., 1999); the latter can be synthesised by the slogan ‘learn by changing reality’. This requires that an attempt be made to understand the population’s aptitudes and attitudes; only then can its preferences and needs be incorporated into the assessment model.

Table 3 – Variables used to determine current use intensity according to the type of use

Type of use	Variables considered
Livestock	• Number of animals involved; use in transport should be noted • % area of the municipality occupied by meadows, plains and pasture land • % area of the municipality occupied by fallow land, grazing land and crops • % of the population occupied in agriculture (with respect to the total occupied population)
Compatible uses	• % of the agricultural area with respect to the entire area of the municipality • Amount of agricultural machinery using the section • % of the population occupied in agriculture (with respect to the total occupied population)
Complementary uses	*Resources of the physical, historic-cultural and socio-cultural environment:* • Type of cultural resources (including natural and scientific-educational resources) • Type of historic-cultural, architectural and archaeological resources • Fiestas and traditions, gastronomy, folklore, folk customs *Leisure: possibilities on offer:* • Rural accommodation, restaurants • Sale of local and artisan made products • Complementary activities: sport, leisure *Analysis of tourist demand in the municipality:* • Number and types of visitors (their level of education, profession, etc.) • How tourists arrive at and move around the area • Types of visit (number of times the municipality is visited, length of stay, distribution of visits by season, motivation behind visit and degree of satisfaction) • Consumption of goods and services (type of accommodation selected, amount of money spent on accommodation and in restaurants, complementary activities, level of hotel occupancy)

The integration of this social information generates the following social preference matrix $S_{(x,k)}$:

$$S(x,k)=\begin{pmatrix} s_{11} & s_{12} & s_{13} & s_{14} & s_{15} & s_{16} \\ s_{21} & s_{22} & s_{23} & s_{24} & s_{25} & s_{26} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ s_{n1} & s_{n2} & s_{n3} & s_{n4} & s_{n5} & s_{n6} \end{pmatrix} \tag{6}$$

$S_{x,k}$ is the assessment according to social preferences of section x under use k, x the section number ($x = 1,2\ldots,n$) and k is the activity or use considered.

2.4.2. *Assessment according to potential use*

This estimates the current value of the section with respect to its ability to take on a certain use, and can be obtained by integrating the carrying capacity, transitability and connectivity. The potential use value of section x under use k, $p_{(x,k)}$, can be expressed as the additive function:

$$p_{(x,k)}=\alpha_1 c_{(x,k)}+\alpha_2 t_{(x,k)}+\alpha_3 q_{(x,k)} \tag{7}$$

where, for section x and use k: $c_{(x,k)}$ is the index value for the carrying capacity, $t_{(x,k)}$ is the index value for transitability, $q_{(x,k)}$ is the index value for connectivity and α_1, α_2, and α_3 are the weighting coefficients for each of the above indicators.

2.4.3. *Assessment according to current use*

The current use value was obtained above via the determination of the values for the use intensity indicators. The matrix that expresses the assessment of current use for each section x under use k is the following:

$$U(x,k)=\beta\begin{pmatrix} v_{11}w_{11}z_{11} & v_{12}w_{12}z_{12} & v_{13}w_{13}z_{13} & v_{14}w_{14}z_{14} & v_{15}w_{15}z_{15} & v_{16}w_{16}z_{16} \\ v_{21}w_{21}z_{21} & v_{22}w_{22}z_{22} & v_{23}w_{23}z_{23} & v_{24}w_{24}z_{24} & v_{25}w_{25}z_{25} & v_{26}w_{26}z_{26} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ v_{n1}w_{n1}z_{n1} & v_{n2}w_{n2}z_{n2} & v_{n3}w_{n3}z_{n3} & v_{n4}w_{n4}z_{n4} & v_{n5}w_{n5}z_{n5} & v_{n6}w_{n6}z_{n6} \end{pmatrix} \tag{8}$$

The use index values obtained for each use and each section are classified as either very high, high, medium, low or nil.

2.4.4. *Assessment according to official/legal category*

Knowledge of the official/legal categories of multifunctional droving routes is essential in decision-making (Conine

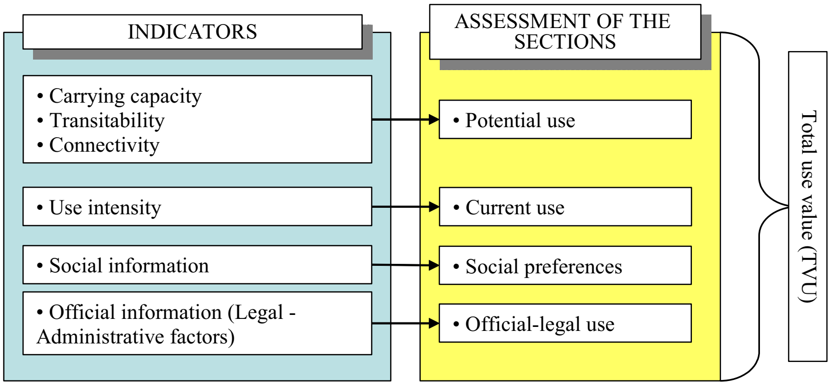

Fig. 2 – Structuring of indicators for assessment of sections and constructing the TVU.

et al., 2004). The official/legal category could either increase or decrease their overall value. The factors involved in the 'official value' include: the category of the route with respect to its legal classification, the protection afforded it, the presence of protected natural areas along it and other official/legal factors (authorised usurpations, etc.) For the determination of the value function for a section x under use k, multiplicative decomposition can be used:

$$A_{(x,k)} = \gamma b_{(x,k)} c_{(x,k)} d_{(x,k)} e_{(x,k)} \tag{9}$$

where $A_{(x,k)}$ is the official/legal value with respect to current use k in section x, $b_{(x,k)}$ is the value of the administrative status of the section (e.g., whether its limits are officially recognised on a map, whether it has milestones, etc.), $c_{(x,k)}$ is the value of official/legal category of the section, $d_{(x,k)}$ is the value regarding the presence of protected natural areas, $e_{(x,k)}$ is the value for the presence of other official factors and γ is the weighting coefficient for each value function.

In the majority of cases, the determination of the official value of a section is simplified since the different sections of a corridor may often take on the same value. The global matrix expressing these administrative-type evaluations is similar to the last matrix, and values of 'very high, high, medium, low and very low' are used to qualitatively characterise the numerical result.

2.5. *Overall assessment of droving route sections*

The four assessments, social preferences of use, potential uses, current uses and official/legal category, allow the different sections to be ordered and compared. The proposed model requires two integrations now be performed: (1) the integration of the value functions to obtain the total value for use k in section x, $TVU_{(x,k)}$, and (2) the integration of the values to obtain a total value for all uses in each section x, $TVU_{(x)}$. For the first of these, the overall value function can be obtained via an additive decomposition process involving the four value functions:

$$TVU_{(x,k)} = \eta_1 S_{(x,k)} + \eta_2 P_{(x,k)} + \eta_3 U_{(x,k)} + \eta_4 A_{(x,k)} \tag{10}$$

where $S_{(x,k)}$ is the value for social preferences, $P_{(x,k)}$ is the value for potential use, $U_{(x,k)}$ is the value or current use, $A_{(x,k)}$ is the value for official/legal category and η_1, η_2, η_3, η_4: weightings for each of the values.

The mathematical expression of this is

$$\begin{pmatrix} VTU_{11} & VTU_{12} & VTU_{13} & VTU_{14} & VTU_{15} & VTU_{16} \\ VTU_{21} & VTU_{22} & VTU_{23} & VTU_{24} & VTU_{25} & VTU_{26} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ VTU_{n1} & VTU_{n2} & VTU_{n3} & VTU_{n4} & VTU_{n5} & VTU_{n6} \end{pmatrix}$$
$$= \eta_1 \begin{pmatrix} s_{11} & s_{12} & s_{13} & s_{14} & s_{15} & s_{16} \\ s_{21} & s_{22} & s_{23} & s_{24} & s_{25} & s_{26} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ s_{n1} & s_{n2} & s_{n3} & s_{n4} & s_{n5} & s_{n6} \end{pmatrix}$$
$$+ \eta_2 \begin{pmatrix} p_{11} & p_{12} & p_{13} & p_{14} & p_{15} & p_{16} \\ p_{21} & p_{22} & p_{23} & p_{24} & p_{25} & p_{26} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ p_{n1} & p_{n2} & p_{n3} & p_{n4} & p_{n5} & p_{n6} \end{pmatrix}$$
$$+ \eta_3 \begin{pmatrix} u_{11} & u_{12} & u_{13} & u_{14} & u_{15} & u_{16} \\ u_{21} & u_{22} & u_{23} & u_{24} & u_{25} & u_{26} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ u_{n1} & u_{n2} & u_{n3} & u_{n4} & u_{n5} & u_{n6} \end{pmatrix}$$
$$+ \eta_4 \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & a_{n4} & a_{n5} & a_{n6} \end{pmatrix} \tag{11}$$

For the second integration, the total value for the use (TVU) of a given section can also be determined by additive decomposition:

$$\begin{aligned} TVU_{(x)} = {} & \lambda_1 TVU_{(x,1)} + \lambda_2 TVU_{(x,2)} + \lambda_3 TVU_{(x,3)} \\ & + \lambda_4 TVU_{(x,4)} + \lambda_5 TVU_{(x,5)} + \lambda_6 TVU_{(x,6)} \end{aligned} \tag{12}$$

where 1 is the movement of animals; 2 the movement of vehicles and agricultural machinery; 3 the linear plantations; 4 the walking and hiking; 5 the sporting use of non-motorised vehicles; 6 the riding. λ_1, λ_2, λ_3, λ_4, λ_5, λ_6 the weighting coefficients for each of the uses taken into account.

The matrix expression for the TVU for a section is therefore:

$$TVU(x) = \begin{pmatrix} TVU_1 \\ TVU_2 \\ \vdots \\ TVU_n \end{pmatrix}$$
$$= \begin{pmatrix} TVU_{11} & TVU_{12} & TVU_{13} & TVU_{14} & TVU_{15} & TVU_{16} \\ TVU_{21} & TVU_{22} & TVU_{23} & TVU_{24} & TVU_{25} & TVU_{26} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ TVU_{n1} & TVU_{n2} & TVU_{n3} & TVU_{n4} & TVU_{n5} & TVU_{n6} \end{pmatrix}$$
$$\times \begin{pmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{pmatrix} \tag{13}$$

The results of the integration allow the different sections to be classified according to their value indices and qualitative value class.

3. Using the model in rural areas of Spain

The droving routes of Spain are recognised as an important part of the country's historical heritage. The network is composed of wide routes, along which there are resting places, bridges and drinking troughs. Although similar networks are found in other countries (notably in the Mediterranean), none are as large as those of Spain, which covers some

125,000 km and occupies some 422,000 ha of land (0.83% of the country's surface area). The proposed model was tested in the Madrid Province (central Spain) which has an extensive network of some 1796 droving routes measuring 4168 km in length and covering a surface area of 13,093 ha (Cazorla et al., 2004). The study area was the extreme southwest of the province; the area (Fig. 3) is home to the municipalities of Rozas de Puerto Real and Cadalso de los Vidrios and has a population of 33.4 inhabitants/km^2. Essentially rural in terms of its landscape, land uses and socioeconomic activities, the area boasts 14 droving routes measuring a total of 54 km in length. All these corridor zones fall within the protected area of *Encinares del Río Alberche y Cofio*, which has been declared an area for the special protection of birds and is a the focus of an EU Leader initiative. This area was selected because of the large amount of information available for it. The cartographic scales used were 1:25,000 and 1:5000; this provides an adequate degree of detail for the model.

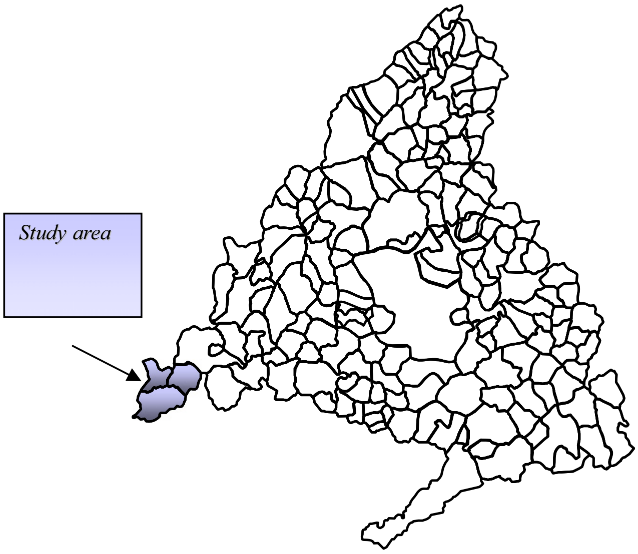

Fig. 3 – Geographic location of the study area within the Province of Madrid.

Table 4 – Classification of TVU. Summary of results, Madrid Province, 2003/04

TVU result for each section	Value
>12,5	Very high
>10 but ⩽12.5	High
>7.5 but ⩽10	Medium
>5 but ⩽7.5	Low
⩽5	Very low

4. Results and discussion

Inventories were made for the 14 corridor zones studied. The network was divided into 64 sections, each of which was characterised using the four indicators mentioned above, and by social preferences regarding use, potential use, current use and official/legal category. The final TVU results were classified on a five-point scale (Table 4).

The studied corridor zones were mostly in good repair and had high potential for different uses (livestock movements, rural communications, hiking, riding, sporting movement of non-motorised vehicles, linear plantations, etc.). The final TVUs were mostly between 7.5 and 10 (medium values), although some sections had a high or a very high value (Table 5).

The indices in Table 6 reveal a certain preference that the droving routes be used for livestock movements and complementary activities (tourism, sport). This is because the study area is moderately intensely exploited for raising stock

Table 5 – Final values for the droving routes studied. Summary of results, Madrid Province, 2003/04

Corridor name	No. of sections identified	Length (m)	TVU of the corridor	
			Index	Class
Cañada Real Leonesa	5	3000	13.20	Very high
Cordel del Boquerón	6	6700	10.39	High
Colada del Camino de la Higuera	2	2000	9.97	Medium
Colada de la Higuera	5	6000	9.06	Medium
Colada del Camino de Escalona	6	5000	8.90	Medium
Colada del Camino Real de Escalona	4	5800	8.89	Medium
Colada del Poniente	5	2000	8.86	Medium
Colada del Camino del Castañar	6	2500	8.76	Medium
Colada de los Cuatro Caminos	3	1460	8.56	Medium
Colada de las Majadillas	3	1700	7.87	Medium
Colada del Camino de Navahondilla	3	1400	7.81	Medium
Colada del Mediodía	3	1300	7.64	Medium
Colada del Saliente	3	6000	4.47	Very low
Cordel de San Juan	10	10,000	7.76	Medium
Total	64	54,860	8.72	

Table 6 – Average use indices for the corridor network. Summary of results, Madrid Province, 2003/2004

	Average values for indices of use					Total (TVU)
	Movement of livestock	Movement of vehicles and agricultural machinery	Walking and hiking	Sporting movement	Riding	
Mean	3.10	2.64	3.10	2.97	2.99	8.72
Median	3.07	2.74	3.08	2.98	3.01	8.81

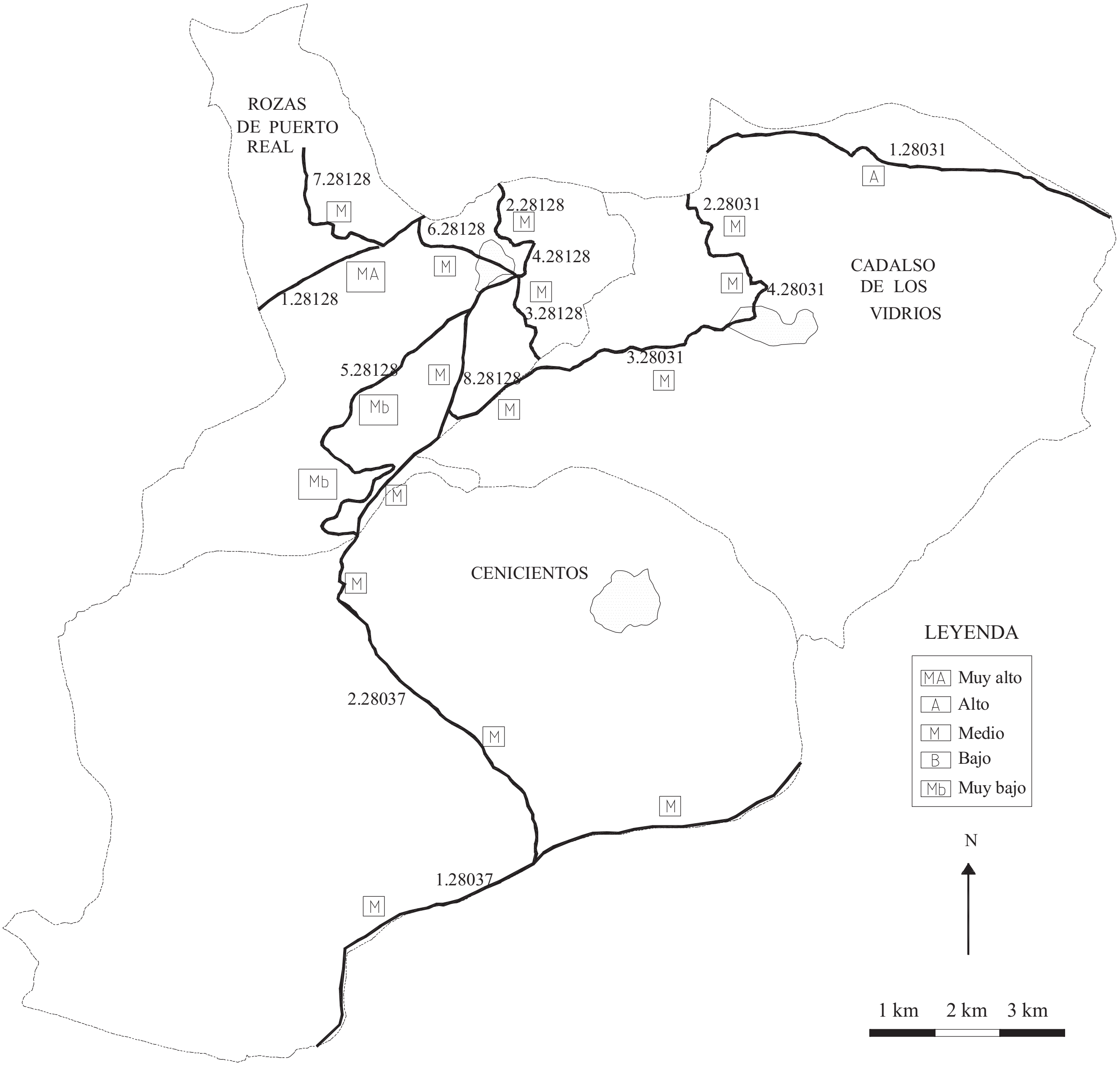

Fig. 4 – Overall assessment of the corridor zones.

(which contributes towards the conservation of the droving routes), and in that landscape, environmental and historic-cultural characteristics of the area favour tourism and other complementary activities.

The results obtained provide an overview of the droving route network. An analysis of the final use values is important for a complete understanding of the network's multifunctional nature. The values for each section of the corridor zones, the main units in the synthesis of information, reflect their uses (both current and potential), which are important in the management of the network. The mean TVU for the 64 sections considered was 8.72, with individual values being mostly medium or high: five sections (7.8%) had very high values, 15 (23.4%) had high values, 28 (43.8%) had medium values, 15 (23.4%) had low values and one (1.5%) had a very low value. The mean length of the sections was 857 m, quite a short distance, because of the great diversity of landscape and land use. The section with a very low value was associated with usurpations that greatly inhibited the movement of any kind of traffic. Fig. 4 shows a map, based on information in the GIS associated with the model, that provides the resulting TVUs for each of the corridor zones studied.

5. Conclusions and recommendations

The public sector planning and management of droving route networks should nowadays regard them as having multiple uses and functions. In addition to facilitating the movement of livestock, they have important social, cultural and ecological functions. The model is the first to incorporate a synthesis of specific information in order to obtain values for the current and potential uses of these corridor zones. The integration of the information in the inventory via the use of indicators and the employment of scalar techniques allow social preferences to be taken into account. The main novelty of the model arises from the use of scalar techniques for the assessment of the routes examined, via the use of indicators and specific value functions adapted to their characteristics. The model could be employed in a great diversity of territorial contexts, and its use in the present work shows that the role of these corridor zones should be taken into account in their management. The model also provides information on different sections of the corridor zones as well as for its entirety, which may allow decisions to be taken with different interests in mind.

The results obtained with the model in the study area show how the territory crossed by droving routes can influence the values obtained. In this case, the movement of livestock and agricultural machinery was still important; however, the physical environment and landscapes through which the corridor zones pass invest them with other possible uses, such as walking, hiking, riding and cycling. The usurpation rate was low, the most common type being the expansion of private estates and agricultural land. Some of the sections, however, had become irreversibly occupied, which shows that planners and managers need to study possible changes in the course of some corridor zones as part of a global conservation strategy. Knowing the index of connectivity and the characteristics of such usurpation would be of great help in this.

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