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Forest owners and fuels management coordination. When neighbours' actions matter

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ABSTRACT

Forest owners' coordination for wildfires prevention is still a largely unexplored area of research, and an important social issue in contexts in which there is an increase in the frequency, extent, and severity of wildfires, such as Portugal. Our approach innovates by introducing a social interaction between plot-neighbourhood owners to the analysis of attitudes and behaviours toward fuels management coordination. As a case study, we focus on a parish in the Northwest of Portugal, and using data from a forest owners' survey, we compare the owner's willingness-to-coordinate and his/her current fuels treatments implicit-coordination with his neighbouring property owners. Our findings show that indeed neighbours' actions count, that is, they are interdependent with the owner's current management practices and owner-neighbours behaviour interaction is relevant to his/her willingness-to-reduce fuels load. Local social capital favours similarity of behaviour toward bush-clearing by plot-neighbours. The owners' willingness-to-coordinate, conversely, is not influenced by the plot-neighbours' actions or by the local social capital, and is instead strongly correlated with the owner' sociodemographic profile. We conclude for the need to look for context-dependent constraints of the owners' fuels reduction and coordination practices.

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Cross-boundary coordination; collective action; social dilemma; neighbourhood effects; freeriding; wildfires prevention; private forest owners

Introduction

Forest owners' coordination for wildfires prevention is still a largely unexplored area of research (Fischer and Charnley 2012). In Portugal, the current increasing trend in frequency, extent, and severity of wildfires, in addition to the preponderance of non-industrial private ownership, and its very small-scale and large fragmentation over several scattered plots, make this an issue of the utmost importance (Canadas et al. 2014, 2016; Ribeiro et al. 2014).

Since property limits do not stop wildfires, fuel treatments coordination amongst geographical neighbours is essential to assure physical contiguity and size (area), and thereby the effectiveness of risk reduction (Busby and Albers 2010; Collins et al. 2013; Fernandes 2013; OECD 2013). Despite their importance, the effects of social interaction among adjacent forest owners in their attitudes and behaviour toward management coordination have seldom been investigated.

In order to overcome this gap in social forest science, we first clarify the main concepts that frame our approach by examining the modalities of coordination in question, the concepts mobilized to look at owners' attitudes and actions regarding those arrangements, and the notions supporting the analysis of social interactions between the owner and his neighbours.

The range of coordination and cooperation modalities for forest management is considerably broad. In the literature this diversity includes the nature of the participants, the type of owners involved (only private and non-industrial or not), the size of the group of owners, their geographical proximity, the formality or informality of the arrangements, the object of the cooperation or sharing, the extent of sharing (which may encompass all interventions or be decided for each intervention), and the planning approach (centralized or not) (Kittredge 2005; Schulte et al. 2008; Canadas et al. 2016; Górriz-Mifsud et al. 2018). Whenever involved owners are spatially adjacent or nearby, the coordination is called cross-boundary (Finley et al. 2006; Gass et al. 2006, 2009; Ferranto et al. 2013; Fischer et al. 2018). Considering the arrangement's formalization and the nature of the coordinator, we can distinguish between: informal agreement between multiple owners; formal agreement with an organization created for the purpose as coordinator; and formal agreement with a forester, a contractor, or a forest enterprise as coordinator, or third-party coordination (Gass et al. 2006, 2009; Van-Gossum and De-Mayer 2006; Blinn et al. 2007; OECD 2013). Regarding the object of sharing or cooperation, Kittredge (2005) begins by distinguishing three modalities: information, equipment, and financial cooperation. In all of these, the technical management of private property is carried out independently by the owners. In a fourth modality, which may be called forest joint management, the owners manage cooperatively or jointly a single area consisting of all their properties, integrating decisions on a spatial and temporal scale.

When it comes to a future behaviour, the analysis usually focuses on attitudes, perceptions, intentions, and willingness of the owners as to a possible coordination of practices with

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other owners and enrolment in forest cooperatives (Belin et al. 2005; Finley et al. 2006; Van-Gossum and De-Mayer 2006; Ferranto et al. 2013). The attitude-behaviour models of Ajzein and Fishbein (2005), among others, frame the analyses and the concepts used. The owners' segmentation procedure allows the definition of profiles that are more cooperation-prone or more cooperation-averse (Finley et al. 2006; Ferranto et al. 2013). Looking for greater accuracy in predicting a future behaviour, some authors study the preferences and evaluation made by the owners on different coordination arrangements (Stevens et al. 1999; Gass et al. 2006; Ferranto et al. 2013). For example, instead of asking owners about their predisposition or interest in coordination, Gass et al. (2009) enquire about their views and preferences regarding various approaches or arrangements that ensure the coordination of their forestry practices. Whether studying dispositions or preferences, using the collective action theories or the principal-agent theory, the analytical frame usually focuses on the owner or on his relationship with the coordinator (Gass et al. 2009). The influence of peers' (other owners') behaviour on the owner's own behaviour is usually absent in the study of coordination, and the neighbourhood action context is taken into account solely through variables such as social values and norms (Poteete and Ostrom 2008; Ostrom 2011).

Social dilemma and freeriding are important concepts for studying social interactions between landowners (Kollock 1998; Ostrom 2003; Muradian and Cardenas 2015). Social dilemmas are situations in which there is a conflict between personal and collective interest, and individually reasonable behaviour leads to a situation in which everyone is worse off than they had been otherwise (Kollock 1998; Mulder et al. 2006). In a public goods dilemma, a type of social dilemma, the individual faces an immediate cost (for instance, an opportunity cost with forestry interventions or replacement of forest species to reduce the fuel load) that generates a benefit that is shared by all, a landscape with lower fire susceptibility (Busby and Albers 2010; Prante et al. 2011). So a self-interested individual has an incentive to avoid the cost of interventions (bush-clearing) or the loss of benefits (from firebreaks or from the less profitable slow-growing trees), but if everyone avoids this cost, each will be worse off than if they had faced the cost together (Kollock 1998). Given the difficulty of excluding someone from benefiting from a public good, there is the temptation to freeride, that is, to benefit from the good without contributing to its creation or maintenance. As fires do not stop at property limits, coordination between neighbouring owners is essential to ensure contiguity, size, and the consequent effectiveness of fuels reduction (Canadas et al. 2016). Hence the importance of examining social interaction between neighbouring forest owners, in anticipation of freeriding for some authors (Crowley et al. 2009; Busby and Albers 2010; Prante et al. 2011), or simply neighbourhood effects and behaviour similarity for others (Tsusaka et al. 2015). This similarity is explained by mutually reinforcing behaviour and common constraints or institutions (Canadas and Novais 2014b; Tsusaka et al. 2015). In the context of forest management, attention has fallen instead on the search for freeriding, and has so far favoured the interaction between public and private or industrial and non-industrial private ownership.

Our case study of a parish in the Northwest of the Portuguese mainland focus on a territory with Eucalyptus and Pine plantations for wood production, largely dominated by small and very small non-industrial private forest (NIPF) owners, without formal management plans. This territory has a history of large recurring wildfires that imposes losses in private and public goods (wood and water quality or biodiversity). Foresters advise a general reduction of fuel loads at individual and landscape levels (Fernandes 2013; Oliveira et al. 2016). Thus, coordination for fire risk mitigation implies that, besides landscape-level interventions (fuel breaks, water points and land cover patches), all the owners must carry out regular bush-clearing activities. Since present interests and institutions do not seem enough to assure those activities and interventions, this context clearly frames a social dilemma situation.

Within a setting where formal initiatives to implement joint management amongst NIPF owners are still absent, our study seeks to reveal forest owners' attitudes and practices toward fuels management coordination and how these are affected by the actions of the owners and their neighbours. Specifically, we want to know if there is interdependent bush-clearing behaviour within the owners' neighbourhood, why, and how is it related with the owners' willingness-to-coordinate fuel treatments and willingness-to-reduce fuels load.

Our objectives are: (a) to inquire if the owner's willingness-to-coordinate fuels management is influenced by his informal coordination behaviour, implicit in his fuel control practices and his neighbours' practices; (b) to compare both the willingness-to-coordinate and the implicit-coordination with the willingness-to-reduce fuels load; (c) to discuss the importance of social capital to explain the owner's willingness and implicit-coordination options.

Material and methods

The information used was collected in face-to-face interviews with 112 forest plot owners, during the summer of 2014, in the parish of Aguiar de Sousa, municipality of Paredes. These plots were randomly selected from a 25×25 m grid of coordinated points, within the boundaries of the parish and the area classified as "Agroforestry systems" and "Forests and natural or semi-natural environments" in the Land Use and Occupancy Chart of Continental Portugal (COSN2-2007), excepting the area managed by pulp industries. The choice of point-sampling comes from the relevance of the spatial dimension in the effectiveness of fuel load reduction (Fischer and Charnley 2012). Because of this sampling procedure, and the high fragmentation of local ownership structure (high number of plots per owner), 68% of the owners responded for only one plot, and 32% for more than one plot. As a result, the number of owners surveyed (76) is less than the number of plots in the sample (Table 1).

The interview questionnaire included three parts: a first part concerning forest plot attributes and management, including the owner's willingness-to-reduce fuels load; a second on attitudes and opinions towards management at the landscape level, including the perception of neighbours'

Table 1. Owners' willingness-to-coordinate management.

	Owners		Plots	
Willingness-to-coordinate	Number	%	Number	%
Not willing	16	21.0	23	20.5
Willing under informal agreement	30	39.5	45	40.2
Willing under formal agreement	30	39.5	44	39.3
Total	76	100.0	112	100.0

fuel management and the owner willingness-to-coordinate; and a last group of questions on the owner social profile.

The variables to be compared are the owner's willingness-to-coordinate management for fire risk reduction and the current implicit-coordination of bush-clearing. It should be noted that bush-clearing is the most usual practice in local fuel management activities (conducted in 58% of the 112 plots surveyed). Values assigned to the first variable are: (a) not willing to, (b) willing under an informal agreement between neighbours, about the fuels treatment to be carried out by each one and (c) willing to hand over the coordination to an entity, under a formal agreement. The second variable, which expresses the coordination of practices between the owner's plot and its neighbourhood, results from a cross between two dichotomous variables, the "owner does bush-clearing" (over the last ten years) in the plot surveyed (yes or no) and the "plot's neighbouring owners do bush-clearing, according to the owner's perception" (yes or no).[1]

This second variable, whose short designation of implicit-coordination will be justified below, takes the following values, (a) *yes-yes*, (b) *yes-no*, (c) *no-yes*, and (d) *no-no*, which by analogy to the outcomes of a social dilemma (Kollock 1998) from the owners' perspective and the convenience of expression are named hereinafter, respectively, mutual-activity, neighbours-passivity, owner-passivity, and mutual-passivity. It should be emphasized that what is at stake is, therefore, the coordination regarding bush-clearing only and no other silvicultural interventions (Gass et al. 2009).

One should bear in mind that the willingness-to-coordinate refers to the owner while the implicit-coordination refers to the plot. To assure the comparability of the two variables, all data are reported to the plot. Since the plot is the unity of analysis the Pearson's Chi-square tests have also been performed at the owner level for the associations involving owner's characteristics.

To explain the owners' willingness-to-coordinate and the implicit-coordination, an association analysis (Pearson Chi-square test and residual analysis) was performed with plots' characteristics and owners' characteristics. The selection of these characteristics is supported by collective action and social capital theories (Ostrom 2011; OECD 2013), and their findings in the context of private ownership (Fischer and Charnley 2012), complemented with the perspective of studies on NIPF owners' management logics and work models (Novais and Canadas 2010).

The owners' characteristics include the owners' socio-demographic profile (such as age, gender, education, place of residence), the area of their forest property, the weight of the forest income in the family income (<10% and ≥10%), the importance attached to the forest considering the income derived from it (very important and not important), their participation in informative session(s) on fires (yes or no), and their enrolment in at least one association or cooperative (yes or no).

The plots' characteristics include: area (<1ha and ≥1ha); shrubland as main cover (yes and no); bush-clearing patterns (non-clearing, manual clearing with family labour, and motorized clearing with wage labour or clearing outsourcing); the reasons for not doing bush-clearing or not investing; and the three dichotomous (yes/no) variables neighbours' inter knowledge, mutual help, and conflict, respectively, "know the majority of the owners on the borders or proximity of the plot", "perceive an ambience of information exchange and mutual aid in the plot's neighbourhood", and "perceive frequent problems of ownership borders positioning". The variable plot-owners management models take on the values Property-Reserve, Holding-Reserve, and Forest-Enterprise, which were established by cluster analysis considering, among other variables, the execution of at least one productive intervention and at least one investment (plantation/densification, water points and road network improvement, machinery and equipment purchase) (Novais and Canadas 2010).

The owner's willingness to undertake fuels reduction management in the plot was queried after visual (photo) identification by the respondent of the plot's current fuel load (A – Low and B – High). For the same species, and according to local forest experts, the set of photographs A and B represented, respectively a low and high fuel load pattern. The aim was to recall or inform the respondent of the estimated cost of interventions needed for, respectively, maintaining the "Low" fuel load or changing it from "High" to "Low", and place him/her in a scenario as realistic as possible. Abbreviated as willingness-to-reduce fuels load, this variable takes the values "not willing", "willing with incentives", and "willing without incentives" (Baptista et al. 2015).

The binary variable plot's wildfire susceptibility (very high to high and medium to very low), is the only one not provided by the survey, and whose source is the map elaborated by Verde and Zêzere (2010). It assesses susceptibility by integrating the land cover (fuel), the slope, and the fire history (burned areas), therefore capturing the structural dimension of susceptibility, which along with risk perception has been admitted as favouring cooperation propensity (Fischer and Charnley 2012).

Results

We begin by presenting the overall results regarding the owners' willingness-to-coordinate and the implicit-coordination between neighbours. We proceed to the identification of the factors associated with these two variables (only those variables with significant relationships are presented in the tables), and conclude with the analysis of their relationship to the owners' willingness-to-reduce fuel loads.

Willingness-to-coordinate and implicit-coordination

In order to estimate a possible behaviour of coordinated management adoption, two variables are used: the willingness-to-coordinate, which refers to future informal or formal coordination, and is a stated intention, and the current coordination, informal, and implicit in the owner's practices and perceptions.

Table 2. Owners' implicit-coordination (plots %).

		The owner does bush-clearing		
		Yes	No	Total
Neighbours do bush-clearing (according to the owner perception)	Yes	Yes – Yes = 44.9 Mutual-activity	No – Yes = 20.2 Owner-passivity	65.1
	No	Yes – No = 14.7 Neighbours-passivity	No – No = 20.2 Mutual-passivity	34.9
	Total	59.6	40.4	100.0

Pearson's Chi-square = 11.622, df = 2, and $\rho = 0.003$.

Starting with the first variable (Table 1), we find that the lack of willingness or coordination-aversion covers only one fifth of the plots surveyed, since in the vast majority of them (79%), their owners are willing to coordinate informally under agreement between neighbours "regarding the fuel treatments to be carried out by each one of them" (39.5%), or are even open to the coordination formalization (39.5%). Recognition of the need for coordination between owners (neighbours) for fire risk reduction is also very much present in the answers to other open questions or observations to closed questions expressed during the inquiry.

Among those owners who chose formal agreement, preference goes to multi-owners' organizations (Forest Owners' Associations, FOA, and Forest Intervention Zones, FIZ) as coordinator, with 57% of the answers. Then comes third-party coordination (30% of the answers), with a forest contractor or service provider as coordinator, 16% of the answers, and forest industries, 14% of the answers. Formalization without specifying the coordinator accounts for the remaining 13% of the answers.

Regarding the second variable (Table 2), first, we find that there is a significant association between the owner's behaviour and his/her neighbours' behaviour (see Chi-square test) suggesting their direct interdependence. Second, the similarity of behaviour owner-neighbours is dominant (65% of the plots), including mutual-activity, *the owner and his neighbours clean* (45%), and mutual-passivity, *the owner and his neighbours don't clean* (20%). Non-similarity includes the neighbours-passivity, the owner cleans but his *neighbours don't clean* (15%), and the owner-passivity, *the owner doesn't clean* but his neighbours do (20%).

Concerning non-similarity, it would be expected that neighbours-passivity (none of the neighbours clean), would prevail, because it is evaluated according to the owner's perception, who could emphasize a more negative reading of his neighbours. Nevertheless, this is precisely the least representative category: only 15% of the plots surveyed.

On the whole, the cases conducing to a social dilemma, because of mutual-passivity, the owners-passivity, and the neighbours-passivity, are the majority, accounting for just over half (55%) of the plots surveyed.

Willingness-to-coordinate and owners' profile

The willingness-to-coordinate management establishes three groups of plots whose owners are not willing to coordinate (21%), willing under an informal agreement between owners (40%), and willing to formalize coordination (39%). Education, gender, place of residence, and willingness-to-reduce fuel load clearly distinguish each group profile (Table 3). Regarding age, the distinction is statistically significant (at 10%) only when considering the owners' percentage and not the plots' percentage.

Amongst coordination-averse owners there is a greater weight of residents at the same municipality where the plot is located, 87% of the plots compared to 69% in total sample, and of those owners 65 years old or more, 48% of the plots compared to 38% (and 63% of the owners, even if only statistically significant when considering the owners' percentages), whereas in education and gender this group is close to the sample's average, in which about half of the plots belong to owners with the first grade basic education, and 23% to female owners. Their willingness-to-reduce fuels also does not significantly differentiate them from the average, given that, for almost half of the plots (48%), their owners need financial incentives to carry out fuels reduction. In short, aged owners and inhabitants at local municipality are willing to change management with incentives on an individualized basis, that is, without coordination.

Amongst those willing to accept informal agreement, there is a greater weight of less educated owners (in 66% of the plots, their owners have the first grade basic education or less), of female owners (34% of the plots), and a higher refusal to adopt a fire risk reduction management (36% of the plots). Simultaneously, this group also presents the highest percentage of plots whose owners are willing to carry out a fire risk reduction management without expecting public incentives (39%). That is, more female and less educated owners, willing to keep the current fuel management or willing to change without incentives.

On the other hand, among those willing to formalize coordination, there is greater relative weight of those with higher education, male owners, and residence outside the municipality. These are also the owners who reveal a more pronounced claim for public financial incentives as a condition for adopting or maintaining fuels reduction practices (14 in B and 12 in A). With higher education, and more outside residence, they want to change management with incentives and formal coordination.

Here one should keep in mind that the willingness-to-reduce refers to the interventions at the plot level, while the willingness-to-coordinate refers to both the interventions at the plot/owner level and those at the landscape level (fuels breaks, land use patches …). Therefore, refusal to reduce fuels in the plot is compatible with willing to coordinate for risk reduction. In fact, from ongoing studies in another

Table 3. Owners and their willingness-to-coordinate management (plots %).

Owners' profile and management practices and attitudes		Not willing	Willing under informal agreement	Willing under formal agreement	Total
Age (a)	≤ 65 years old	52.2	68.2	61.4	62.2
	> 65 years old	47.8	31.8	38.6	37.8
Education*	1st grade basic or less	47.8	65.9 ++	36.4 −	50.5
	Others	52.2	34.1 −	63.6 +	49.5
Gender*	Female	21.7	34.1 +	13.6 −	23.4
	Male	78.3	65.9 −	86.4 +	76.6
Residence* (a)	At the same municipality	87.0 +	77.3	50.0 −	68.5
	Other	13.0 −	22.7	50.0 ++	31.5
Implicit-coordination	Yes – Yes	40.9	45.5	46.5	45.0
	Yes – No	22.7	11.4	14.0	14.7
	No – Yes	13.6	22.7	20.9	20.2
	No – No	22.7	20.5	18.6	20.2
Willingness-to-reduce fuels load*[?]	Not willing	21.7	36.4 +	17.8	25.9
	Willing with incentives	47.8	25.0 −−	57.8 ++	42.9
	Willing without incentives	30.4	38.6	24.4	31.3

Notes: *Pearson's Chi-square test is significant at 0.05. Significant deviations from expected values (SPSS), at $\rho < 0.05$ and $\rho < 0.01$, are represented, respectively, by "+" or "−", and by "++" or "−−". (a) Pearson's Chi-square test is significant at 0.05 for owners.
[?]Pearson's Chi-square = 10.345, gf = 4, $\rho = 0.035$, contingent coefficient = 0.291)

Portuguese area, we find that same type of owners are more willing to forgo their land for fuels breaks maintenance under a collective management body than carrying out regular bush-clearing on their remaining land.

Thus, formal coordination willingness is associated with a search for public incentives on a joint basis between owners. The informality of coordination, conversely, seems to be averse to public policy and fuel load change. A large share of coordination-refusal owners demands public incentives to reduce fuels load on an individual basis. For this reason, informal coordination cannot be viewed as an intermediate category on an ordinal scale from coordination refusal to formal coordination acceptance.

The other variables mentioned in the methodology, such as plot-owners' management models, importance attached to forest, work models, social capital, having information regarding fire prevention, and risk perception, do not show statistically significant association with the willingness-to-coordinate.

Implicit-coordination, management practices and neighbourhood

Taken as a measure of the implicit-coordination between the owner and his neighbours, the modalities defined above are not distinguished by the owners' sociodemographic profile (age, education, gender, place of residence), but have a strong association with some of the plot characteristics (forest cover, fire susceptibility) and management (namely bush- clearing pattern, and the plot-owner management model), as well as some of the social capital indicators, such as inter-knowledge and mutual-help (Table 4).

The *yes-yes* plots (mutual-activity) are associated with the lowest fire susceptibility (27% of these plots have low to very low fire susceptibility). Even if knowing the majority of the neighbouring owners is a preponderant attribute in the sample (84% of the plots), the perception of inter-knowledge stands out in this group: for 92% of the plots the owner reports knowing the majority of his neighbours. Mutual-help also has the highest incidence in this group, but is much less dispersed (only 49% of the plots). Bush-clearing is carried out manually with family labour (53% of the plots) and motorized with wage labour or outsourced (47%). All the plots had at least one productive intervention and one investment (Holding-Reserve and Forest-Enterprise) carried out.

In the *yes-no* plots (neighbours-passivity) the perception of neighbourhood inter-knowledge remains strong (88%). However, contrary to the previous one, this group shows a low perception of mutual-help and information exchange between neighbours (for only 13% of the plots versus 42% in the sample as a whole), revealing low explicit collaboration. Bush-clearing is carried out manually with family work (69%), the characteristic management model is the Holding-Reserve type, with interventions and investment in small-scale properties whose forest revenue represents a small part of the household income (81%).

The *no-yes* plots (owners-passivity) have shrubland as the main cover in more than a quarter of them, high to very high fire susceptibility in almost all of them, and the lowest perception of neighbourhood inter-knowledge that includes only about half of the plots. In spite of this limited knowledge, they view their neighbours as active bush cleaners. The reasons they give for their absence of bush-clearing and forest investment (96% of the plots follow a Property-Reserve management) relate to the geographical constraints of their plots, low availability of family labour and of financial resources, or the lack of property rights definition (inheritance shares).

The *no-no* plots share with the previous (no-yes) the high fire susceptibility, the Property-Reserve management model, and the management constraints. They differ with respect to the land cover (shrubs as the main cover in only 9% of the plots), and to the inter-knowledge that is again preponderant (91% of the cases).

It can thus be said that a strong perception of neighbours inter-knowledge favours the positive similarity of behaviour (*yes-yes*), while a weak perception promotes self-passivity, and the perception of low mutual-help is associated with the perception of neighbours-passivity (yes-no).

Table 4. Implicit-coordination and plot-owner's management (plots %)

		The owner does bush-clearing – Neighbours do bush-clearing								
		Yes – Yes		*Yes – No*		*No – Yes*		*No – No*		Total
Main forest cover – Shrubs	Yes	6.1		6.3		27.3	++	9.1		11.0
	No	93.9		93.8		72.7	−−	90.9		89.0
Wildfires susceptibility	High	73.5	−−	87.5		95.5	+	95.5	+	84.4
	Low	26.5	++	12.5		4.5	−	4.5	−	15.6
Knowing the majority of plot's neighbours	Yes	91.8	+	87.5		54.5	−−	90.9		83.5
	No	8.2	−	12.5		45.5	++	9.1		16.5
Information sharing and mutual help among owners	Yes	49.0		12.5	−	45.5		45.5		42.2
	No	51.0		87.5	+	54.5		54.5		57.8
Reasons for not clearing bush or not investing	Fire risk. no need of clearing	18.4		25.0		13.6		18.2		18.3
	Management constraints	12.2	−−	25.0		86.4	++	81.8	++	43.1
	Does bush-clearing or no answer	69.4	++	50.0		0.0	−−	0.0	−−	38.5
Bush-clearing pattern	Non-clearing	0.0	−−	0.0	−−	100.0	++	100.0	++	40.4
	Manually with family labour	53.1	++	68.8	++	0.0	−−	0.0	−−	33.9
	Motorized with wage labour or outsourced	46.9	++	31.3		0.0	−−	0.0	−−	25.7
Management model plot-owner	Forest-Enterprise	26.5	++	18.7		4.5		0.0	−	15.6
	Holding-Reserve	73.5	++	81.3	++	0.0	−−	4.5	−−	45.9
	Property-Reserve	0.0	−−	0.0	−−	95.5	++	95.5	++	38.5
Willingness-to-coordinate management	Not willing	20.4		31.3		13.6		22.7		21.1
	Willing	79.6		68.7		86.4		77.3		78.8
Willingness-to-reduce fuels load [?]	Not willing	14.3	−	31.3		45.5	+	22.7		24.8
	Willing with incentives	34.7		31.3		45.5		68.2	+	43.1
	Willing without incentives	51.0	++	37.5		9.1	−−	9.1		32.1

Note: Significant deviations from expected values (SPSS) at $\rho < 0.05$ and $\rho < .01$ are represented, respectively, by "+" or "−", and by "++" or "−−".
[?]Pearson's Chi-square = 26.113, gf = 6, $\rho = 0.00021$, contingent coefficient = 0.443)

The bush-clearing patterns also contribute to the separation of the implicit-coordination modalities. In particular, *yes-no* plots (neighbours-passivity) are associated with manual and family clearing, while *yes-yes* plots (mutual-activity) are associated with outsourced or motorized clearing in addition to the first pattern. Various restrictions on management mark the *no-no* and *no-yes* plots.

In these latter plots (*no-yes* and *no-no*) owners follow a Property-Reserve logic, which is to say, they do not execute silvicultural practices and do not invest, while the remaining owners do both, caring and investing, that is, they follow a Holding-Reserve logic. Implicit mutual-activity (yes-yes) is distinguished from neighbours-passivity (yes-no) by the greater weight of the Forest-Enterprise logic.

Implicit-coordination and willingness-to-reduce fuel loads

It was expected that comparing implicit-coordination to the willingness-to-coordinate would allow some distinction between the modalities of the latter. It was admitted that the willingness-to-coordinate would prevail in the cases of practices similarity (*yes-yes* and *no-no*) or those in which the owner positively perceived the neighbours' practices (yes-yes and no-yes) and that it would be less in the cases of neighbours-passivity (yes-no). However, the association between implicit-coordination and willingness-to-coordinate is not statistically significant (Table 4).

Conversely, implicit-coordination is closely associated with the willingness-to-reduce fuels ($\rho = 0.000$, contingent coefficient = 0.443) and this association is stronger than the one existing between willingness-to-coordinate and willingness-to-reduce ($\rho = 0.035$, contingent coefficient = 0.291).

Among the *yes-yes* owners, about half declare that they are *willing without incentives*, while the *no-yes* owners are associated with *not willing*, and the *no-no* plots are *willing with incentives*. In the non-similarity of practices (*yes-no* and *no-yes*) an attitude of lack of willingness to change management is relevant. In other words, the owners who consider not needing incentives to practice fuels management are those who have a spatial neighbourhood context of mutual activity or contribution. The need of incentives is associated with mutual-passivity among the neighbourhood (*no-no*). Those who are not willing to reduce fuels load depend on situations that can be said to be self-passivity (*no-yes*).

In summary, in the group of *yes-no* plots, neighbours-passivity parallels an ambience of low explicit collaboration (high inter-knowledge without exchange of information and mutual aid), with 1/3 of owners not willing-to-coordinate and not willing-to-reduce. On the contrary, the *no-yes* plots, whose owners consider that inter-knowledge is not high (dominating the sociability in only half of the plots), is a group with a small proportion of those who are not willing-to-coordinate (only 14%), and the least receptive to adopting a reductive management. *Yes-yes* and *no-no* are not distinguished by the willingness-to-cooperate, nor by the inter-knowledge or mutual-help, or the management practices (bush-clearing pattern and management logics), and the willingness to adopt a reductive management differentiates them: while the former, with low fire susceptibility plots, intend to carry out this reductive management without incentives (in 51% of the plots in this group), the latter need incentives to do so (in 68% of the plots).

Discussion

The main results are discussed, namely the interdependence between neighbours' actions and the owner's own management, the lack of a relationship between the willingness-to-coordinate management and the implicit-coordination, and

the prevalence of both favourable attitudes toward coordination and similarity between neighbours' fuel reduction practices. Some lessons are drawn from the perspective of promoting coordinated management to reduce the fuel load in forest spaces.

Plot-neighbours interaction and forest management

In this section, we consider one of our main findings, the heuristic character of the variable implicit-coordination, that is, the argument that the interaction owner-neighbours' actions matters, namely for the owner's willingness-to-reduce fuel loads.

Peers' impact on economic behaviour has already received attention in the literature, but so far not in the context of NIPF owners and their geographical and plot neighbours (Busby and Albers 2010; Prante et al. 2011; Aswani et al. 2013; Tsusaka et al. 2015).

The implicit-coordination, which attests the interaction between neighbours' behaviour is associated with the owner's perception of local social capital. This association and positive relation between mutual-activity and inter-knowledge uphold, firstly, the idea of a likely interdependence between decisions of geographic neighbours (Crowley et al. 2009; Busby and Albers 2010; Tsusaka et al. 2015), in this case between FPNI owners. Secondly, it corroborates the importance of plot-neighbourhood rather than residential-neighbourhood for those effects (Tsusaka et al. 2015). In our setting, the proportion of plots whose owners live outside the municipality is only 32%, but in contexts in which the ownership of residents is more important, or the inter-knowledge between residential-neighbours is small because of the recent presence of new residents (Kvarda 2004; Ziegenspeck et al. 2004; Baptista and Santos 2005), it is expected that the plot-neighbourhood affects management behaviour far more than the residential-neighbourhood.

Having confirmed the interdependence of behaviour in the plot-neighbourhood among FPNI owners, we examine whether this interaction translates into behaviour similarity, or disparity derived from a freeriding temptation. Actually, it has been found that the interaction mostly translates into similarity of bush clearing behaviour among plot- neighbours. On the other hand, this finding corroborates the existence of local/regional patterns of forest management in NIPF (Canadas and Novais 2014a, 2014b). Still, the similarity of behaviour seems to be a result of mutual reinforcement of the decision of the owner and his neighbours (so far as inter-knowledge is at its maximum precisely among *yes-yes* and *no-no* plots, in the proximity of which the exchange of information is also relevant) and also the sharing of common institutional, socioeconomic, and geographic contexts (Canadas and Novais 2014b; Tsusaka et al. 2015).

The similarity of behaviour among neighbours, however, is not necessarily good in a social perspective, namely when it pertains to undesirable behaviour (Kollock 1998; Mulder et al. 2006; Ostrom 2011). Nevertheless, whether mutual-passivity or mutual-activity (as in both cases the perceptions of inter-knowledge and mutual-help are simultaneously higher), it seems fair to speak about implicit-coordination. That is, inter-knowledge and mutual-help favour the similarity of behaviour between neighbours. What distinguishes desirable from undesirable implicit coordination are local or personal constraints shared by an ensemble of neighbours. Mutual-passivity owners actually have their reasons for their bush-clearing behaviour, extendable to the cases involving owner-passivity.

As a whole, cases of mutual-passivity, self-passivity and neighbours-passivity are dominant in our sample, conducing to a social dilemma (Kollock 1995; Mulder et al. 2006). Intentional opportunistic behaviour, e.g. freeriding, however, hardly explains this passivity, mutual or unilateral (OECD 2013). First, in a context where regular bush-clearing is socially valued, one might expect a tendency of the respondent to overestimate self-effort and underestimate neighbours effort, in order to preserve his reputation (Ostrom 2011; Muradian and Cardenas 2015). This, however, is not observed in our sample, as neighbours-passivity (*yes-no*) covers fewer plots than self-passivity (*no-yes*). Second, self-passivity owners, more than viewing themselves as freeriding on the diligent action of their neighbours, declare greater management restrictions, which in most of the cases are given as insurmountable, and explain the unavailability of about half of them to change the present management.

Thus, the owners hypothetically involved in freeriding and mutual-defection (Kollock 1995; Mulder et al. 2006) actually have "objective" reasons for bush-clearing passivity: biophysical constraints, poor family labour availability, and higher cost of interventions. It is worth remembering that these owners are not differentiated on sociodemographic or size grounds, and so self-passivity is not related to a situation of small-scale *vis-à-vis* large-scale, corporate or public owner, as mentioned for other contexts (Busby and Albers 2010; Prante et al. 2011). Further below some of the assumptions (with which the rationality of the agents is often analysed and the notion of social dilemma is outlined) are discussed, such as the selfishness or the individualism of the agents and the homogeneity of the contexts of economic management (Olson 1971; Kollock 1995; Sen 1999).

Coordination, stated or implicit, attitude or behaviour

Despite the relevance of neighbourhood interaction, a second finding refers to the absence of an association between the willingness-to-coordinate and the implicit-coordination. That is, the interdependence of neighbours' practices does not affect the owner's willingness-to-coordinate.

In fact, the willingness-to-coordinate of an owner who actively manages fuels (yes-no) does not seem to be sufficiently affected by a hypothetical idea of ineffectiveness of personal action resulting from the perceived passivity or freeriding behaviour of the neighbours (Olson 1971; Mulder et al. 2006; Ostrom 2011). The rationale for this absence of association forces us to clarify the nature of each variable, their plots' profile, unit of inquiry, and purpose.

Starting with the nature of the variable, it should be stressed that the willingness-to-coordinate refers to a future coordination with a neighbourhood of the owner's residence or property (note that the owner surveyed has on average

eight plots), and is expressed in a statement. Also, the implicit-coordination variable expresses an owner-neighbours interaction implicit in the current practices (binomial practice-perception of practices), and refers only to the neighbourhood of the plot surveyed or plot-neighbourhood as opposed to residential-neighbourhood (Tsusaka et al. 2015). Because for about half of the plots with similarity of owner-neighbours behaviour (*yes-yes* and *no-no*), their owners perceive an ambience of information sharing and mutual–help, it can be said that the coordination defined as implicit, in part can be effective, even though not verbalized and explicit (Gass et al. 2006).

The fact that the willingness-to-coordinate is associated with the owner's social profile and is not associated with social cohesion capital or current management practices, leads us to admit its alignment with general values and attitudes related to the owner's social condition and defined by his education, place of residence, and gender, thereby confirming what has been recognized in other contexts (Ajzen and Fishbein 2005; Finley et al. 2006). The attitude toward coordination then emerges as independent of the management practices carried out in the plot and the proximity context (perception of what the neighbours do, inter-knowledge, and mutual-help)

Conversely, implicit-coordination has a strong association with management practices, neighbourhood context, and fire susceptibility. These aspects and the difference in the unit of inquiry (plot or owner) justify precisely that the association of the willingness-to-reduce with the implicit-coordination is greater than with the willingness-to-coordinate. The ownership fragmentation and geographical dispersion implies that the same owner may have different practices in different plots depending on their location and neighbourhood. The willingness-to-coordinate is a characteristic of the owner, while implicit-coordination and willingness-to-reduce fuel loads are plot characteristics. In small samples, this distinction limits the statistical validity of the tests carried out, a disadvantage of point sampling in territories with similar ownership structure.

In opposition to the willingness-to-coordinate, the willingness-to-reduce fuels was asked specifically for each sampled plot while confronting the respondent with the estimated cost of fuels reduction for that plot. The owner's understanding and familiarity with fuel reduction practices, while expressing his willingness-to-reduce, is clearly greater than familiarity with any eventual management change imposed by his enrolment in a FIZ or a FOA. His willingness-to-coordinate, whether formal or informal, is stated facing an *a priori* unknown scenario of change in his practices, and in fact seems to accommodate an expectation of financial support for forest activities. It should be recalled that the familiarity is considered as a determinant for a strong relationship between attitude/disposition and behaviour (Mitchell and Carson 1993; Ajzen and Fishbein 2005).

Regarding the purpose of each of the variables, it is worth remembering that many studies that consider behaviours regarding the coordination, resort to the analysis of owners' attitudes, preferences, perceptions, and interests, with the elaboration of typologies that allow rural extension to fine-tune more directed messages (Stevens et al. 1999; Belin et al. 2005; Finley et al. 2006; Gass et al. 2006). When it comes to joining a FIZ or FOA or handing over management procedures to another entity, this type of analysis seems well suited for accessing a future behaviour of the owner. However, if what is really at issue is a future coordinated management behaviour to reduce fuel loads, taking into account the current interactions at the plot-neighbourhood should provide more consistent clues. The history of the FIZ creation in Portugal clearly illustrates the difference between joining this organization, in a first stage, and the difficulty of implementing joint management, in the following stage (Kittredge 2005; Canadas et al. 2016).

Individualism and coordination arrangements for forest management

One of the main results presented above is the predominance (in our case study setting) of attitudes in favour of coordination (formal or informal), and the current similarity of practices between neighbours. Recognition that individually it is impossible to deal with fires and that the owner is responsible for protecting his plot against forest fires, can justify a strong willingness-to-coordinate.

This finding stands at odds with the often repeated argument of the individualism of forest owners in general and small landowners in particular, which ultimately leads to proposals that discredit those same owners by assuming the impossibility of cooperation. This individualism is also deemed to explain a slow progression of the FIZ, even though its creation since 2005 is at the same time taken, by others, as evidence of the shortcomings of this interpretation (Valente and Coelho 2012; Feliciano et al. 2015). When expressing his willingness-to-coordinate, the owner of Aguiar de Sousa certainly does not ignore the existence of FIZs constituted in contiguous or nearby parishes and municipalities, as well as the activity of the FOA that manages them.

The study of collective action in rural areas similar to our setting concludes for the very weak formalization of collective action and low participation in groups, networks, or organizations of an economic character, such as commercial networks, cooperatives, unions, or associations (Baptista 2010). At the same time, the strong inter-knowledge in these rural areas, place of birth of the vast majority of their residents, encourages high levels of mutual-help and strong participation in networks or organizations with religious, cultural, sports, or social solidarity purposes (Baptista 2010), which is to say weak collective action aimed at outside representation of local interests, and strong informal collective action inside the locale, apparently of non-economic character. Therefore, it is not surprising that, for owners in our study, there are the outside (urban) residents, and the more educated owners are those who are most willing to coordinate formally, in both cooperative or associative form (FOA and FIZ).

Strong social ties among the group of owners are usually pointed out as favouring the coordination (Poteete and Ostrom 2008; Ostrom 2011). This applies to implicit-coordination, but not to the willingness-to-coordinate. The preferences regarding formal or informal coordination have more

to do with the bridging capital, trust in the people, or in the entity leading the coordination (Finley et al. 2006; Canadas et al. 2014), than with the bonding capital evaluated by mutual-help and inter-knowledge amongst owners (Ishihara and Pascual 2009; López-Gunn 2012; Aurenhammer 2017).

But what do the different forms of coordination represent? The profiles of the owners-plots associated with the willingness-to-coordinate lead one to suspect that the non-coordination, the informal coordination, and the formal coordination cannot be regarded as degrees of an ordinal scale (Gass et al. 2009; Canadas et al. 2014). The formal coordination itself is not homogeneous, since the chosen coordinator can be a forest contractor, forest industry, or an entity like a FOA; and, even in the context of joining a FIZ, various hypotheses regarding the management models to be followed are set: responsibility of execution by the enrolled owner or by the coordinator. Thus, the advantages assumed in Gass et al. (2006) of independent coordination by multiple owners, which encompasses the satisfaction of working their own forests, with greater control over the practices and properties, are not exclusive to this modality. It is therefore not surprising that the relationship between the willingness-to-coordinate and the age or education level is not linear. A higher education, for instance, does not assure greater willingness-to-coordinate.

Either way, greater willingness-to-coordinate can coexist with the absence of examples of cross-boundary coordination, as often illustrated for the USA (Kittredge 2005; Finley et al. 2006). Therefore, it is worth noting that, according to Olson (1971), "without meaningful benefits, coordination will (does) not occur: independent action will dominate".

Policy measures for cross-boundary coordination

A last finding has to do with the relationship between the owner's attitude/behaviour toward coordination and his willingness-to-reduce fuels loads, pushing the discussion to the means (formation-information/financial incentives) and the focus (sectorial/territorial) of a policy intended to promote owners' coordinated management.

As for the means, it is important to recall that education favours a positive willingness for formal coordination, but without differentiating the implicit-coordination. In addition, "participation in some activity or informative session regarding the question of fire prevention in the last 5 years" does not differentiate either of the two coordination variables. Thus, the influence of the training/information on the attitude or practices of coordination for fuels management is unresolved (Fischer and Charnley 2012; Canadas et al. 2014).

Education favours formal coordination, but this coordination is viewed as a condition to access the financial incentives that the owners consider essential. Recall that a positive attitude toward informal coordination appears to be independent of public policies for fuels load reduction, while its formalization, including an association as coordinator, is dependent on financial incentives. That is, the formalization of coordination implies an expectation of incentives that is the major constraint of the willingness-to-reduce fuels amongst sampled owners.

From the current implicit-coordination, the cases of positive convergence between the owner and his neighbours are those less dependent on public incentives, and those of non-similarity are precisely the most dependent on these financial incentives for fuels reduction and the disruption with the social dilemma (Kollock 1995). But resistance to reducing fuel loads is much weaker in mutual-passivity plots (*no-no*) than it is in self-passivity ones (*no-yes*). The owner's acknowledgement of his divergence from neighbours' behaviour has objective reasons that not even the financial incentives can overcome. That is, in our setting, public incentives are claimed not for the solution of an individual problem, but rather for solving the social problem among the owners in the plot´s neighbourhood.

This insight forces us to focus on politics. The comparison of the more or less receptive profiles to coordination with the current implicit coordination enlarges the rationale for the need of messages or policy measures territorially focused (Aguilar and Montiel 2011). Measures attending to the proximity and contiguity of interventions, such as FIZs, are important. Nevertheless, without incentives, the changes are unlikely, since the economy has to be taken into account.

This approach, however, should not forget the heterogeneity of local owners' management logics, which confers complexity to the implementation of coordinated management (Gass et al. 2006). Once again, it is important to consider the typology of rural areas and the different profiles of the owners in each one of them (Canadas and Novais 2014b). The reductionist and often established duality between resident and non-resident owners, viewing the latter as more passive managers and considering them a hindrance to collective action, cannot be extended to all contexts. It was shown that aside from the residential neighbourhood, there is a relevant plot neighbourhood perspective.

Concluding remarks

The analysis of attitudes and practices was confronted in order to explore future coordination behaviours for the reduction of fuel loads, discuss the individualism often ascribed to forest owners, and take conclusions from the perspective of public support for the promotion of cross-boundary coordination management to reduce the risk of fire. Grounded on collective action theories and forest owners' management logics tradition, our approach innovates by introducing owner-neighbours behaviour interaction to the study of owners' coordination.

A first conclusion concerns the idea that in contexts of private property domain, the neighbours' actions count, that is, they are interdependent with the owners' management practices. Besides, this interdependence consists more of behaviour similarity rather than self or neighbours non-contribution, which can hardly be seen as freeriding if one looks at the owners' management constraints. Moreover, this interdependence is articulated with a certain social capital in the plot neighbourhood (greater perception of inter-knowledge and mutual-help favour the similarity of behaviour between owners and their plot neighbourhood) and is relevant to the owner's future fuel management practices.

The second conclusion refers to the fact that the willingness-to-coordinate, conversely, is not conditioned by the implicit-coordination in the plot proximity. Indeed, this willingness is very much associated with the social condition of the owner and appears to be independent of the social context in the plot neighbourhood and from the management practices. Hence, the willingness-to-coordinate is important in order to envisage a possible enrolment in a FIZ or FOA, but less important for the prospect of an eventual management cooperation behaviour for the reduction of the fuel loads.

We, therefore, contend that the complementarity of perspectives derived from the comparison of the variables implicit-coordination and willingness-coordinate opens up avenues for further studies on NIPF owners' attitudes/preferences/receptivity towards fuels management coordination for wildfires risk reduction.

It follows from the analyses and discussion that the obstacles to the coordination of fuel loads management and wildfire risk reduction should no longer be confined to the refuge of the owners' individualism (and corresponding opportunistic behaviour). Instead, there is a need to investigate the restrictions owners face in that management in different geographical contexts, and within the plurality of their management objectives and rationales.

Note

1. The question was "The owners doing bush-clearing in the vicinity of your plots are: all, the majority or some (= yes) and none (= no).

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