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1 **How environmental managers perceive and approach the issue of invasive species: the case of Japanese**
2 **knotweed *s.l.* (Rhône River, France)**

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14
15 **ABSTRACT**

16 Studying the perceptions of stakeholders or interested parties is a good way to better understand behaviours and
17 decisions. This is especially true for the management of invasive species such as Japanese knotweed *s.l.* This
18 plant has spread widely in the Rhône basin, where significant financial resources have been devoted to its
19 management. However, no control technique is recognized as being particularly effective. Many uncertainties
20 remain and many documents have been produced by environmental managers to disseminate current knowledge
21 about the plant and its management. This article aims at characterizing the perceptions that environmental
22 managers have of Japanese knotweed *s.l.* A discourse analysis was conducted on the printed documentation
23 produced about Japanese knotweeds *s.l.* by environmental managers working along the Rhône River (France). The
24 corpus was both qualitatively and quantitatively analysed. The results indicated a diversity of perceptions
25 depending on the type of environmental managers involved, as well as the geographical areas and scales on
26 which they acted. Whereas some focused on general knowledge relating to the origins and strategies of
27 colonization, others emphasized the diversity and efficacy of the prospective eradication techniques. There is a
28 real interest in implementing targeted actions to meet local issues. To do so, however, these issues must be better
29 defined. This is a challenging task, as it must involve all types of stakeholders.

30 KEYWORDS

31 Discourse analyses; environmental managers; invasive species; Japanese knotweed *s.l.*; management;
32 perceptions.

33

34 1. INTRODUCTION

35 **1.1. When scientific uncertainties make management more difficult**

36 Biological invasions, which are believed to be the result of global change, are of growing interest in the
37 biological sciences (Vitousek *et al.* 1997) because of their potential effects on biodiversity. Invaded ecosystems
38 are generally considered as disrupted areas, where native species are strongly threatened. Thus, the control of
39 invasive species has become a priority for many countries, and several policy engagements have already been
40 ratified and are being implemented (Genovesi and Shine 2004; Heywood and Brunel 2011). Therefore, managers
41 need to find efficient and feasible control methods (Delbart *et al.* 2012). However, in the case of particularly
42 efficient invaders, managing such species presents a considerable challenge, and while ecological studies are
43 numerous and can help to define successful management techniques (Genovesi, 2011), the complexity of the
44 ecological processes involved in invasion often makes it difficult to develop effective control methods.

45

46 Biological invasions pose not only a critical ecological issue but also an important social issue. The social
47 dimensions of biological invasions were first considered in the early 2000s (McNeely 2001), following
48 initiatives in environmental economics (Perring *et al.* 2000; Pimentel *et al.* 2000). If managers want to
49 efficiently manage invasive species when defining a management strategy, they must also consider the social
50 dimension of the issue (Binimelis *et al.* 2007; Gobster 2011). On the one hand, the impacts of biological invasions
51 are many and not limited solely to ecological consequences. They may also affect market or non-market goods
52 and services produced (or no longer produced) by invaded systems (Colautti *et al.* 2006). On the other hand, what
53 we define as a biological invasion (the degree to which the colonization of an area by a species becomes an
54 invasion) as well as the management strategies we use to control them are widely influenced by human
55 perceptions (Mack 2001).

56 **1.2. Human perceptions, a key factor for managing biological invasions**

57 When managing complex ecological processes, there are no standard rules defining what constitutes a good
58 decision or action. Human perceptions that guide the definition of strategies rely sometimes on non-scientific
59 criteria (Lévêque *et al.* 2012). For example, Starfinger *et al.* (2003) showed that when there are insufficient data
60 available to tackle a specific issue, there is a tendency to believe in stories about the beneficial or noxious impact
61 of an alien species. Focusing on human perceptions as well as human values associated with biological invasions
62 is a good way to better understand behaviours and decisions. Furthermore, this focus may help to define more

63 efficient management strategies (Vanderhoeven *et al.* 2011). This research direction is also legitimized given
64 the fact that there is a wide diversity of stakeholders or interested parties involved in the management of
65 biological invasions, each of them having a specific perception regarding the issue and a specific point of view
66 regarding the action to take (Simberloff *et al.* 2005). Human perceptions are at their most heterogeneous when
67 addressing questions that are confounded by many scientific uncertainties (Pahl-Wostl 2006), as everyone tends
68 to have his or her own perceptions depending on his or her personal experiences. With respect to invasive
69 species, uncertainty is the norm (Williamson 1999; Horan *et al.* 2002). The definition of action relating to
70 biological invasions must therefore take into account this diversity of perceptions (Binimelis *et al.* 2007; Garcia
71 Llorente *et al.* 2008). This article aims to serve this objective by choosing an original angle: the study of
72 managers' perceptions.

73 **1.3. The choice of studying managers' perceptions**

74 Many scientific studies until now have been interested in characterizing public perceptions of the control and
75 eradication of invasive species (Simberloff *et al.* 2005; Hulme 2006; Bardsley and Edwards-Jones 2007; Bremner
76 and Park 2007; Andreu *et al.* 2009), and public opposition has repeatedly caused delays in or the abandonment
77 of control efforts (Marshall *et al.* 2011; McNeely 2011). Better knowledge of public opinion towards these
78 actions is a first step in fostering public involvement and gaining social acceptance (Selge *et al.* 2011).
79 Nevertheless, the perceptions of environmental managers require specific attention.

- 80 - Environmental managers are charged with defining and implementing environmental plans. They are
81 the ones who have to act (or not) and who have to meet the challenge of overcoming uncertainties (Liu
82 *et al.* 2011). How do these uncertainties influence their perceptions, decisions and behaviours towards
83 the plant and its management?
- 84 - They are also the ones in charge of producing and communicating information about invasive species to
85 other stakeholders, tasks that require certain skills and principles (Jurin *et al.* 2010). Beyond the
86 uncertainties that they must address, when communicating on issues relating to a biological invasion,
87 they face the challenge of correctly informing stakeholders about the invasive species. Indeed, the
88 ambiguous and inconsistent use of terminology (Richardson *et al.* 2000; Collauti and Richardson
89 2009) and the use of emotive and manipulative language (Gobster 2005; Larson 2005; 2008; Stromberg
90 *et al.* 2009; Selge *et al.* 2011) have already been widely criticized.

91 **1.4. The case of Japanese knotweed *s.l***

92 *1.4.1. The importance of conducting case studies*

93 Research conducted on invasive species is instructive. In particular, these studies show that different criteria
94 influence human perceptions regarding a biological invasion. Several researchers have listed influencing criteria
95 (Garcia Llorente *et al.* 2008; Selgeet *et al.* 2011), and some have even proposed a model to explain human
96 perceptions of biological invasions (Gobster 2011). The following are among the influencing criteria identified:

- 97 - The impact caused by an invasive species appears to be one of the main structuring factors of human
98 perceptions. These impacts can be negative or positive (Shapiro 2002; Bardsley and Edward-Jones
99 2006) and may affect ecosystems as well as social systems (Garcia Llorente *et al.* 2008). The negative
100 impacts of invasive species on ecosystems are found to be a strong motivation for their eradication
101 (Levine *et al.* 2003; Garcia Llorente *et al.* 2008; Selgeet *et al.* 2011). Nevertheless, ecological functions
102 provided by species (Binimelis *et al.* 2007) or values associated with them (i.e., the aesthetic value of
103 colourful plants such as purple loosestrife; the cultural value of feral pigs for particular ethnic groups,
104 etc., Gobster 2011) may help to attenuate the observed negative impacts.
- 105 - Time can also influence human perceptions of a biological invasion such that the older the invasion, the
106 less the species is identified as exotic, and the better it is valued (Bardsley and Edwards-Jones 2006;
107 Garcia Llorente *et al.* 2008; Gobster 2011). Moreover, Starfinger *et al.* (2003) showed that perceptions of
108 an invasive species can evolve over time, according to the scientific data available.
- 109 - Personal factors add many variations to the perceptions of an invasive species. Such factors include
110 education, economic status, rural or urban residence, cultural or regional characteristics, house size and
111 distance: the closer the invasion, the more concerned people are likely to be (Garcia Llorente *et al.* 2008;
112 Ehrenfeld 2010; Gobster 2011). Knowledge and expertise also play a critical role in the way we consider
113 issues linked to biological invasions. Consequently, different stakeholders will often have different
114 perceptions of the issue.

115 The previous studies show that reflections about biological invasions cannot be exclusively conducted in a
116 global framework, as human perceptions of biological invasions depend on which species is under consideration,
117 which area has been invaded and which stakeholder is affected. Data, therefore, should be focused on the effect
118 of a single species over a single area on a single-type stakeholder.

119 1.4.2. *The Japanese knotweed s.l. invasion: a preoccupation of environmental managers*

120 Taxa from the hybrid complex *Fallopia* (mainly *Fallopia japonica*
121 (Houtt.)RonseDecraene,*Fallopia sachalinensis* (F. Schmidt ex Maxim.) RonseDecraene and the hybrid *Fallopia*
122 *x bohemica* (ChrtketChrtkovaĭ)) are widespread invaders of North America (Shaw and Seiger 2002) and Europe
123 (Child and Wade 2000). *F. japonica* and *F. sachalinensis* are rhizomatous perennial herbaceous plants that
124 originated from Asia and were introduced in Europe in the XIX century because of their ornamental qualities
125 (Bailey and Conolly 2000). Today, *F. japonica* is one of the most common invasive species in Europe, having
126 been identified in 40 countries (Lambdon *et al.* 2008), including France. Hybridization between *Fallopia* taxa
127 produces *F. x bohemica*, which exhibits higher genetic diversity (Tiébré *et al.* 2007), higher phenotypic variation
128 (Herpigny *et al.* 2012), and higher performances (Parepaet *et al.* 2014). *Fallopia* spp. colonize mainly in riparian
129 habitats and disturbed areas (Bailey *et al.* 2009). In invaded sites, identified functional impacts include altered
130 nutrient cycles (Dassonville *et al.* 2007; 2011) and reduced plant species diversity (Vanderhoeven *et al.* 2005;
131 Gerber *et al.* 2008). Numerous mechanical, chemical or biological techniques have been tested, but none have
132 demonstrated satisfying outcomes (for a review of these techniques and their effectiveness, see Delbart *et al.*
133 2012). In fact, some of them may even promote further invasion, as is the case for mowing interventions
134 (Beerling *et al.* 1994; McHugh 2006), the most frequently used technique. Little is known about the response of
135 the different taxa to the control methods. Moreover, as they invade similar habitats and as it is sometimes
136 difficult to distinguish between them, they are often considered together. For these reasons and for convenience,
137 in this paper, the term Japanese knotweed *s.l.* will be used to refer to the three taxa of interest: *F. japonica*, *F.*
138 *sachalinensis*, and *F. x bohemica* (Bailey *et al.* 2009).

139 Because of the uncertainties regarding management, there is no consensus with respect to the most effective way
140 to control Japanese knotweed *s.l.* (Delbart *et al.* 2012) or even whether it should be controlled. Ongoing ecological
141 field research may produce knowledge likely to help define the best management plan for this plant (Rouifed
142 2011). Nevertheless, this research must be completed with data relating to the field of human perceptions,
143 especially to better understand the main issues associated with the management of Japanese knotweed *s.l.* and the
144 best action to take from the perspective of the managers.

145 1.4.3. *A need for research relating to human perceptions of Japanese knotweed s.l.*

146 Only a few studies have considered the social dimension of Japanese knotweed *s.l.* invasion. Child *et al.* (1998)
147 conducted a contingent valuation study to assess the socially acceptable cost of controlling the plant. Apart from
148 this study, only factual and incomplete data relating to the human perceptions of Japanese knotweed *s.l.* are

149 available. For instance, Vanderhoeven *et al.* (2011) determined that, in Belgium, Japanese knotweed *s.l.* is one of
150 the species mentioned by horticulture professionals and nature reserve managers during surveys when asked
151 which species would become a problem in the next few years. Further research on human perceptions of
152 Japanese knotweed *s.l.* is therefore required.

153 Herein, we aim to extend these initial data by characterizing the perceptions of environmental managers working
154 along the Rhône River with Japanese knotweed *s.l.* By analysing what they have written about this plant, we aim
155 to determine:

156 (1) What types of environmental managers are actually concerned about Japanese knotweed *s.l.* and produce
157 information about it?

158 (2) What are the perceived issues linked with the management of the plant?

159 (3) What strategies do the environmental managers recommend to manage this plant, and what arguments do
160 they use to justify their choices?

161 2. MATERIALS AND METHODS

162 2.1. Study area

163 The Rhône River, one of the main Mediterranean rivers, originates at the Furka glacier in the Swiss Alps. The
164 river is 812 km long, with more than 500 km located in France. The Rhône flows into the Mediterranean Sea,
165 where it terminates in a very large delta. Upstream of this delta, at Beaucaire, the mean river flow reaches 1700
166 m³/s (Olivier *et al.* 2009). The Rhône River is a powerful unifying element of southern and eastern France
167 because it crosses or delimits many administrative areas, including regional, infra-regional and local authorities.
168 Many environmental managers attached to these various geographical areas are facing the challenge of how to
169 control Japanese knotweed *s.l.* as part of their mission.

170

171 While few data are available concerning the intensity of the Japanese knotweed *s.l.* invasion along this
172 watercourse, according to the inventory conducted in 2001 for the regional water authority (Boyer and Laval
173 2001), the invasion is variable, with the upper region exhibiting a far greater invasion than the lower region.
174 However, two sectors appear to be more specifically colonized. One, in the Upper Rhône, is the 40 km section
175 downstream from the confluence with Les Ussets River, and the second, in the Middle Rhône, is a 90 km section
176 downstream from the city of Lyon. The Japanese knotweed *s.l.* invasion is of major concern to environmental

177 managers and has led to numerous management plans, following the measures (2010 to 2015) defined by the
178 regional water authority to “fight against invasive exotic species” (article OF6-C).

179 **2.2. Constitution of the corpus**

180 We aim to gather all documents relating to Japanese knotweed *s.l.* produced by managers involved in the
181 management of this plant along the Rhône River in France. The preliminary analysis suggests that printed
182 documents on this plant are relevant sources for studying stakeholders’ perceptions, as each document published
183 by a management structure is often collectively written and validated. The discourse it produces about a given
184 issue is therefore assumed to correspond to management structure’s perceptions regarding the issue.

185

186 To be as exhaustive as possible when collecting this documentation, a multi-step, rigorous collection strategy
187 was established. As a first step, we conducted a general search of the Internet, using the scientific and common
188 names of the plant, place names, and words such as ‘management’, ‘control’, and ‘management practices’, in
189 French. As a second step, we contacted by telephone different types of management bodies whose
190 responsibilities included issues related to the Rhône River. They were asked to send us by post or e-mail a copy
191 of any documents relating to Japanese knotweed *s.l.* that they had produced or had in their possession. For some
192 of these institutions, we went on-site to gather the available documents. This contact procedure was pursued at
193 three geographical levels:

- 194 - at the local level: all "communautés de communes" (a regrouping of local authorities with jurisdiction
195 on certain matters) or individual municipalities (when not collectively organized), as well as all local
196 water associations;
- 197 - at the regional or infra-regional level: every regional or infra-regional authority (“conseils régionaux et
198 départementaux”) as well as all decentralized state services (“direction régionale de l’environnement, de
199 l’aménagement et du logement”, “direction départementale des territoires”);
- 200 - at the Rhone-Mediterranean basin level: the Rhône-Mediterranean Corsica water agency (“Agence de
201 l’eau Rhône Méditerranée Corse”).

202 Two criteria were used to justify the inclusion of a document in the corpus. First, it had to specifically focus on
203 Japanese knotweed *s.l.* (not simply on invasive species); second, it must have been produced by an environmental
204 manager who was responsible for the management of an area crossed or bordered by the Rhône River or one of
205 its tributaries. We digitally scanned each document using OCR software (Omnipage professional©, Nuance

206 Communications Inc., Burlington, Massachusetts, US) and built a database to associate metadata with each of
207 these documents. These metadata included the following:

- 208 - the publication date. In the case that the publication was in draft (i.e., not final) form, the date planned
209 for publication was entered into the database. As a result, the corpus includes some sources listed as
210 published in 2013;
- 211 - the type of stakeholder producing the document;
- 212 - the nature of the document.

213 The collection of the documentation for the corpus ended in April 2012 and allowed us to gather 81 documents.
214 In spite of the systematic sampling, we may have missed certain documents. Nevertheless, since we have
215 collected every document that the managers have archived or have heard about, we can consider that our
216 collection is a large sample of the universe of relevant documents. One limit must however be underlined: we
217 chose to gather only the printed documentation, which excludes online publications dealing with the question of
218 Japanese knotweed *s.l.*, such as websites, blogs... As the environmental managers are more and more inclined to
219 use these media as a way for communicating, this exclusion may have biased our sample.

220 **2.3. Corpus analysis: a statistical analysis of textual data**

221 The corpus was both qualitatively and quantitatively analysed. A statistical analysis of textual data (Lebart *et al.*
222 1998) was performed using the open source software Iramuteq© (Ratinaud and Dejean 2009), which was
223 recently developed (2008) and which is regularly updated. It relies on R software (R Core team, 2013) as well as
224 the python language.

225 Iramuteq© reproduces the classification algorithm, described by Reinert (1983; 1990) and implemented in the
226 Alceste© software, which has led to numerous publications (Brochet and Dubourdieu 2001; Dransfield *et al.*
227 2004; Parr *et al.* 2011). It corresponds to a top-down hierarchical classification based on five stages.

- 228 (1) Segmentation. The corpus is segmented into two textual units: (a) the texts composing the corpus –
229 in our case, each document produced by environmental managers and qualified by the metadata
230 defined above (publication date, type of stakeholder and nature of the document); (b) the text
231 segments (through an iterative process, each text is cut into a number of segments, defined
232 according to a number of words – 40 by default).
- 233 (2) Lemmatization. Using a grammatical dictionary, each verb, noun, adjective, *etc.*, is reduced to its
234 basic dictionary entry, named a lemma.

235 (3) Production of a contingency table. The matrix crosses the reduced forms (in columns) and the text
236 segments (in rows). Among the reduced forms, only the analysable forms (nouns, verbs, adjectives,
237 adverbs, *etc.*) are retained; supplementary forms (prepositions, pronouns, conjunctions and
238 auxiliary verbs, *etc.*) are excluded from the table. The presence or absence of each analysable
239 reduced form within each text segment is specified at intersections of the matrix (respectively noted
240 as 1 vs. 0).

241 (4) Processing of a top-down hierarchical classification from the contingency table. Relying on an
242 iterative algorithm, the software aims at defining classes that maximize the distance between two
243 subsets (using χ^2 metrics). The iterative process stops when sub-classes are not significantly
244 different. Specific forms of a class are then removed from the other class. This analysis is then
245 repeated on the larger of the two classes, and so on, until the requested number of classes is reached
246 (10 by default). Two independent analyses with different lengths of text segment are processed, and
247 their results are statistically compared to test the stability of the classes.

248 (5) Description of the classes. The number of text segments classified in each class is specified. For
249 each class, a list of the reduced forms associated with it is created (the degree of association with
250 the class is indicated by the χ^2 value). The modality of the metadata variables most associated with
251 each class is also specified. These classes are then finally interpreted as “lexical worlds” (Rouré
252 and Reinert 1993).

253 We also performed statistical treatments relying on the co-occurrence analyses of specific lexical forms (Lebart
254 *al.* 1998). In particular, using Iramuteq©, we conducted similarity analyses. Based on graph theory,
255 these analyses aim to study proximity and relationships between components (in our case, the lexical forms) of a
256 set (in our case, the corpus) using a maximum tree (Marchand and Ratinaud 2012). The plot resulting from this
257 analysis had specific properties: (a) the greater the occurrence of a lexical form, the greater the size of the
258 characters; (b) the greater the co-occurrence between two lexical forms, the thicker the line that linked them.
259 Such a graph was used to analyse the relationships between all lexical forms associated with a class, which
260 resulted from the top-down hierarchical analysis.

261 3. RESULTS

262 **3.1. Who produces information about Japanese knotweed *s.l.*, and in what form?**

263 The corpus was composed of 81 documents (195,006 words total) published between 1998 and 2013. However,
264 the production of information about Japanese knotweed *s.l.* was marginal until 2006 (Fig1A). That year marked a
265 strong increase in the number of documents produced, and the number continued to increase in the following
266 years.

267 Diverse types of environmental managers were involved in this production (Fig1A). Some were attached to the
268 regional water authority, to local or regional authorities or state services, to environmental protection
269 associations, to environment consultancy firms, to building companies operating on the river, to regional
270 conservation bodies (conservatoires botaniques régionaux), or to local water associations. Thus, both public and
271 private stakeholders contributed to the production of information about Japanese knotweed *s.l.* Managers
272 working within local water associations were the main stakeholders diffusing information about Japanese
273 knotweed *s.l.* as they alone produced almost half of the documentation. However, their contribution to the
274 production was relatively late and occurred mainly from 2010 onward. In other words, the strong increase in
275 production observed over these last few years was mainly due to this one group of stakeholders. Nonetheless,
276 local and regional authorities, state services, and environmental consultancy firms also had a significant input.

277 The documentation produced was quite diverse, consisting of management plans, syntheses of technical
278 meetings, management guides, identification guides, information leaflets and specialized journal articles (see
279 Table 1 for a description of the documents). The various documents addressed diverse target groups in that some
280 - management guides and synthesis studies - were intended for environmental managers who already confronted
281 ecological invasions and thus focused on management methods. Others - specialized journal and information
282 leaflet - addressed the general public with potentially no knowledge of the issue and thus provided
283 information about the plant, its colonization and its impacts. These two uses were roughly equally shared if we
284 consider the number of produced documents per category (Fig1B).

285 Following a spatial analysis, we observed that the production of documents relating to Japanese knotweed *s.l.*
286 also turned out to be diverse (Fig2), with the number of documents produced upstream being far higher than the
287 number produced downstream. This longitudinal division of the river seemed to correspond to the intensity of
288 the invasion (Boyer and Laval, 2001). That is, the more invaded the area was, the more documentation on the
289 plant being produced by environmental managers.

290 3.2. What is said about Japanese knotweed *s.l.*

291 3.2.1. Main components of the discourses

292 The top-down hierarchical clustering classified 97.7 % of the text segments within 5 lexical classes (Fig3a). The
293 clustering tree marked a first segmentation dividing textual segments into two parts, each having a semantic
294 unity. The first regrouped classes 1 and 2 (including 13.2 % and 24.2 % of the textual segments, respectively), and
295 focused on the fight against Japanese knotweed *s.l.* The second regrouped classes 3, 4 and 5 (including 19.6 %,
296 18.7 % and 24.3 % of the textual segments, respectively), and involved information on the invasion (mechanisms
297 of dispersion) as well as strategies for managing the plant. The most significant textual segments for each class
298 are presented in Table 2.

299
300 Class 3 (Fig3b) brought together all available strategies and resources for managing Japanese knotweed *s.l.* On
301 the one hand, it listed all possible actions aimed at controlling the plant: it mentioned both preventive measures
302 aimed at limiting its expansion, such as awareness actions (“prevention”, “awareness”, “communication”) or
303 follow-up actions (“cartography”, “diagnostic”, “monitoring”, “inventory”), and restorative measures when the
304 plant is already established (“eradication”, “fight”, “techniques”, “method”, “means”). The need to acquire
305 knowledge also held a significant position within this class (“information”, “knowledge”, “to know”). On the
306 other hand, this class took stock of all stakeholders concerned with the invasion of Japanese knotweeds *s.l.* in that
307 it referred both to management experts (“manager”, “Rhône-Méditerranée-Corse” [water agency], “local” or
308 “field” stakeholder”, “authority”), to economic actors (“company”), and to the general public (“public”). Many
309 geographical areas and many spatial scales involved in the management of the plant were also listed, including
310 “basin”, “Saône”, “Rhône”, “regional”, “*région*” (or regional authority), and “*département*” (or local authority).
311 This inventory responds to the concerns of developing specialized stakeholder networks to better control
312 Japanese knotweeds *s.l.* (“network”, “work[ing]” “group”).

313
314 Classes 5 (Fig3d) and 4 (Fig3c) comprised knowledge relating to the dispersal mechanisms of Japanese
315 knotweed *s.l.* Class 5 described the origins of the introduction of the species (“to introduce”, “exotic”, “Europe”,
316 “Asia”, “origin”, “ornamental”, “century”, “human” “activity”), its strategies of colonization and adaptation
317 (“hybrid”, “competition”, “reproduction”, “pioneer”), including its preferred environments for developing
318 (“wetland”, “railway” “track”, “road”, “side”) and finally, problems it could cause (“ecological” “impact”,
319 “nuisance”, “biodiversity”, “monospecific”, “ecosystem” “functioning”, “bank” “erosion”). This class appeared

320 to more generally describe certain dispersal mechanisms common to invasive species (“giant hogweed”,
321 “ragweed”, “animal”). Class 4 was more specifically focused on watercourses, described as one of the main
322 affected environments but also one of the main means of dispersal.

323

324 Eradication was at the core of classes 1 (Fig3e) and 2 (Fig3f). Class 2 listed a considerable number of the
325 techniques used – either today or in the past – to fight Japanese knotweed *s.l.* (“to mow”, “to cut”, “chemical”
326 “treatment”, “uprooting”, “tarpaulin”). Actions specifically focused on the main reproductive organs of the plant:
327 its aerial (“stalk”), or its underground parts (“rhizome”) – as both are strongly involved in its reproductive
328 capabilities in vegetative propagation. Therefore, a significant place in this class was given to the physiology of
329 the plant. The experimental component of these actions was strongly present, as the effectiveness of the
330 eradication techniques used was assessed experimentally (“protocol”, “experimentation”, “plot”, “counting”,
331 “m²”). Finally, the lexicon relating to seasons and seasonality was very much present (“end”, “beginning”
332 “May”, “June”, “season”, “period”, “month”), as was the lexicon linked to repetition (“to repeat”, “times”,
333 “repetitive”). This finding indicated, on the one hand, that environmental managers were used to relying on a
334 seasonal calendar to implement actions against Japanese knotweed *s.l.*, and on the other hand, that their
335 interventions must necessarily be repeated. Class 1 focused on a specific technique that was experimentally used
336 to eradicate the plant. This technique involved mechanical action aimed at crushing the rhizomes into small
337 enough particles (using construction machinery) to impede their vegetative reproduction. This class insisted on
338 the effectiveness of this method (“complete” “mortality”, “to achieve” “result”, “efficiency”) and mentioned the
339 necessary preventive measures to implement in such experimental trials so as not to further disperse the plant
340 (“cleaning”, “to clean”, “caterpillar” “machine”).

341 3.2.2. *A technical discourse responding to a wish for effective action*

342 This classification shows that more than one-half of the discourses were dedicated to actions aimed at controlling
343 Japanese knotweed *s.l.*, and more than one-third specifically focused on restorative methods. The discourses of
344 environmental managers appeared to strongly promote the implementation of actions to eradicate the plant. This
345 willingness to take action against Japanese knotweed *s.l.* was specifically obvious when we considered the
346 “efficiency” lemma, cited as many as 121 times in the corpus. Table 3, presenting its co-occurring lemmas,
347 highlights the fact that the “efficiency” lemma relates, above all, to the actions implemented for controlling this
348 plant, as this wish to be “more efficient” (36 co-occurrences) led environmental managers to be creative about
349 the methods used to destroy the plant. Figure 4 summarizes the new techniques proposed (and when) and how

350 their uses have evolved over time. We observed that while many techniques were tested, some were only very
351 marginally cited in the documentation produced by environmental managers (thermal actions, grazing, *etc.*), and
352 others had sometimes been abandoned (chemical treatments). On the other hand, other techniques were often
353 mentioned. Mowing, for example, was the most cited method for controlling the plant. Uprooting was also well
354 represented. It can be concluded that the information produced about Japanese knotweed *s.l.* was highly
355 technical.

356 3.2.3. *Issues mentioned for controlling this plant*

357 In the documentation produced by environmental managers, actions against Japanese knotweed *s.l.* were strongly
358 motivated by its impacts: there were 228 occurrences of the “impact” lemma present in the corpus. However,
359 when we considered its co-occurring lemmas (Table 4), discourses on their possible impacts appeared to be
360 rather weakly explained. While “environments” (n=30), “ecosystems” (n=16) and “landscapes” (n=11) were said
361 to be affected by Japanese knotweed *s.l.*, the ways in which they were affected were unclear. The only impacts
362 concretely qualified, albeit with very poor frequency, were related to the loss of biological diversity
363 (“biodiversity”, n=11; “diversity”, n=7, “monospecific”, n=4) or landscape diversity (“homogenization”, n=2;
364 “standardization”, n=2). Few references were made to the role of foliage in reducing biodiversity (“foliage”,
365 n=4; “shade”, n=3). Reduced access (“accessibility”, n=4), and bank erosion (“undercutting”, n=2), both induced
366 by the plant, were only marginally mentioned.

367 **3.3. Does every type of environmental manager have similar views about Japanese knotweed *s.l.*?**

368 3.3.1. *A diversity of arguments focusing on certain themes*

369 The distribution of textual segments within the different classes of the top-down hierarchical classification,
370 according to the type of environmental manager who produced them, provided information about the diversity of
371 proposals relating to Japanese knotweed *s.l.* Each type of stakeholder was inclined to use certain classes of
372 discourse. The probability of occurrence of classes, for each type of stakeholder, is particularly high a low in
373 respect to a hypothesis of independence (Pearson’s residuals; tables 5a and 5b).

374 - Class 3, which describes all strategies and stakeholders involved in the management of Japanese
375 knotweed *s.l.*, was significantly more represented in the discourse of regional conservation bodies
376 compared to other stakeholders.

- 377 - Class 5, which describes origins, colonization strategies and the potential impact of Japanese knotweed
378 *s.l.* invasion, was greatly more represented in the discourse of the regional water authority, whereas less
379 represented in the discourse of consultancy firms.
- 380 - Class 4, which describes the role of watercourses in dispersing the plant, was more represented in the
381 discourse of consultancy firms but also, to a far lesser extent, of environmental protection associations.
382 It was on the contrary less represented in the discourse of other stakeholders. Class 2, which describes
383 all the techniques used to eradicate Japanese knotweed *s.l.*, was generally more represented in the
384 discourse of local or regional authorities or state services, of local water associations, and, to a lesser
385 extent, of environmental protection associations. Conversely, it was greatly less represented in the
386 discourse of the regional water agency.
- 387 - Class 1, which is related to mechanical means of crushing rhizomes, was more represented in the
388 discourse of consultancy firms and, to a lesser extent, of building companies operating on the river. This
389 class is less represented in the discourses of other stakeholders, particularly the regional water agency.

390 These results show that each group had a specific position when approaching the issue of Japanese knotweed *s.l.*
391 Some types of stakeholders, such as the regional water agency, tended to emphasize all knowledge relating to the
392 Japanese knotweed *s.l.* invasion processes. On the other hand, other types of stakeholders, such as local or
393 regional authorities, state services, local water associations and environmental protection associations, were
394 more likely to diffuse information relating to the techniques used for eradicating the plant. This was also the case
395 for consultancy firms, who more specifically mentioned mechanical crushing techniques. Regional conservation
396 bodies appeared to take a particular stand, as they gave a more general view of the issue, mentioning both
397 strategies and the stakeholders involved in the management of Japanese knotweed *s.l.*

398 3.3.2. *Degrees of emotionalism linked to the Japanese knotweed s.l. invasion*

399 Four terms that were frequently used to qualify the Japanese knotweed *s.l.* invasion were “impact”, “nuisance”,
400 “risk” and “menace”, all of which have a negative connotation. Nevertheless, they were associated in the French
401 language (the original language of the corpus), with different significations, thus revealing information about the
402 way the environmental managers perceived the invasion. The “nuisance” and “impact” terms (in this corpus,
403 systematically considered as negative) characterize the invasion in a tangible, measurable way. Other terms, such
404 as “risk” or “menace”, on the other hand, refer to the invasion in a more intangible way: both evoke a potential
405 danger. The former supposes that ecosystems and/or societies (often not specified further) were vulnerable to

406 this invasion. The latter clearly evoked the danger associated with the invasion, as the terms were related to the
407 vocabulary of fear and had a strong emotive connotation.

408 The different types of environmental managers seemed to have different uses for some of these terms (Fig5). In
409 particular, the terms “impact” and “nuisance” were more represented in the discourse of the regional water
410 agency compared to the whole population of managers. Conversely, the term “menace” was more represented in
411 the discourse of local water associations. Thus, the Japanese knotweed *s.l.* invasion appeared to generate strong
412 emotions, specifically among this group of environmental managers.

413 4. DISCUSSION

414 4.1. Discourses promote an integrated action and focus on the eradication stage

415 This study indicates that environmental managers of the Rhone River strongly want to take action against
416 Japanese knotweed *s.l.* This attitude may be encouraged by the many policy engagements aimed at controlling
417 and even eradicating priority invasive species (Delbart *et al.* 2012). As there is heavy pressure being placed on
418 the environmental managers who are held responsible for maintaining environmental quality for the future, the
419 uncertainties linked with the management of Japanese knotweed *s.l.* may have contributed, in several ways, to
420 the willingness to take action. Most invasions are spreading too fast and too unpredictably to do anything other
421 than respond immediately (Sims and Finnoff 2013). Thus, the “wait and see” approach appears to be, in many
422 cases, inappropriate, thereby justifying the motivation for environmental managers to act. Moreover, behavioural
423 studies have demonstrated that the threat of fearsome risks (those that induce strong emotional response, such as
424 fear and anxiety) activate certain cognitive mechanisms that push people towards action (Loewenstein and
425 Lerner 2003; Sunstein and Zeckhauser 2011). Such reactions are thought to be more frequent in uncertain
426 situations (Patt and Zeckhauser 2000). The emotional response of environmental managers to a Japanese
427 knotweed *s.l.* invasion – tangible in their discourses – may explain their willingness to take action against the
428 plant. This tendency may also be reinforced by uncertainties relating to the effectiveness of the proposed
429 experimental methods of control. The absence of visible results and the need for repeated interventions encourage
430 managers to experiment with other methods. This series of successive failures and the lack of control over the
431 plant may have resulted in frustration among the network of environmental managers (Allison 2011), thus
432 encouraging them to pursue other strategies.

433 Which actions are considered by environmental managers? Their discourses tackle a wide diversity of modalities
434 of intervention and promote an integrated approach towards environmental management:

435 - They take into account every stakeholder (managers, economic actors, the public) and every territorial
436 scale (local, regional, catchment) concerned with Japanese knotweed *s.l.*

437 - They consider different actions depending on the invasion stage. During introduction stage, knowledge
438 acquisition and information campaigns are recommended; during colonisation stage, follow-up actions
439 are proposed; and during establishment stage, eradication measures are advanced.

440 Nevertheless, the discourses of environmental managers focus, above all, on possible actions when the plant is
441 already established. They have tested over time a large variety of techniques aimed at stopping or at least
442 slowing down colonization. The information produced about Japanese knotweed *s.l.* is very technical, and
443 environmental managers mention all of their successes and failures, sometimes describing in detail the way they
444 implemented actions and sometimes recommending certain procedures for increased efficiency. We believe that
445 the development of discourses – and consequently of actions – relating to the invasion prevention and monitoring
446 stages are beneficial, and we argue that it is best to act at the earliest possible stage of the invasion, that is, before
447 it is too advanced to be reversed (Boyer, 2005). In the Rhône River case, for instance, we have found that
448 uninvaded areas, such as the downstream section of the river, produce little information about the Japanese
449 knotweed *s.l.* invasion. Conversely, the more heavily invaded an area is, the more documentation the
450 environmental managers produce about these plants, and therefore, the more they worry about the presence of
451 the plants. An efficient management system should consider implementing action before this stage.

452 **4.2. Varying positions of environmental managers**

453 Japanese knotweed *s.l.* has led to widely differing proposals, according to the type of environmental manager
454 making the proposal. In particular, there appears to be a strong difference of approach between those managers
455 who define policy at a regional level (regional water agency) and focus on the knowledge available and those
456 who implement policy at a regional or local level (local or regional authorities, state services, local water
457 associations) and focus on action. Managers implementing environmental policies are highly interested in control
458 and eradication techniques and the effectiveness of these techniques. They are also the ones more frequently
459 using emotional language to characterize the Japanese knotweed *s.l.* invasion. This use of language may reflect
460 their strong and increasing need for success in managing this issue given that since 2006, the majority of
461 information produced about Japanese knotweed *s.l.* has come from these stakeholders. The pressure resulting
462 from management policies that expect quick results in managing invasive species may be a more sensitive issue
463 for managers in the field, as they directly experience the success or failure of their intervention and feel more
464 directly responsible for it. From another perspective, the emotional component of their discourses may not be a

465 sign of a greater preoccupation but may only translate their willingness to bring the Japanese knotweed *s.l.* issue
466 to the attention of funding bodies (including the regional water agency) to obtain funds to act against the spread
467 of this plant. The use of controversial language in the field of invasion biology has already been widely
468 observed, sometimes because its terminology connotes nativism, racism or xenophobia (Subramaniam, 2001;
469 O'Brien, 2006), sometimes because it is militaristic (Davis et al., 2001; Larson, 2005). These criticisms have led
470 some authors to advocate that scientists use more neutral terms for introduced species (Larson, 2005; Davis,
471 2009). The results of our study may suggest that environmental managers do the same and be more attentive to
472 the terminology used. We doubt that this evolution of language, if indeed possible (Larson, 2010; Simberloff,
473 2006), will lead to a consensus in the way that Japanese knotweed *s.l.* is perceived and has to be managed: those
474 attitudes appear to be more firmly embedded and to be influenced by heterogeneity of worldviews about relation
475 (and definition) of human society and biota (Simberloff, 2012). Nevertheless, such an effort would enable
476 sharing of views and discussion about actions to implement on a more neutral basis.

477 The information provided by the regional water agency (the managers defining policy at a regional level) uses
478 less emotive terms. Moreover, this agency says little about the available methods for controlling the plant but
479 rather focuses on the diffusion of knowledge related to the origins of the Japanese knotweed *s.l.* invasion, its
480 colonization strategies and the nuisance it creates. The position of the regional water agency appears to be more
481 reflective, or at least more dedicated, to the diffusion of information related to the Japanese knotweed *s.l.*
482 invasion. Nevertheless, the attitude of the agency is far from disassociated with action, as the control of invasive
483 species is part of the programmed measures (2010-2015) that it defined and funded¹. However, as the
484 information it produced did not focus on a way to achieve this objective, a gap exists between the two types of
485 managers: environmental managers who implement management policies need effective methods to efficiently
486 control the plant, as required by the regional water agency, but the agency only diffuses general knowledge
487 related to colonization processes. Misunderstandings and frustrations may result from these heterogeneous
488 positions. The communication strategy of the regional water agency may be more successful if their general
489 information was complemented with more technical details regarding methods of eradication. However, even if
490 the information produced by the regional water agency does not meet the expectations of environmental
491 managers who have to implement these management projects, the efforts aimed at diffusing general knowledge
492 regarding the origins, mechanisms and impacts of Japanese knotweed *s.l.* colonization should be maintained.

¹ Article OF6-C requiring to “fight against invasive exotic species”.

493 4.3. Towards a more targeted management

494 In the environmental managers' discourses, the management of Japanese knotweed *s.l.* is approached from a global
495 perspective. Recommendations for action define general rules regardless of the socio-economic and
496 environmental context of the area under consideration. These rules flow from the premise that ecosystems are
497 bounded by frontiers within which are found, either exclusively or primarily, native species. This premise,
498 however, is far from the reality, and defining such a reference state is delicate if not impossible (Dufour and
499 Piégay 2009). This perception of a stable and balanced nature has long been called into question by academic
500 ecologists (Simberloff, 2014). According to this author, the idea of a balance of nature lives on especially among
501 conservationists and environmentalists. This may explain why this point of view is salient in the discourse of
502 environmental managers.

503 The efficiency of management may be improved if a targeted strategy for each identifiable plant area was
504 defined. Such a definition should then be the result of a wide collective reflection relating to local issues linked
505 with action against invasive species. In view of this idea, environmental managers may have interest in clarifying
506 the local issues linked with action (or inaction) against the plant in each given context and in defining the
507 priorities related to its control. There are questions that must be addressed. For example, are there
508 ecological issues (detrimental to other species)? aesthetic issues (size of plant and visual place in the
509 landscape)? security issues (decrease in visibility)? economic issues (bank erosion)? Are ecological or
510 geomorphological characteristics of the invaded area favourable to a rapid dispersion of the plant? The efficiency
511 of the management may benefit from a more specific, spatially heterogeneous action that considers local issues
512 (Epanchin-Niell and Hastings 2010). Certain studies have already considered this approach and merit a specific
513 attention (Filippi and Aronson 2010).

514 5. CONCLUSION

515 This article studied the documentation relating to Japanese knotweed *s.l.* produced by environmental managers
516 working along the Rhône River and characterized their views on this invasive plant. The results indicated that
517 there is a gap between the proposals of stakeholders defining management plans at a regional level and those of
518 stakeholders who are implementing actions locally. Whereas the former were focused on providing general
519 knowledge about invasion processes, the latter were focused on listing technical methods for controlling and
520 eradicating the plants and providing information regarding the effectiveness of these methods. These different
521 approaches result, each in their own way, from uncertainties related to biological invasions and may lead to
522 misunderstandings among stakeholders. Nevertheless, they all agreed on one point: the need to take action

523 against Japanese knotweed *s.l.* While there was an interest in conducting targeted actions to meet local issues, to
524 do so, the issues must be better defined. This is a challenging task that must involve all types of stakeholders
525 including environmental managers, scientists, association members, users and the public. Uncertainties relating
526 to environmental management can only be overcome if management projects result from political projects that
527 have been collectively discussed and validated.

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534 gather the documentation included in our analysis corpus.

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