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Optimizing shared recreational vehicle service areas: A multi-strategy approach for economic performance and user satisfaction

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Abstract

In order to reduce overtourism and traffic congestion, local authorities may have to divert recreational vehicle traffic to off-site service areas. The problem that will arise is how best to accommodate different types of users with opposing preferences in the same area, some wanting to be as close as possible to the major site to be visited, others seeking peace and quiet. We have represented their specific attitudes using a two-stage decision-making process via a conjunctive model followed by a compensatory model. We then propose to model three strategies, seeking either to optimise customer attractiveness, or profit, or space occupation, in order to define a location, capacity and price for this shared area. Using a realistic data set, the results show that economic performance follows a concave curve as a function of the population mix. Moreover, only the strategy of maximising attractiveness suggests always mixing users in the same area.

Keywords

overtourism, recreational vehicles, service areas, optimisation, heterogeneous preferences

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Introduction

The pressure on popular tourist sites is leading them to evolve. Seasonal peaks in visitation are increasing. Better management of flows, especially in summer, can reduce this pressure. Moreover, in such a context of overtourism (Mihalic, 2020; Pechlaner et al., 2020), uncontrolled demand will have a negative impact on both territories and local communities (Capocchi et al., 2019). Different *tourism exit strategies* (*trexit*) have been implemented to reduce the environmental impact and the saturation of certain sites (Seraphin et al., 2018). Among these, the EU *Committee on Transport and Tourism* aims to stimulate and assist organizations to spread visitors around and beyond crowded destinations (Peeters et al., 2018). They invite stakeholders to (*i*) create events in the less visited parts of these places and in neighbouring areas, (*ii*) create a common identity of these destinations with their neighbouring areas and (*iii*) market the whole tourism region to stimulate visitation to the less visited parts. In the same vein, Vlès (2019) notes the lack of a global vision for developing sustainable tourism in a study of tourist flows in the Pyrenean protected natural areas. He recommends managing the flows in a complementary manner by distributing them and linking different territorial resources to develop more diversified tourism. Within a framework of a sustainable approach to tourism, it is not a question of welcoming more people on already overcrowded sites, but of welcoming them better, with a constant concern for the protection of the environment. Motorists, buses, motorcyclists and some recreational vehicle users (RVers) often seek parking near a popular site for the duration of their visit, often planned on a reservation site. They then organise their onward journey and accommodation or off-site parking. In the case of recreational vehicles (RVs) wishing to stay several days, a service area is both a parking place and a place to spend a few nights allowing them to fill up with water, empty grey and black water and recharge their batteries because their electrical autonomy is only two to three days (Boulin and Perroy, 2007). As the average growth rate of the RV market is estimated at 4% per year between 2023 and 2032 (GMI, 2023), service areas will continue to fill up. The decision to divert RV flows to external service areas in order to reduce overtourism raises the question of how to accommodate different populations of RVers with different or even opposing preferences in a same external service area. Dodier (2018) and Mattingly (2005) identify two types of RVers: Community builders who want to reach people with similar tastes and claim to belong to an RVer network and individual roamers who try to escape people and crowds (Mayo, 1975) and see gatherings as a place of frustration (Lorentzen, 2015). For Dodier (2018), freedom and safety are values that differentiate between user types. Those who seek safety by parking close to others at night and those who, on the contrary, wish to isolate themselves and avoid social interactions. Hardy and Kirkpatrick (2017) recommend differentiating overnight service areas to attract and attempt to satisfy each type of RVer. They observe that most users are looking for a quality nature experience that is generally not provided by service areas with a high concentration of RVers. They avoid destinations with overcrowded service areas when they are the only option for overnight camping. According to these works completed by professional surveys (Dublé et al., 2018; VDL MAG, 2021), we have chosen to represent the behaviour of two types of RVers. RVer1s want to stay within a busy site, for example, on the coast with a view of the sea, near a large natural site or within a famous historical centre. They are generally less sensitive to the price (also confirmed by Ma et al., 2013) or to promiscuity which, on the contrary, will allow them to create a social link with others and feel more secure. In contrast, RVer2s will mainly look for a quiet place at a distance from the major tourist site to be visited. To complement this choice, we carried out an exploratory study, which is presented in this paper.

The aim of our research is to propose optimisation models for locating, sizing and pricing this type of off-site service area according to the heterogeneous clientele preferences. The paper is

organised as follows. We first present a review of the literature, which led us to develop an exploratory study aimed at completing the few references dealing with RVers' preferences when choosing a service area. We carried out a textual analysis of RVers' comments published on the French Web site www.lemondeducampingcar.fr created by Editions Larivière (MCC, 2022a). On the basis of the different, even opposing, preferences of the two types of RVers, we then present models for solving three optimisation problems corresponding to strategic decisions consisting of either (*i*) maximising the attractiveness of the customer, which corresponds to minimising the loss of customers, (*ii*) maximising the profit of the service area or (*iii*) maximising the occupancy rate. The results, based on a realistic data set, are then discussed. To demonstrate the applicability of our models, an empirical case study of the location of external service areas at the Rocamadour tourist site in France is presented, with the aim of minimising the loss of a heterogeneous clientele wishing to stay in the region for several days. After outlining the limitations of this research, we conclude by highlighting the theoretical and practical contributions of this work.

Literature review

In the academic literature, self-drive tourism aimed at freedom and independence is largely understudied (Joppe and Brooker, 2014); this is particularly true in the case of RVers (Hardy and Kirkpatrick, 2017). It has been observed that most RVers tend to plan their trips in a rather haphazard way according to their desires (Green, 1978) and do not reserve their parking place or reserve them very late (CCN, 2021). Our research aligns with Peltier's (2018) recommendation of limiting the number of RVer parking spaces near highly congested sites and with Li et al.'s proposal (2016) to relieve parking pressure at tourist attractions by dispersing tourists throughout the region (see also Wall, 2020). The question of diverting these flows leads to an increase in the reception capacity to be planned. Knowing that existing service areas and campsites in the same territory can already offer pitches and that other areas could be developed, local officials will seek to increase the attractiveness of their areas. This objective of maximising attractiveness is strongly linked to the diversity of RVer behaviour. Among the existing research in these fields, Su et al. (2020) develop an optimisation model for scheduling rural leisure tourism passenger flows and propose to disperse tourists in a relatively large area rather than in heavily visited places especially during holidays. They find that very few tourists are attracted to other locations that are usually not far from these popular sites and advise regional tourism regulators to offer tourists a broader experience that would maximise the operating profit of the whole region. The main objective of their model is to determine the number of tourists in an overcrowded location that should be relocated and calculates the capacity requirement of undercrowded locations. In order to avoid a high concentration of a tourist location, Gearing et al. (1976) propose a distribution of flows within the framework of a surrogate approach. They quantified the attractiveness of a site by a multi-attribute utility function. Ben-Akiva and Lerman (1985) define the concept of utility as an objective function expressing the attractiveness of an alternative in terms of its attributes. None of this research looks at the particular case of RVers and their specific choice of parking over several days around an overcrowded tourist area. Moreover, a policy of decongesting popular tourist sites leads to a diversion of RVer traffic to external areas often already occupied by RVers with opposite preferences. Ma et al. (2013) investigate the shared parking choices of a mixed clientele in a tourist site where parking demand varied by time of day and location of each car park. They find that distance and parking rates are the most important attractiveness factors. Their study also shows that car drivers are more sensitive to walking time and less sensitive to price. These few available research papers highlight an issue not addressed in the existing literature of cohabitation of different types of RVers in a same shared area with a risk of

dissatisfaction and loss of customers. In addition, numerous studies and practical advice on attractiveness and profitability are presented in specialized journals or issued by territorial representatives to local decision-makers on how best to locate their service area. Moreover, we have not identified any studies or research dealing with the situation of sharing a service area and taking into account factors of attractiveness that may be contradictory between different types of RV customers. This research gap and the lack of practical advice in these particular conditions leads us to focus our research on this probable and forced cohabitation of two types of RVers, which poses a new problem for local decision-makers wishing to set up or reorganise shared service areas to best meet the expectations of two types of RVers.

Exploratory study

We propose to carry out a qualitative study in order to identify the preference criteria for choosing a service area for two types of RVers. We conduct a textual study of 51 comments (7884 words) published on the *Monde du Camping Car* Website in September 2022 (MCC, 2022b). An interview was conducted in October 2019 with the founders of *Camping-Car Park* on their vision of RVer accommodation (CCP, 2023). Following this interview, numerous online reactions from RV owners were formulated and analysed between the first publication in 2019 and early 2020. The choice of this Web site seems also appropriate as a source of additional information to match the objective that gives rise to such qualitative analysis (Woodrum, 1984), namely, to position ourselves in relation to the few research studies that have addressed the behaviour of RVers. The corpus was analysed using a computer-aided text analysis program based on the co-occurrence text analysis methodology proposed by Reinert (1990) called *Analyse Lexicale par Contexte d'un Ensemble de Segments de Texte*. It is used to extract classes of meaning composed of the most significant words and sentences, the classes obtained representing the dominant ideas and themes of the corpus. The results show that 78% of the textual units in the corpus were classified (with a high relevance level) and 22% were rejected from the analysis.

The classified units are divided into five groups which we call classes of significant statements.

- Class 1 is the most specific, it is the first to stand out in the classification tree, its vocabulary is the most homogeneous, it represents 41% of the total number of statements and is characterised by words such as *water, need, drain, pay, clean, and electricity.*
- Class 2 stands out, representing 31% of the classified textual units: its significant words are *make, damage, wild, true, safety, nice.*
- Class 3 represents 7% of the classified textual units: its significant words are *live, year, become, barrier, dear, hello.*
- Class 4 represents 13% of the classified textual units, marked by the words *public, network, space, private, rule.*
- Class 5 represents 8% of the classified textual units, marked by the words *centre, beach, interest, practical, arrange, elected.*

Class 1 highlights the factors for choosing a service area (focus of our research) which correlates with Class 3 which reflects the pleasure of travelling in a RV and Class 2 which illustrates the use of a RV. The two other classes, also correlated, reflect the users' expectations of local decision-makers and the role of public authorities in planning the space and reception of RVs. A factorial analysis allowed us to highlight a representative axis distinguishing between the essentially practical aspect

of a service area (emptying waste water, electricity, etc.) and the users' desire to be close to a centre of interest (town centre, beach, etc.).

Below are a few verbatims translated into English and sorted by class expressing the preferences of RVers looking for a service area.

Table 1 presents testimonials from some of the classes identified, which help to justify the hypotheses formulated in this research concerning RVers' preferences.

These testimonies on price sensitivity also lead us to mention the questioning of municipalities wishing to welcome RVers, who often ask themselves whether or not the area should be free of charge. Table 2 shows the price sensitivity of users and the opinion of the union of French RVers, which defends the right to park and puts pressure on local councillors (CLC, 2023; VDL MAG, 2021).

Table 3 shows RVers' views on the role that local and regional authorities should play in providing the best possible welcome for recreational vehicles.

The aim of this exploratory study is to confirm two types of RVer behaviour when choosing a service area, to find out about their sensitivity to price and their expectations in terms of local policies. The models presented in the next section are based on these two types and can help decision-makers to respond as effectively as possible to the expectations of RVers.

Table 1. Verbatims illustrating the different preferences of two types of RVers.

	Type 1 RVers	Type 2 RVers
Class 1		'I only look for small campsites…' 'I need not to feel cooped up'
Class 2		'Few service areas have the charm of a small corner of the countryside where you can be alone in the middle of nature'
Class 5	'We don't want to be excluded and far away from our interests' '(Single) women also feel safer there'	

Table 2. Verbatims illustrating RVers' sensitivity to parking area prices.

Class 1	'We take advantage of the paying sites, of course, but with pleasant pitches close to towns and villages to spend pleasant evenings in peace and quiet' 'It's too expensive, too many people, I prefer a small campsite, less expensive' 'I don't like being forced to pay for electricity either, when I'm self-sufficient with my solar system and my landings. But if you like to pay €14 a day for an all-inclusive package, even offering services you don't use or need every day, that's your right'
VDL (2021)	'Whether or not a service area is free of charge should depend on the attractiveness of the municipality, the cost of the facility and the services provided. RV owners are generally prepared to pay a reasonable sum in exchange for real services, but it seems important to find the right price for everyone, so that the area remains attractive. The choice can also be made between services, which are known to be charged (usually €2 to €4)'

Table 3. Some views on the role of local and regional authorities.

Class 4	'If we want to have a real network of free, paying, public or private RV areas, the only solution is for the elected representatives to want to welcome us and create RV areas'
Class 5	'This poses problems of space management for the elected representatives of tourist towns. The more complicated the possibility of parking will be, the more important the network of RV parks will become, and this is in the interest of the RVers'
	'When the elected representatives are sure that there will be no pollution, that there will be no parking problems and no congestion in the tourist areas, and that it will not be a budgetary burden for the town'
	'The point is to be one of the actors who shape the development of the territory and thus the practice of motor-homing'

Modelling the problem

According to Gilbride and Allenby (2004), we represent the RVer's choice by a two-stage decision-making strategy. Firstly, the area will only be chosen by a user if each criterion is within a certain range, which we represent by a conjunctive model (Coombs, 1951). Secondly, a compensation process is based on partial utility functions depending on the distance or travel time between the main site and the external area, the occupancy rate and the price. This is in line with the approach of Gearing et al. (1976) of quantifying the notion of tourist attractiveness on the basis of a multi-attribute utility function. Their function incorporates the criteria by which tourist attractiveness is judged, and the relative importance of these criteria in relation to each other assessed by numerical weights. We have assumed that price and distance (or travel time) are objectively perceived and easily identifiable by the customer. However, customer perceptions of occupancy rate and level of social interaction are much more subjective, which justifies conducting a specific survey in a given territory. In our model, the occupancy rate is considered to capture the degree of social interaction. RVer1s looking for network sociality in the sense of Wittel (2001) or a community claimed by community builders, will seek high occupancy to facilitate socialising and satisfy their need for security. In contrast, a high occupancy rate will have a negative impact on RVer2s who want to stay in a quiet place. The higher the occupancy rate, the smaller the distance between the RVs, which can facilitate inter-individual communication and thus satisfy RVer1s at the expense of RVer2s. It is assumed an extensive spatial distribution of RVer2s (they seek maximum possible distance between vehicles) and an intensive distribution of RVer1s. In the case where the occupancy rate is low and the area is predominantly occupied by RVer2s, it is rather a matter of a desire for social non-interaction that a low occupancy rate allows. Having modelled the demand of these two types of RVers, we search for the best location, capacity and price of a shared service area by following a strategy to minimise losses, or by seeking to maximise the occupancy rate, or to maximise profits. We have considered that the demand corresponds to a constant "stock" of RVs during the peak tourist period, which means that the average number of entries per day and the average number of exits per day is considered the same. The proposed model consists of dimensioning an external area with a number of pitches greater than or equal to this stock.

Definition of variables

i	Type of RVer: $i \in \{1, 2\}$
N	Total number of RVers expected to visit the tourist area
n_2	Number of RVer2s already installed at service area P_2
η	Number of visiting RVers who make a one-night stop in P_2
n_1	Estimated number of RVer1s who will always seek first to settle for several days in the overcrowded service area P_1: $n_1 = (N - n_2 - \eta)$
k_1	Number of P_1 parking spaces with a capacity limitation such that $k_1 < n_1$
m_1	Number of RVer1s to be convinced to divert to P_2: $m_1 = (n_1 - k_1) > 0$
k_2	Number of P_2 parking spaces in the external service area
g	Expected occupancy rate of P_2 area: $g = \frac{(m_1+n_2+\eta)}{k_2}$
p_1, p_2	Prices per night proposed by areas P_1 and P_2 ($p_1 > 0$ and $p_2 \geq 0$)
pr	Relative price ratio: $pr = p_2/p_1 \leq 1$
U_i	Partial utility functions for each type i of RVer
π_i	Probability that a RVer of type i agrees to stay in P_2
θ_i	Risk of losing customers: $\theta_i = 1 - \pi_i$
L	Total number of customer losses: $L = m_1\theta_1 + n_2\theta_2$
u	Estimation of the number of RVers that could use service area P_2 $u = (m_1 + n_2 + \eta - L)$ (the initial value of u is such that $L = 0$)

Conjunctive model as a first phase for deciding to park on the external area

We represent the attitudes of the RVers by a non-compensatory model based on three attributes: the distance d, the occupancy rate g and the relative price ratio pr. We consider that each type i of RVer will choose to stay in the P2 external area only if d, g and pr are suitable for them according to the following conditions C_1 and C_2:

$$\text{Conditions } C_1 \text{ for RVer1s:} \tag{1}$$

$$d \in [\, d_{\min 1},\ d_{\max 1} \,]$$

$$g \in [\, g_{\min 1},\ g_{\max 1} \,]$$

$$pr \in [\, 0,\ pr_{\max 1} \,]$$

$$\text{Conditions } C_2 \text{ for RVer2s:} \tag{2}$$

$$d \in [\, d_{\min 2},\ d_{\max_2} \,]$$

$$g \in [\, g_{\min 2},\ g_{\max 2} \,]$$

$$pr \in [\, 0,\ pr_{\max 2} \,]$$

We have assumed that $pr_{\max 1} \leq 1$ for RVer1s to be attracted to P2, while the RVer2 seeking calm may accept that $pr_{\max 2} > 1$.

For a possible mix between the two RVer populations to exist in the P2 area, it will be necessary that the acceptable range of the distance d between P1 and P2 is between a minimum distance $d_{\min 1}$

and a maximum distance $d_{\max 1}$ for RVer1 and that it overlaps that of RVer2 accepting a minimum distance $d_{\min 2}$ and a maximum distance $d_{\max 2}$. In addition, the acceptable relative price ratio ranges from $pr_{\min 1} = pr_{\min 2} = 0$ (free area P2) to $pr_{\max 1}$ for RVer1 and $pr_{\max 2}$ for RVer2 must overlap for there to be a possible mix.

This can be expressed by the constraints : (3)

$$[\, d_{\min 1},\ d_{\max 1}\,] \cap [\, d_{\min 2},\ d_{\max 2}\,] \neq \emptyset$$

$$[\, g_{\min 1},\ g_{\max 1}\,] \cap [\, g_{\min 2},\ g_{\max 2}\,] \neq \emptyset$$

$$\text{if } \ pr_{\max 1} \leq pr_{\max 2} \text{ then } pr \leq pr_{max1} \quad \text{or} \quad \text{if } \ pr_{max2} \leq pr_{max1} \text{ then } pr \leq pr_{\max 2}$$

Compensatory model as a second phase for deciding to park on the external area

We estimate the probability of staying or not in P2 for each type i of RVer from an additive utility model (functions varying from 0, no utility, to 1, maximal possible utility).

$U_i(d)$ The utility of P2 according to the distance from the overcrowded site P1 to P2
$U_i(g)$ The utility of P2 according to the expected occupancy rate of P2
$U_i(pr)$ The 'disutility' of P2 according to the relative price between P2 and P1

All these functions can be estimated through surveys of RVers.

The overall utility for each type i of RVer is:

$$U_i = \omega_{di}\, U_i(d) + \omega_{gi} U_i(g) + \omega_{pri} U_i(pr) \tag{4}$$

with ω_{di}, ω_{gi} and $\omega_{pri} \geq 0$ the relative influence weights of the three factors.

The maximal utilities are:

$$U_{1\max} = \omega_{d1} U_1(d_{\min 1}) + \omega_{g1} U_1(g_{\max 1}) + \omega_{pr1} U_1(pr_{\min 1}) \tag{5}$$

$$U_{2\max} = \omega_{d2} U_2(d_{\max 2}) + \omega_{g2} U_2(g_{\min 2}) + \omega_{pr2} U_2(pr_{min2}) \tag{6}$$

Risk of losing customers. We can model the two-stage decision-making process by the following discontinuous functions for each type i of RVers:

$$F_i(d,g,pr) = \begin{cases} 0, \text{if at least one of the three } C_i \text{ conditions} \\ \text{in expressions (1) and (2), respectively, is not satisfied} \\ U_i, \text{if all three} C_i \text{ in inexpressions (1) and (2), respectively, are satisfied} \end{cases} \tag{7}$$

If all conditions are satisfied, we determine that the probability p_i that an RVer of type i agrees to stay in P2 is:

$$\pi_i = \frac{U_i}{U_{i\max}} \tag{8}$$

and $p_i = 0$ if at least one of the three C_i conditions is not satisfied.

This results in a risk θ_i of customer loss equal to:

$$\theta_i = 1 - \pi_i \tag{9}$$

Principle of single objective optimisation models

Figure 1 illustrates the problem to solve and shows the input variables, the decision variables with the optimisation objectives.

The decision-makers usually choose one of three optimisation objectives consisting of either (*i*) minimising the mathematical expectation of the customer losses L, which may also ultimately

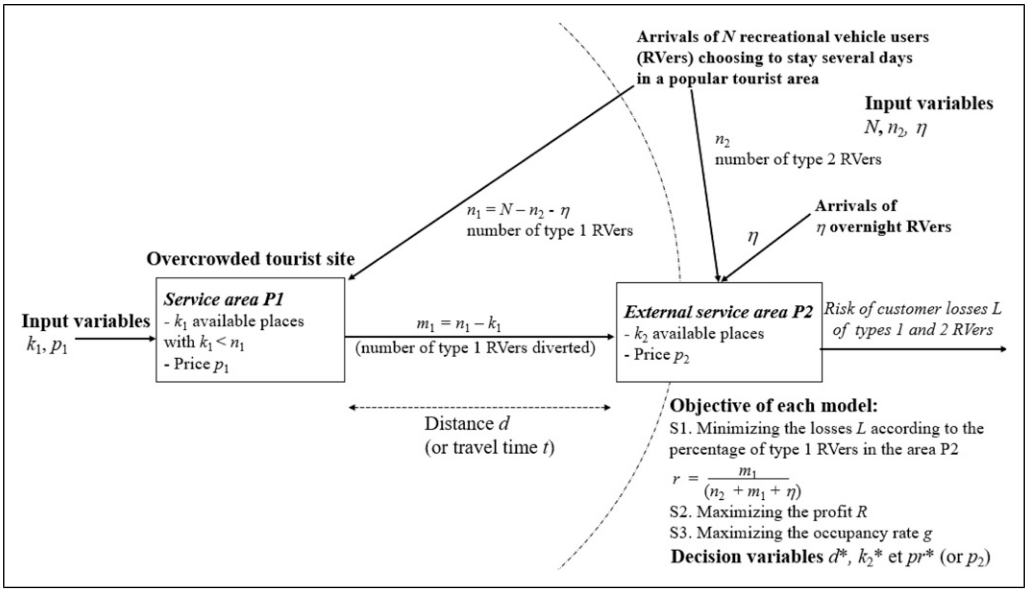

Figure 1. Objectives of the optimisation models.

degrade the image of the tourist area, (*ii*) seeking only to maximise the expected occupancy rate g of P2 or (*iii*) seeking only to maximise the daily profit R of the external area P2.

Three optimisation problems to solve:

$$\min L = m_1\theta_1 + n_2\theta_2 \tag{10}$$

$$\max R \tag{11}$$

$$\max g = \frac{u}{k_2} = \frac{(m_1 + n_2 + \eta - L)}{k_2} \tag{12}$$

To estimate the daily profit R during peak periods, the professionals add the estimated revenues SP linked to parking services and tolls on the basis of an average price p_1 per night with the revenues

SC linked to local purchases h. The variable costs per day VC are calculated on the basis of the variable cost vc per pitch per day corresponding to the maintenance of the area multiplied by the number of pitches k_2. For a given loan corresponding to an investment INV for k_2 pitches, the daily fixed cost FC of the annual instalments can be calculated on an 18-year basis with a given interest rate.

To summarise:

The revenues related to local purchases of RVers are: $SP = u\ p_2 = u\ pr\ p_1$

The revenues related to local purchases of RVers are: $SC = u\ h$

The variable costs per day for k_2 pitches are: $VC = vc\ k_2$

$$R = SP + SC - VC - FC = (pr\ p_1 + h)\,u - vc\ k_2 - FC \tag{13}$$

Decision variables. The distance d, the capacity k_2, the relative price ratio pr (or the price p_2) are the three decision variables and the inputs that the optimisation algorithm can modify in an attempt to improve the values of L, g or R corresponding to the initial strategic choice targeted.

Input variables

$N, n_2, \eta, p_1 \in \mathbb{R}^+$

$k_1 \in \mathbb{N}^*$

Constraints

$d \in [\ \max(d_{\min 1}, d_{\min 2}),\ \min(d_{\max 1},\ d_{\max 2})\ ]$

$k_2 > \min[\ (m_1 + \eta), (n_2 + \eta)\ ]$

$pr \in [\ 0, \max(pr_{\max 1},\ pr_{\max 2})\ ]$

$k_1 < n_1$

Problem complexity

Non-convex and non-smooth optimisation problems have to be solved. Another complication arises from the fact that the three objective functions each depend on the expected numbers m_1 and n_2 of RVers likely to stay at P2. The probability that each RVer of type i will agree to stay at P2 also depends on these estimations which do not take initially into account any loss of customers. But the final number u of customers after optimisation will include probable losses $L > 0$ because of conflicting preferences which will change the value of u and therefore the utility functions underlying the functions to be optimised. The occupancy rate g depends on this estimated load u and the capacity k_2 to be defined. If $L > 0$ than the load u decreases and consequently the occupancy rate for a given capacity k_2 capacity. To solve this problem, after the first optimisation step, we run the three optimisation algorithms again, modifying the value of u to take account of L losses, until we reach a state of equilibrium in the best values of L, g or k_2.

Remark. The problem of optimising the three functions $L(d, k_2, pr)$, $R(d, k_2, pr)$ and $g(d, k_2, pr)$ could be more complex if some variables were interdependent. For example, if the best value of capacity leads to a too low or very high occupancy rate, decision-makers could modify the price accordingly, which would again modify consumer attitudes and change the optimal values. Some studies take into account decision variables that may be dependent on each other and propose to solve these optimisation problems using non-linear mathematical programming methods (Yang et al., 2008; Tiwari and Roy, 2002).

Optimisation results based on a realistic dataset

Main data

$N = 100$	Total expected population in the tourist area
$\eta = 0.08\ N = 8$	Proportion of visiting users who make a one-night stop (FDOTSI, 2017)
$k_1 = 70$	Capacity of the central area P_1 ($k_1$constant)
$u = (m_1 + n_2 + \eta - L) = (N - k_1 - L) = (30 - L)$	Expected number of RVers that could use service area P_2
$m_1 = (n_1 - k_1) = (n_1 - 70)$	Number of RVer1s to be diverted to P2
n_1 increasing from k_1 to $(N - \eta)$	Numbers n_1, m_1 and n_2 of RVers of each type in the tourist area
$\Rightarrow n_2$ increasing from $(N - k_1 - \eta)$ to 0	
$\Rightarrow m_1$ increasing from 0 to $(N - \eta - k_1)$	
d with $D_{min} \le d \le D_{max}$ and $D_{min} = 1$ km; $D_{max} = 10$ kms	Possible location interval of P_2
$r = m_1/(m_2 + n_2)$ with r increasing from 0% to $(n_1 - k_1)/(n_1 - k_1 + n_2) = 73\%$	Proportion of m_1 RVers of type 1 that will be diverted to an expected maximum of RVers of two types that could stay in P_2

Parameters of the conjunctive model. This first stage of customer decision-making is represented by a non-compensatory conjunctive model, the parameters chosen for the acceptability conditions C_1 and C_2 indicated in expressions (1) and (2) are presented in Table 4:

According to these data, it can be seen that the mixing condition of the two types of RVers is such that d must be between 2 and 5 km, g between 40% and 60% and the P2 price must be less than or equal to that of P1 otherwise the area P2 will be exclusively intended for one of these populations.

Utility functions of the compensatory model. The second stage is represented by a customer compensatory decision-making model. We consider monotonic distance and price utility functions increasing between 0 and 1 or decreasing between 1 and 0 and a maximal occupancy rate utility of 1 if g is between *gmin* and *gmax* (see Table 5).

To calculate the overall utility of P2 for each type of RVer according to equation (6), we propose respective weights ω_{di}, ω_{gi} and ω_{pri} for each type i of RVer, for distance d, occupancy rate g and price difference pr (see Table 6). We consider distance d to be the most important criterion for the RVer1 and occupancy rate g for the RVer2.

Table 4. Model parameters

	d_{min} (km)	d_{max} (km)	g_{min}	g_{max}	pr_{min} [a]	pr_{max}
RVer1	2	5	40%	100%	0	1
RVer2	2	10	0%	60%	0	1.2

[a]A relative price ratio $pr = 0$ corresponds to a free area P2, $pr = 1$ to a price identical to that of P1 and $pr > 1$ to a higher price for P2 compared to P1.

Table 5. Utility functions.

RVer1	$U_1(d) = -0.33d + 0.66$	$U_1(g) = 1$	$U_1(pr) = -pr + 1$
	$U_1(d_{min1}) = 1$; $U_1(d_{max1}) = 0$	$U_1(g_{min1}) = U_1(g_{max1}) = 1$	$U_1(pr_{min1}) = 1$; $U_1(pr_{max1}) = 0$
RVer2	$U_2(d) = 0.125d - 0.25$	$U_2(g) = 1$	$U_2(pr) = -0.84\ pr + 1$
	$U_2(d_{min2}) = 0$; $U_2(d_{max2}) = 1$	$U_2(g_{min2}) = U_2(g_{max2}) = 1$	$U_2(pr_{min2}) = 1$; $U_2(pr_{max2}) = 0$

Table 6. Respective weights of distance, occupancy rate and price difference in utility functions.

RVer1	$\omega_{d1} = 2$	$\omega_{g1} = 1$	$\omega_{pr1} = 1$
RVer2	$\omega_{d2} = 1$	$\omega_{g2} = 2$	$\omega_{pr2} = 1$

Financial data

p_1 = €25 per night	Average prices for overnight stays (Quimper Cornouaille Développement, 2022)
h = €37.4	Average expenditure per RVer (Dublé et al., 2018)
vc = €0.72	Variable cost per pitch per day (MLV Conseil, 2019)
$INV = 150{,}000k_2/30$	Investment level of an area of k_2 pitches on the basis of €150,000 for 30 pitches (MLV Conseil, 2019)

According to these data, the three objective functions to optimise are L, g and R (see the functions (10)–(12)). The initial estimation of the number of RVers that could use service area P2: $u = (m_1 + n_2 + \eta - L)$ is such that $L = 0$.

$$L = (n_1 - 70)\theta_1 + n_2\theta_2 \tag{14}$$

$$g = \frac{(30 - \mathrm{L})}{k_2} \tag{15}$$

According to equation (13):

$$R = (25pr + 37.4)(30 - L) - \left(0.72 + 150000 * 0.025 * \left(1/\left(1 - (1 + 0.025)^{18}\right)\right)/(365 * 30)\right)k_2 \tag{16}$$

As a reminder, the decision variables are *pr,* k_2 and d, each of which depends on θ_1 *and* θ_2.

Method of resolution

To address these non-convex and non-smooth optimisation problems, we use the *Excel* evolutionary solving method based on a genetic algorithm searching for good quality solutions better than the initial values of the decision variables (see also its applicability in the field of tourism marketing in Hurley et al., 1998). To find the best solutions, which may not all be optimal, we test different convergence values, increase the population size and change the mutation rate in order to increase the diversity of the population and expand the solution search space.

The best parameters chosen for the evolutionary algorithm are as follows:

Population size	1000
Convergence rate	0.0001
Mutation rate	0.075
Maximum duration without improvement	120 sec

When a good solution with minimised losses L, maximal occupancy rate g or maximal profit R is proposed by each model, we choose the one L^*, g^* or R^* that proposes a minimum capacity k_2 resulting in maximum profit and occupancy rate. We carried out the calculations several times and in less than 10 iterations with different initial values, we were able to observe convergence towards the best result each time. This can be explained by the fact that the utility functions chosen in the dataset are linear but piecewise discontinuous, which makes the problem to be solved complex and non-smooth. In addition, in order to resolve the problem caused by the initial lack of knowledge of the losses L considered to be zero during the first optimisation, the algorithms are rerun iteratively until the best values of the three decision variables d, k_2 and pr (or p_2) stabilise as a function of variations in the expected frequentation u of P2 including the losses L at each stage.

Results according to the three optimisation objectives

In this section, we choose to compare all the model results obtained on the basis of a rate r equal to the number m_1 of RVer1s diverted to P2 divided by the total expected number (m_1+n_2) of RVer1s and RVer2s in P2.

Five sub-sections present the results obtained as follows. For each triplet (d^*, k_2^*, p_2^*) resulting from each chosen optimisation strategy, we compare first the customer losses L, then the estimated profits R, then the occupancy rates g. The best values of these three decision variables obtained after optimisation are then presented and discussed. Finally, these results lead us to note the influence of each decision on the proposed mix rate of these two heterogeneous populations. Based on a realistic data set, the results obtained are presented in the form of 13 observations, which confirm the interest of these models in terms of decision support for implementing a service area shared by two types of RVers.

Estimated customer losses. **Observation 1.** When r increases following a rise in tourist numbers, and whatever the optimisation objectives, the percentage of customer losses $\%L = \frac{L}{(m_1+n_2)}$ does not follow a monotonic trend but a concave curve with an intermediate peak which differs according to the strategy, as shown in Figure 2.

Observation 2. According to its own objective, strategy S1 for minimising losses is obviously the most interesting, but still achieves a maximum percentage loss of 4% when the proportion r is between 15 and 25%. It is minimal at the two extremes of this ratio r, that is, when r is close to 0 and 73%, which explains why the models segment the P2 offer proposed by favouring either

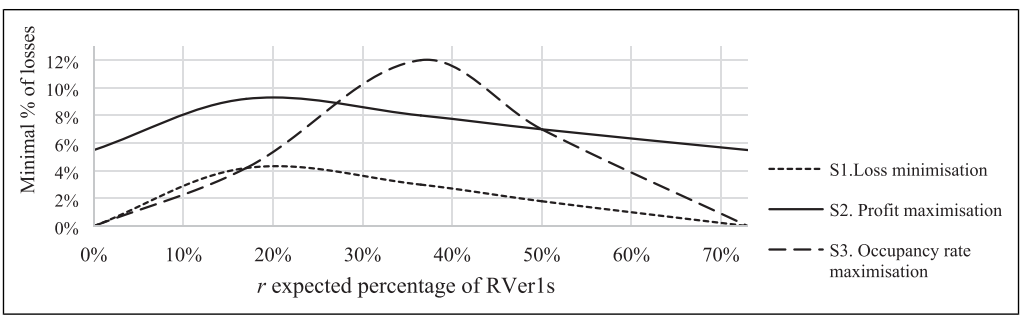

Figure 2. Minimised percentage of customer losses $\%L^*$ according to three optimisation objectives.

RVer1s when r is low, or RVer2s when r is high (which is also the case for the S3 strategy seeking to maximise the occupancy rate).

Observation 3. The S2 profit maximisation strategy leads to maximum losses for a rate r between 15 and 25% and will always generate customer losses whatever the value of r with a minimum of around 5%.

Observation 4. Furthermore, it is interesting to note that the S3 strategy of maximising the occupancy rate of P2 should be avoided when the rate r varies between 30 and 50%, as it will generate the most losses of the three strategies.

Observation 5. Table 7 shows that customer losses are mainly at the expense of RVer2s when the proportion of RVer1s increases. Only the strategy of maximising the S2 occupancy rate makes it possible to spread the losses between the two types of tourists.

Estimated profits.

Observation 6. The S2 profit maximisation strategy is naturally the most attractive (see Figure 3). However, it is more interesting when the proportion of RVer1s is either low or maximum, which can be explained by a choice to segment the offer of a P2 area that will only be aimed at one type of customer.

Observation 7. For values of r of between 30 and 50%, an S3 strategy of maximising the occupancy rate should be avoided, as the expected profit could fall to €600/day compared with almost €1000/day for the S1 strategy and €1300/day for the S2 strategy.

Estimated occupancy rates.

Observation 8. This time, it is the S3 strategy of maximising the occupancy rate of the P2 service area which, quite naturally, is the most interesting (see Figure 4). It is nevertheless curious to observe that this occupancy rate can fall to 50% for low values of r, which can be explained by the preponderance of RVer2s looking for a very uncongested area and by the opposing preferences of these two types of RVers.

Observation 9. The choice to maximise profit (S2 strategy) leads to the lowest P2 occupancy rate, varying from 50 to 80% depending on r, with a minimum value of 40%.

Observation 10. As for the S1 loss minimisation strategy, it can be as effective as the S3 strategy when r is between 18 and 25%. It has the disadvantage of 'oscillating' as the proportion of RVer1s increases and of offering a very unfavourable occupancy rate when r is less than 10%.

Table 7. Percentage of customer losses %L^* by type of RVers.

		S1. Loss minimisation		S2. Profit maximisation		S3. Occupancy rate maximisation	
	r	RVer 1 loss (%)	RVer 2 loss (%)	RVer 1 loss (%)	RVer 2 loss (%)	RVer 1 loss (%)	RVer 2 loss (%)
No Rver1	0%	0	0	0	6	0	0
	17%	0	4	5	9	0	4
Same expected number of Rver 1s and 2s	36.5%	0	3	3	8	0	12
	50%	0	2	4	7	0	7
No Rver2	73%	0	0	6	6	0	0

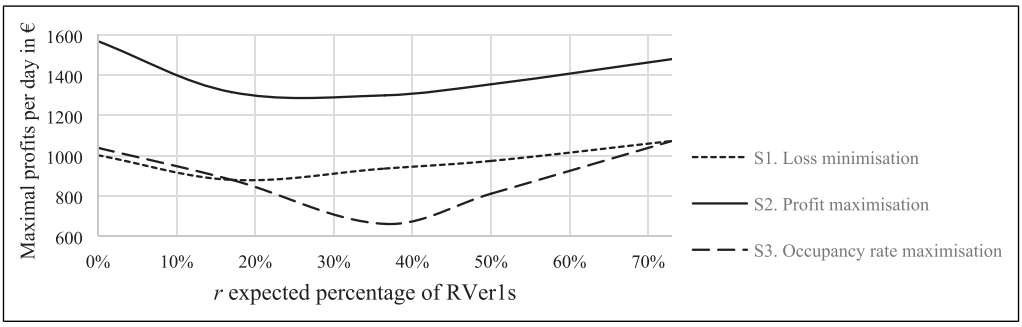

Figure 3. Maximal profits R^* according to three optimisation objectives.

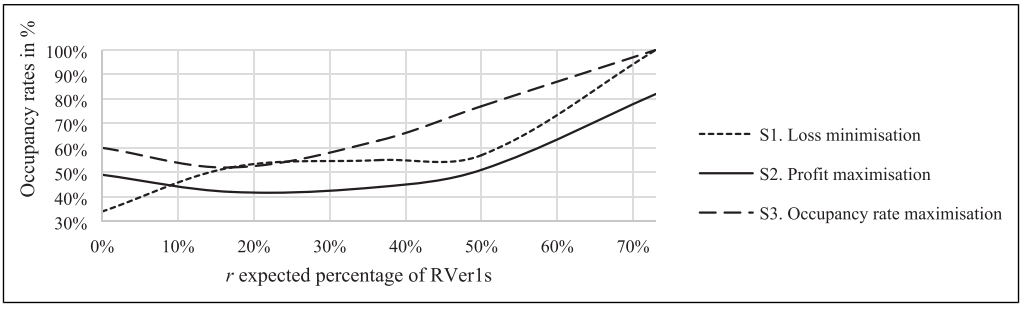

Figure 4. Occupancy rates g^* according to three optimisation objectives.

Table 8. Best values of decision variables.

		S1. Loss minimisation			S2. Profit maximisation			S3. Occupancy rate maximisation		
	r	k_2^*	d^*(km)	p_2^* (€)	k_2^*	d^*(km)	p_2^* (€)	k_2^*	d^*(km)	p_2^* (€)
No Rver1	0%	72	10	0	50	10	30	50	10	0
	17%	50	2	0	50	10	30	50	2	0
Same expected number of Rver1s and 2s	36.5%	50	2	0	50	2	24.80	30	2	0
	50%	50	2	0	50	2	25	30	2	0
No Rver2	73%	30	2	0	30	2	25	30	2	0

Best values for decision variables. Table 8 shows the values proposed by the optimisation models for distance d^*, capacity k_2^* and price p_2^*.

Observation 11. The proposed values for the distance d^* between the major site and the external area P2 must be either equal to the minimum values acceptable to both types of RVers, or equal to the maximum values $dmax_2$ acceptable only to type 2 RVers. However, this proposal could run counter to a policy of decongesting the major site when the proportion r of RVer1s is higher.

Observation 12. With regard to the need for investment in capacity k_2, for a constant demand of 30 RVers to be accommodated in the P2 area, the S3 strategy of maximising occupancy suggests a capacity of 30 pitches as soon as the expected rate r is greater than or equal to 36.5%, which, after optimisation, leads to the populations not being mixed and priority being given to RVer1s to the detriment of RVer2s. Conversely, when decision-makers choose as a priority to minimise losses S1 or maximise profits S2, the models suggest that attractiveness should also be sufficient to satisfy type 2 RVers by offering 50 pitches instead of 30 for the same r values.

Observation 13. In terms of pricing, the loss minimisation strategy S1 and the occupancy maximisation strategy S3 always offer an area P2 free of charge, unlike the S2 strategy, which seeks to maximise profit, albeit by gradually lowering its prices as the number of RVer1s increases.

Consequence of optimisation choices on the population mixing rate. To express an expected rate mx of mixing of the two populations of RVers, we set mx equal to the number m_1 of type 1 RVers diverted from P1 to P2 divided by the total expected number $(m_1 + n_2)$ of type 1 and 2 RVers. The optimal rate $mxopt$ after optimisation takes into account the final number m_1' and n_2' of type 1 and 2 RVers, respectively, that have finally decided after optimisation to settle on P2.

Notes. If $m_1 \leq n_2$ then $mx = \frac{m_1}{(m_1 + n_2)}$ otherwise $mx = 1 - \frac{m_1}{(m_1 + n_2)}$

As shown in Table 9, only strategy S1 aimed at minimising customer losses always proposes mixing the two populations, unlike the strategies S2 or S3 which maximise profits or occupancy rates which only propose it for a certain proportion $mxopt$ level of RVer1s diverted.

Case study

We study the case of the location of service areas and campsites near a major tourist site in France, Rocamadour. This medieval city labelled as a rural area by the *Grands Sites de France* network since 2012, is located in the south-west of France, in the department of Lot in the heart of the Dordogne valley (see Figure 5).

A strategic plan for development and collective organisation with other villages and sites in the valley has been launched to boost the region's tourism value (Pouzenc and Olivier, 2011).

Table 9. Mixing rates according to three optimisation objectives.

			Optimisation strategies		
	Expected mixing rate		S1	S2	S3
	r	*Mx*	*mxopt*	*mxopt*	*mxopt*
No Rver1	0%	No mix	No mix	No mix	No mix
	17%	23%	28%	No mix	28%
Same expected number of Rver 1s and 2s	36.5%	50%	43%	42%	No mix
	50%	32%	26%	25%	No mix
No Rver2	73%	No mix	No mix	No mix	No mix

Figure 5. Location of the Rocamadour site (google maps).

Site description

In 2021, Rocamadour recorded 300,000 overnight stays over the year 2021 with averages of 2000 overnight stays per day in July and August (Lot Tourisme, 2022). We have estimated the proportion of RVers at 5% based on several sources, in particular the reception of RVers in three private campsites close to the town centre, with public car parks being poorly occupied at night (from 3 to 9 overnight stays by RVers in July and August).

We consider P1 as all the campsites in the immediate vicinity of Rocamadour (Figure 6).

All on-site service areas P1 are occupied at night with an average of 2.5 people per RV (Dublé et al., 2018).

k_1 = 100 Maximum RV parking capacity (Vallée De la Dordogne, 2022).

p_1 = €18 Average price for 24 hrs with access to electricity, water and waste disposal (Mairie de Le Mazeau, 2022; MCC, 2022c).

Current off-site parking areas and campsites for RVs. Among the alternatives for locating an external service area P2, we see that there are already four current areas:

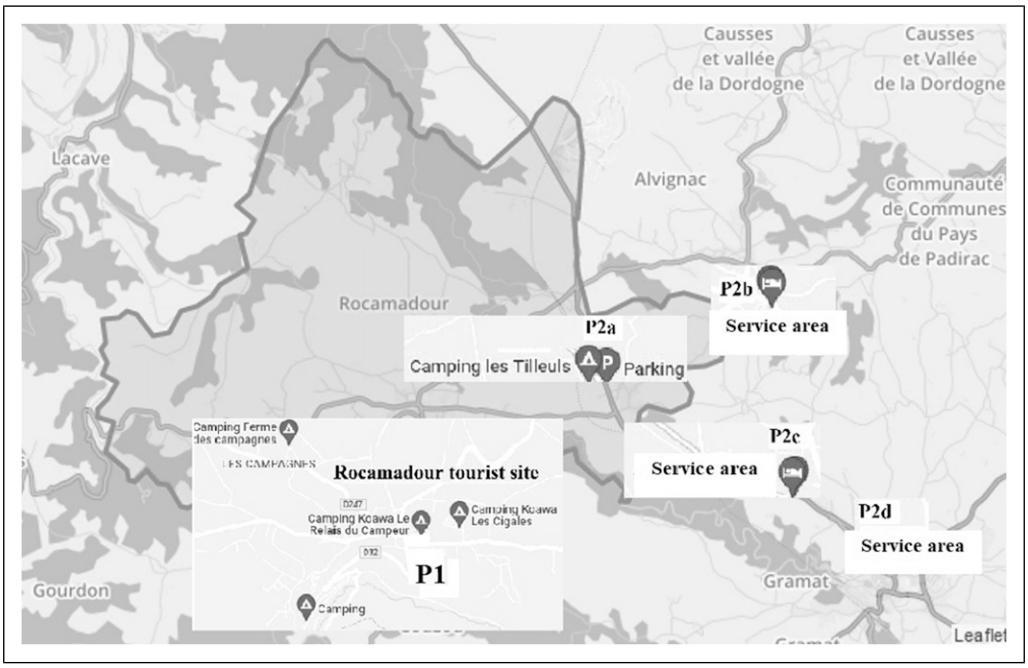

Figure 6. Main RV service areas P1 (left) and external service areas P2a, P2b, P2c and P2d (*Leaflet* map).

P2a	d = 7.2 km	20 pitches at €23 per night for two people at a luxury campsite in Le Roux
P2b	d = 9.5 km	20 free pitches located in Alvignac
P2c	d = 8.1 km	40 pitches at €13.61 located at Causse de Roumegous
P2d	d = 12.3 km	15 free pitches located in Gramat

The occupancy rate g of the P2 external areas is assumed to be equal to 50% on average in summer, which allows us to deduce the daily value of n_2 for the different P2 options: $n_{2a} = 10$; $n_{2b} = 10$; $n_{2c} = 20$; $n_{2d} = 8$.

Model assumptions

In accordance with a possible decongestion policy, when the population n_1 of RVer1s can no longer be fully accommodated in the area close to the saturated site because the capacity k_1 in terms of number of pitches will no longer be increased, $m_1 = (n_1 - k_1)$ RVer1s will then have to be diverted to an external area P2 allowing them to be accommodated in the best way according to their preferences. We assume a growth of n_1 of +10%; +20%; +30%. Knowing that $k_1 = 100$, the number of RVer1s to be diverted m_1 will be 10, 20 and 30 RVer1s, respectively. We consider that n_2 and η will remain constant during the growth of m_1. The total expected number of RVers at area P2 would be $(m_1 + n_2 + \eta)$.

We chose the same parameters and data as in the previous case corresponding to possible behaviours of two types of RVers. To ensure a possible mix of populations, we set $pr_{max2} = 1.4$ to be able to accept the current P2a price of €23 which is 40% higher than P1 and $d_{max1} = 13$ km thus widening the area of acceptability of the maximum distance of the RVer1.

We consider that to initiate the strategy of diverting flows from P1 to P2, the territorial decision-makers of this region will seek first and foremost to minimise the risk of loss of clientele (strategy S1).

Model results

Given the possible growth in the number of RVs of 10%–30%, we compare the estimated values for each current P2 service area of customer losses L, profits R, and occupancy rates g with the results proposed by our model seeking to minimise losses (strategy S1). We also compare the current capacities k_2 of the four current sites with the proposed optimal capacity k_2*, the distances between the main site and the external sites d and d*, the prices p_2 and p_2* and the mix rate suggested by our model (see Table 10).

In case of 10% increase in the number of RVs. By looking for the minimal expected loss of customers L*, the model always proposes to make P2 free of charge in order to increase its attractiveness. In the case of a 10% increase in the number of RVs that should be attempted to divert to an external area P2 (m_1 = 10), the best performing area in terms of expected profitability (€851/day) would be P2c provided that it deploys a capacity of 50 pitches (instead of the current 40). The suggested distance d* would be 2 km instead of the current 8.1 km in order to attract RVer1s which represent 33% of the estimated use of P2c.

In case of 20% and 30% increase in the number of RVs. When the growth rate of the number of RVer1s is 20% or 30%, solution P2c is again the one with the higher profits (€1197/day and €1542/day, respectively) and a mixing rate of the RVer population of 43% and 33%.

Comparison of customer losses and estimated profits. Furthermore, as soon as the population increases by 10, 20 or 30%, the model proposes 2 km as the best distance for the four solutions, which could be counterproductive, that is, to make people discover the more distant villages. For this reason, it would again be preferable to retain solution P2c, which will be able to absorb a 10% increase in demand with 33% expected RVer1s, 59% expected RVer2s and 8% of transient RVers with a fairly balanced mixing rate between RVer1 and RVer2 after cost minimisation of 40%. As soon as the demand increases beyond 10%, for P2a, P2b and P2d with the same L* losses, the model suggests locating a service area to RVer1s closer to the main site.

Figure 7 shows a strong growth in real losses estimated by the model when r increases and efficiently controlled thanks to the loss minimisation model. As for the evolution of the profit when r increases, the opposite is observed (Figure 8), that is, a profit that increases strongly according to the model's proposals and weakly with the estimated real values.

Influence of loss optimisation strategy on the mix of RVer populations. We observe for the four current P2 areas that our model proposes a population mixing rate that evolves concave with respect to r the proportion of deviated RVs out of a maximum expected of RVs in P2 (Figure 9). This means that as the expected proportion of deviated type 1 RVers increases, it is advisable to locate an external P2 service area that best meets the expectations of both types of RVers. However, as can be seen on the curve, when the type 2 RVer population becomes more important than the type 1, the model suggests to favour the type 2 RVer population.

Table 10. Comparison between the values proposed by the model and the current estimated results.

	Input variables				Best values per day found by the model								Current estimated values							Differences/day		
Service areas	m_1	n_2	h	r	k_2*	d*(km)	L*	% L	p_2*(€)	R*(€)	g*	Mixing rate	k_2	d(km)	L	% L	p_2(€)	R(€)	g	R*- R	L*- L	g*- g
P2a	0	10	9	0%	17	13	0	0%	0	346	59%	0%	20	7.2	2	1%	23	304	50%	42	−1	9%
	10	10	10	33%	34	2	2	50%	0	598	51%	43%	20	7.2	15	13%	23	113	13%	485	−13	38%
	20	10	11	49%	50	2	2	67%	0	945	55%	27%	20	7.2	23	17%	23	252	25%	693	−21	30%
	30	10	12	58%	67	2	2	75%	0	1290	56%	20%	20	7.2	30	21%	23	390	38%	900	−28	18%
	0	10	9	0%	17	13	0	0%	0	346	59%	0%	20	9.5	2	2%	0	396	50%	−50	−2	9%
P2b	10	10	10	33%	34	2	8	6%	0	598	51%	42%	20	9.5	18	15%	0	105	13%	493	−10	38%
	20	10	11	49%	50	2	3	2%	0	945	55%	27%	20	9.5	25	19%	0	243	25%	702	−23	30%
	30	10	12	58%	67	2	3	2%	0	1290	56%	20%	20	9.5	33	23%	0	382	38%	908	−30	18%
	0	10	9	0%	50	13	0	0%	0	692	59%	0%	40	8.1	5	5%	13.61	744	50%	−52	−5	9%
P2c	10	10	10	33%	50	2	5	4%	0	851	50%	40%	40	8.1	28	23%	13.61	71	6%	780	−23	44%
	20	10	11	49%	67	2	5	4%	0	1197	52%	43%	40	8.1	35	27%	13.61	210	13%	987	−30	39%
	30	10	12	58%	84	2	5	4%	0	1542	54%	33%	40	8.1	43	30%	13.61	348	19%	1194	−38	35%
	0	10	9	0%	17	13	0	0%	0	346	59%	0%	15	12.3	2	1%	0	304	50%	42	−2	9%
P2d	10	10	10	33%	34	2	0	2%	0	598	51%	43%	15	12.3	15	13%	0	113	17%	485	−15	0%
	20	10	11	49%	51	2	0	2%	0	945	55%	27%	15	12.3	23	17%	0	252	33%	693	−22	0%
	30	10	12	58%	67	2	0	1%	0	1290	56%	20%	15	12.3	30	21%	0	390	50%	900	−30	0%

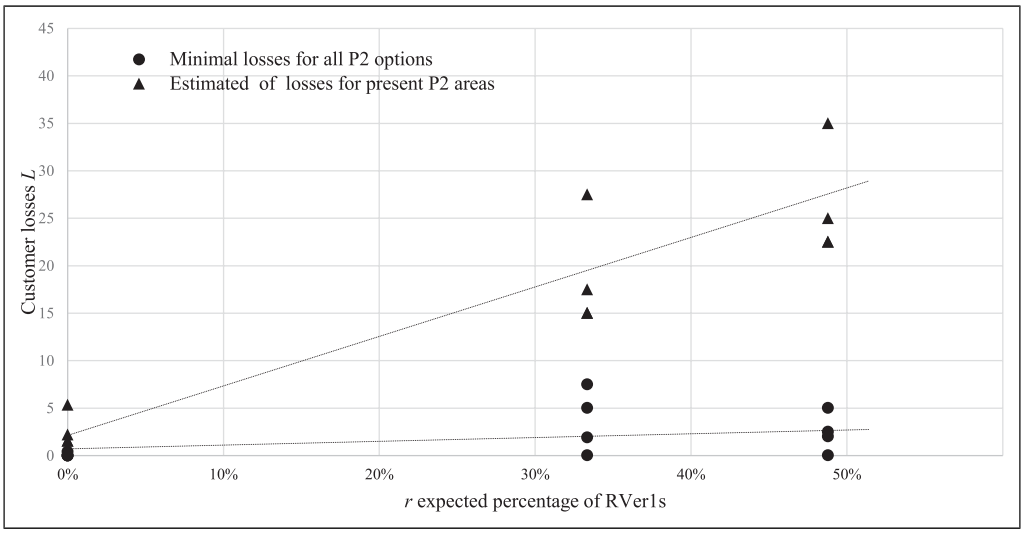

Figure 7. Comparison of the minimised losses *L** proposed by the model with the estimated current losses *L*.

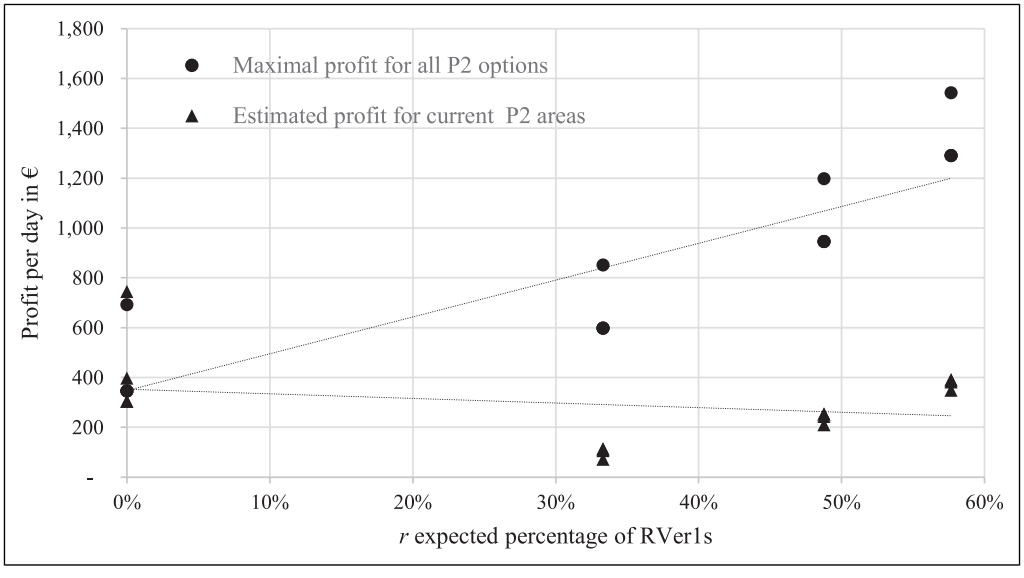

Figure 8. Comparison of the maximal profits *R** proposed by the model with the current profit estimations.

Research limitations

The results presented in this article must be considered in the light of certain experimental uncertainties and assumptions made regarding: empirical utility functions, demand, minimum capacity to be deployed and estimates of income and expenditure per RVer. Each of these points is discussed in this section.

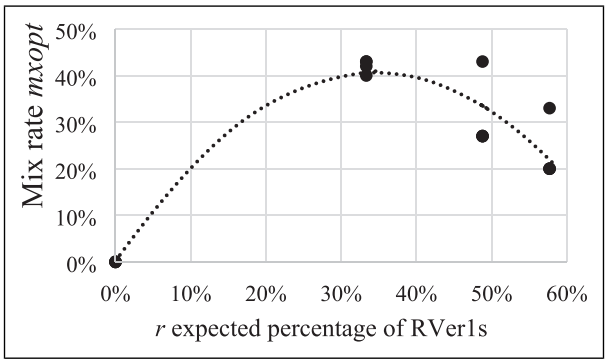

Figure 9. Best mix rate of RVers proposed by the model.

Uncertainties about utility functions

Some studies have shown that for some RVers, the choice of a parking or service area is guided solely by the price offered, without taking into account other factors such as the occupancy rate, distance or services offered. In order to get closer to the actual behaviour of RVer populations, we recommend launching an intensive survey on RVers' criteria for choosing service areas. Using this survey data, decision-makers could modify the shape and parameters of the utility functions of the proposed models, which could turn out to be non-linear and discontinuous. Knowing that it is not possible to calculate the derivatives of a function at the points where a function is discontinuous, it would nevertheless be possible to approximate the step functions $F_i(d, g, pr)$ in expression (7) by smooth functions (Zang, 1981; Díaz-Martín et al., 2000).

Demand uncertainties

We have chosen average values for service area use during the peak tourist season. However, significant variations can be observed, particularly for RVer2s who may decide to visit a busy tourist site quickly and then continue on their way to find an area that meets their expectations. It should be noted that our model does not depend directly on the absolute values of the forecast arrivals of RVers of both types, but on the expected proportion r of RVer1s in the external service area to be sized and located, which may increase mixing and antagonistic behaviour. Statistical analyses of data on RVer1s visiting an overcrowded tourist site would also enable us to incorporate the uncertainty of demand into our models.

Choice of service areas with excess capacity

We assume in our models that the capacity must be greater than or equal to the estimated need in terms of the number of pitches. In fact, the aim is to accommodate as well as possible the RVer1s who have been diverted to these external areas in order to reduce overtourism and traffic congestion, while preventing them from leaving the tourist area. If investors seek to fill their service area as much as possible, they will in this case be occupied exclusively by RVer1s, with the risk of having insufficient capacity and driving away all the RVer2s who will refuse to settle in an area that is too saturated. The return on investment could be better but would be unfavourable at local level in terms of the financial spin-offs linked to the consumption that could have been brought in by both RVer2s

and the surplus of RVer1s leaving the tourist region after a short day's visit to the major site. A study could nevertheless be carried out by analysing the variation in RV flows throughout the year. It might also be worth planning for variable capacity by making certain resources more flexible, depending on the amplitude of demand.

Financial uncertainties

Our challenge was to size and locate an outdoor service area during the peak period of July and August. As an example, in France in 2017, these 2 months accounted for 62% of overnight stays by recreational vehicles. However, in the summers of 2021 and 2022, many RVers have chosen to travel in June and September to avoid the holiday period. Furthermore, we have based our calculations on an average expenditure per RVer, which varies greatly depending on the tourist profile and origin. In 2017, the average expenditure observed by RVer in France was between 0 and €150 per day (Dublé et al., 2018). We finally considered that summer periods, public holidays, long weekends and other holiday periods are the most significant and strategic for making a decision on the size and location of an external service area.

Conclusion

This research was carried out as part of the development of eco-responsible tourism, which aims to divert traffic away from sites facing overtourism and to offer external service areas that best meet the different expectations of recreational vehicle users wishing to stay there for several days. The aim was to locate, size and price these areas, which are often shared by users with heterogeneous or even opposing preferences, the assumption that decision-makers will have made an initial strategic choice to minimise customer losses (S1), maximise expected profit (S2) or maximise the area's occupancy rate (S3). If some users are not satisfied with the optimal offer proposed, they will leave the tourist area after making a quick visit to the popular tourist site and parking in spaces provided next to other vehicles or at the side of a less-frequented road.

Following an exploratory study seeking to identify the factors that make a service area attractive to two types of RVers characterised by Dodier (2018) and Mattingly (2005), we modelled their choice using a two-stage decision-making process. Firstly, a conjunctive model that eliminates any proposal outside the minimum and maximum limits of customer preference factors such as distance or travel time, occupancy rate and price. Secondly, the decision is made according to a compensation process represented by partial multi-attribute utility functions depending on these three decision variables. On this basis, we proposed to solve three non-convex and non-smooth optimisation problems corresponding to the S1, S2 and S3 strategies.

From a theoretical point of view, in addition to the originality of the problem addressed, we have shown how the proposed models make it possible to improve understanding of complex behaviour in a situation where two types of customers with opposing preferences share the same offer. As an example of application using a realistic dataset, we showed that the results made it possible to compare three strategies and to identify non-linear relationships between performance and three key decision variables, namely, the location of a service area, the number of spaces to be offered and the price to be offered in relation to a very busy main service area. This theoretical result is consistent with Easton and Pullman (2001) who also identified complex and non-linear relationships between parking capacity decisions and performance measures such as profit and visitor satisfaction. Our results also show that a strategy aimed at maximising attractiveness and therefore minimising customer losses always proposes mixing the two populations, unlike models aimed at maximising

profits or occupancy rates which, depending on the parameters chosen, only propose it for a certain proportion of diverted RVer1s. We also highlighted the influence of strategic optimisation choices on the possible mixing of two populations with heterogeneous preferences. A result showed that the choice of an S2 strategy based on profitability leads to dedicating an outdoor space to a single type of customer, which is similar to the choice of segmentation of an offer when customer preferences are very different, or even opposed (Bigné et al., 2007; Frochot and Morrison, 2000). In our context, however, a mixing of populations could occur insofar as RVer2s, often already present in the area around a major tourist site, will have to cohabit with diverted RVer1s.

In terms of practical implications, although these results depend on an initial data set, this research highlights unexpected results and non-linearities, which can alert decision-makers to the counter-intuitive consequences of their initial strategic choice. These optimisation models are also intended to help territorial decision-makers by enabling them to simulate the diversion of RVer traffic to small villages in order to relieve a major site, while offering access via soft mobility. This research would also enable local authorities to become aware of the problem of cohabiting different populations of RVers with different expectations, and to simulate the impact of their strategic optimisation choices on this population mix.

In addition, the case of the Rocamadour tourist site presented in this article is a good illustration of a possible trexit strategy that could be followed by local decision-makers in order to divert flows to neighbouring villages, to organise a pattern of external service areas close to this major tourist site, or to help local authorities to size and finance new service areas for RVers. In this case study, we assumed an S1 strategy aimed at minimising the loss of customers in the region during the busiest period of the year. We have shown that our model's proposals outperform current off-site service area locations throughout a potential growth phase in tourist numbers. This leads us to advise decision-makers to estimate the future trend in RVer traffic in their tourist area in order to simulate our model, which will help them to make decisions on the gradual introduction or reorganisation of shared service areas.

In terms of research prospects, we plan to add a dynamic dimension (Hartman, 2021) by modelling the interactions between these two types of RVers and coupling the optimisation model to an agent-based model. Indeed, the inter-community crossing of these two populations could modify the perception of the weights of the attributes of their own utility function and thus could enrich the theoretical and practical results of the models.

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