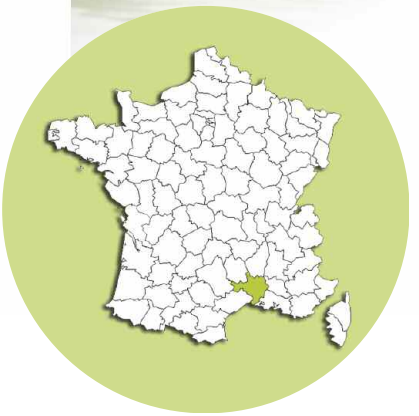


Water primrose

***(Ludwigia* spp.)**

Managing water primrose in the Gardons basin
Management report on four years of work

Board for balanced management of the Gardons basin (SMAGE des Gardons)

■ The SMAGE is a public river-basin territorial agency (EPTB) created in 1995 that represents 127 towns in the Gardons river basin (2 000 square kilometres on the right bank of the Rhône River) and the departmental council of the Gard department.

■ It is the project manager for the SBMP (sub-basin management plan) and for the Gardons river contract. It has set up consistent, basin-wide policies for:

- flood prevention;
- management of water resources (quantity and quality);
- preservation and restoration of aquatic environments.

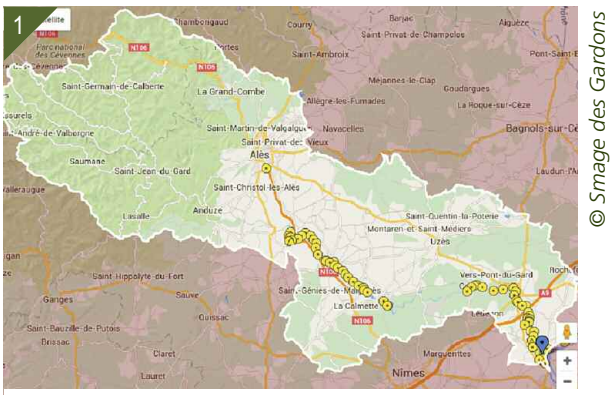
■ Since 2009, management of invasive plant species has become an important part of the policy for natural environments. A multi-year management programme was established in 2012.

■ Contact: Jean-Philippe Reygrobellet - smage.jpr@les-gardons.com

Intervention site

■ The Gardon Rivers flow through the heart of the Languedoc-Roussillon region. The rivers originate in the Cévennes mountains, in the Lozère department. They flow through the Gard department and into the Rhône River. The Gardons basin comprises many remarkable aquatic environments (Cévennes national park, Galeizon biosphere reserve, Natura 2000 sites, the Gardon gorges) that are home to an array of emblematic species such as the otter, the European beaver, Bonelli's eagle, shad, eels, bug orchids and summer lady's-tresses.

■ A large number of invasive species have been observed in the rivers of the basin (water primrose, parrot-feather watermilfoil, water cabbage, alien knotweeds, summer lilac, amorpha, etc.). Given the size of the area (2 000 kilometres of river including 500 km of large rivers), a multi-year (2012-2017) management plan was set up in 2011. It is funded by the Rhône-Méditerranée-Corse water agency, the departmental board and the Gard departmental council.



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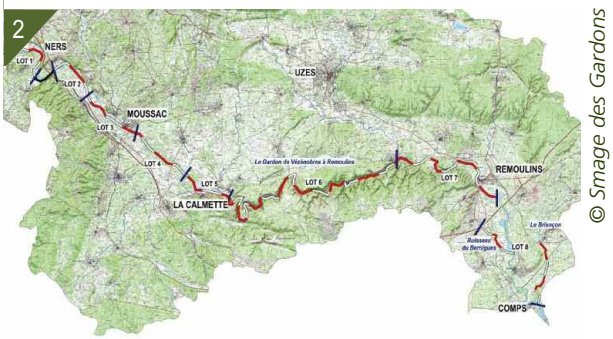

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1. Presence of water primrose in the Gardons basin in 2015.
2. Sites where work on water primrose was done in 2012.

Disturbances and issues involved

■ The species forms dense, single-species stands that completely cover up to several thousand square metres of water bodies and banks. It competes with and locally eliminates certain other species.

■ Beds of plants modify the daily oxygen cycle to the detriment of animal species.

■ Large quantities of biomass are produced, contributing to sedimentation and filling of channels.

■ Detrimental effects on recreational activities (boating, fishing, swimming, etc.).

Interventions

Inventories

An overall assessment was run in 2010 on 1 200 kilometres of river to pinpoint the areas needing work.

In 2012, a more in-depth examination of 70 km of river made it possible to launch the first calls for tenders.

Inventories were subsequently carried out in 2013 and 2014 by the companies in charge of the work. The results are used to determine the effectiveness of the work done the previous year and to prepare future work.

All work sites were identified (GPS) and incorporated in a geographic-information system (GIS).

Manual uprooting

Virtually every section of river colonised by water primrose was treated manually, i.e. 69 km in 2012, then 49 km in 2013 and 2014 (20 km treated in 2012 were subsequently excluded the following years).

The difficulties in accessing the bankfull channel (active tract) of the Gardon and the relatively small surface areas involved in these sectors justified manual uprooting, which made it possible to limit the negative effects of the work on the ecosystem.

The river reaches to be treated were very long and could not be handled by a single firm, which explains why the work was divided into sectors.

Depending on the quantities of water primrose and the period of the year, the work teams (one per sector) consisted of four to ten people on foot, assisted by one or two motorboats, and equipped with nets and sacks.

A quad and trailer were used as needed, in sectors that trucks could not access, to remove the waste.

The use of amphibious equipment made it possible to uproot large beds of plants in water during the initial stage of the work.

Up to four companies at a time were engaged in the work:

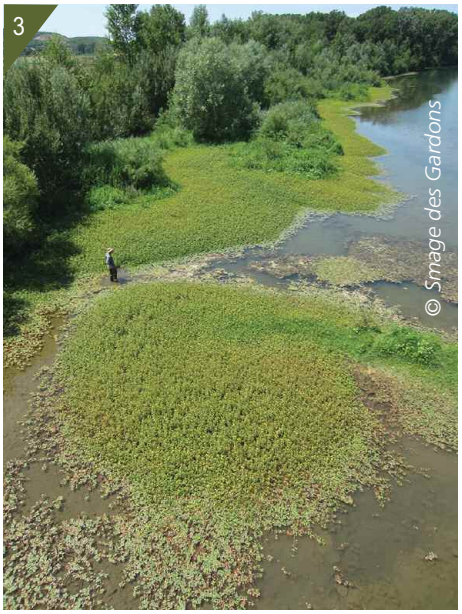
- in 2012, at the start of the multi-year management plan, it was difficult to find companies with the necessary experience in uprooting water primrose in rivers;
- the first year served to adapt the procedures and technical specifications to the various constraints (difficulties in accessing the sites and removing the waste, managing the floating craft in running waters, the many side channels that were difficult to detect, major variations in water levels, etc.) and to locate the companies with the necessary capabilities.

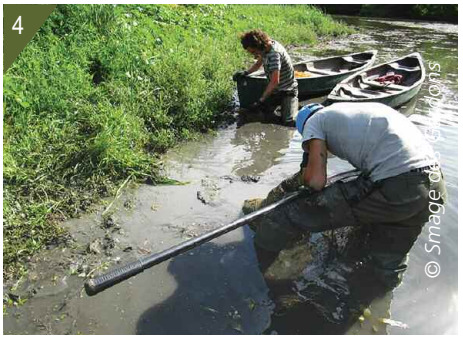
In 2012, the eight work sectors covered a total distance of almost 50 kilometres along the Gardon between Vézénobres and Remoulins, and over 20 km of tributaries to the lower Gardon near the town of Comp.

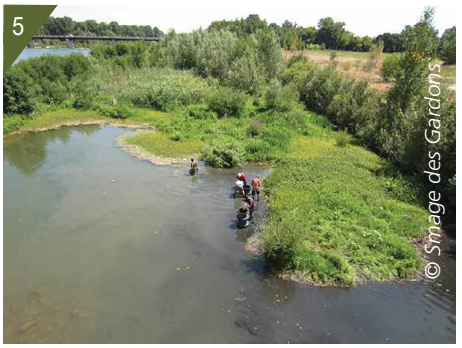
In 2013, the tributaries to the lower Gardon were withdrawn from the project because the low colonisation levels did not require comprehensive management. They were subsequently monitored and uprooted on a less regular basis. The project continued in seven sectors spanning a total distance of almost 50 km of river between Ners and Remoulins (along the Gardon River and a gravel pit, see Figure 2).

Manual uprooting was pursued along these 50 km over the three-year period (2012-2014).

Each year, the work lasted approximately five months from June to October. The initial plan was for a single uprooting period, but in 2013, the technical specifications were modified to include two passages through each area, one in June-July and the second in August-September. The second was deemed







3. An area colonised by water primrose.
4. 5. Manual uprooting.

indispensable to effectively treat the water primrose.

■ In order to anticipate the quantity of work, the technical specifications were adapted to take into account the significant fluctuations in the growth rates of water primrose:

- the colonised surface areas were estimated and included in the call for tenders, thus enabling the companies to prepare a preliminary quote and calculate the unit prices;
- prior to beginning the work, a company was required to examine its entire sector in order to precisely calculate (GPS) the colonised surface areas and submit the results;
- the sectors were then checked by the managing entity;
- a coefficient was applied to the surface areas to take into account the future growth of the plants and the results were compared to the estimates prior to producing the final quotes.

■ This procedure had a number of advantages, namely it provided an "updated" idea of the surface areas to be treated and it put the companies in a position to foresee the full extent of the work (quantity, access to sites, etc.). The resulting map also served as an inventory for the year that could be used to assess the effectiveness of the past uprooting work, information required for the work reports.

■ Mechanical uprooting

■ The former Ners gravel pit (3 hectares in size, of which 80% was colonised by water primrose), was linked to the Gardon and constituted the starting point of the dissemination to the entire Gardonnenque area. The large amounts of water primrose biomass made effective manual work technically and financially unfeasible.

■ In spite of its being located at the upstream limit of the colonised area, the gravel pit was left as is, however its link to the Gardon was cut by installing stone banking and soil in June 2013 to stop the release of cuttings and seeds from the gravel pit. Unfortunately, this barrier was almost completely washed away by the floods in 2015.

■ At the outlet of the gravel pit, the Gardon was heavily colonised. Over a 500-metre reach, the surface areas were so large (6 000 square metres in 2010, 10 000 sq. metres in 2012) that manual uprooting, though attempted in 2010, was abandoned and the decision was made to opt for mechanical uprooting.

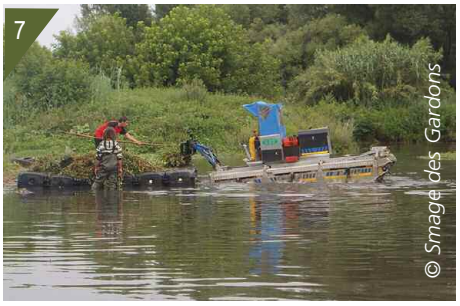
■ The minimal water depth (less than 40 cm in some places), site inaccessibility and the large volumes of plants made it necessary to undertake many technical adaptations and two years of work were required instead of the planned one year.

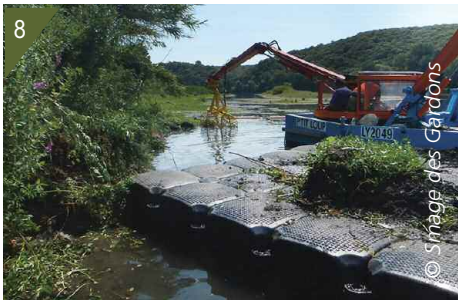
■ The first phase of mechanical uprooting was carried out in 2012. The equipment included a harvester boat, an amphibious excavator and a crane mounted on a boat with very little draft. The harvested plants were transported on a barge to the opposite bank.

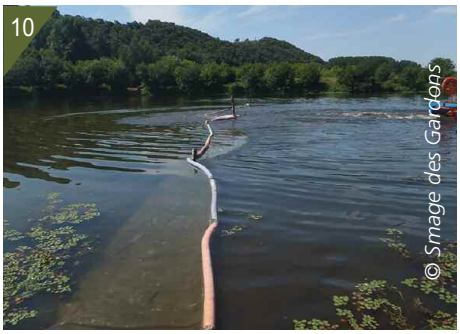
■ During this first phase, significant amounts of seeds freed from the sediment began to germinate. The seeds settled and germinated on the treated sites and on further sites hundreds of metres downstream, at the foot of the river banks and in the accumulated debris. This reduced the effectiveness of the work and study was put into developing other harvesting techniques.

■ The company doing the work suggested testing a technique involving hydraulic dredging and filtering of the sediment. This experimental technique was used during the second (summer of 2013) and third (February-March 2014) uprooting campaigns:

- the boat with the crane was equipped with a suction head and a shredder;







7. 8. Mechanical uprooting with the harvester boat and the raft used to remove the harvested plants (Figure 7), and the boat with the crane and the raft (Figure 8).
9. Seeds freed from the sediment.
10. Nets were installed to avoid dispersal of fragments of water primrose during mechanical uprooting.

- a pump connected to the pipe pulled up the sediment and sent it to the opposite bank where long tubes of geotextile fabric filtered out the stalks, rhizomes and sediment containing the water primrose seeds.

This technique produced positive results concerning the seeds (trapped by the filters), however the low productivity level (only 50 square metres per day for sediment depths of 20 to 40 cm) resulted in excessively high costs that meant the technique could not be continued. In addition, it was effective only in areas under water (at depths of over 20 cm) and therefore could not be used at the foot of the river banks.

■ The elimination of water primrose from the areas under water and the difficulties in mechanically uprooting the edges of colonised areas led to the halt of the mechanised techniques in 2014.

■ The work was done manually on the site in 2015.

■ Given the complexities of mechanical uprooting, the technique is not presented in greater detail in this document.

■ Waste management

■ During the work in 2012, different management techniques for the waste were studied:

- burning in an incinerator for household waste was too expensive (80 euros per metric ton);
- use as a substrate for replanting of landfills at the end of their use was seen as contravening regulations by the State services;
- composting was not possible in the absence of a reliable composting unit;
- spreading in agricultural fields was considered risky due to the danger of the seeds being carried in runoff water during heavy rains.

■ In light of the above conclusions, it was decided to transport the waste in covered trucks to a single storage area outside of floodable zones, i.e. a dry and regularly monitored spot. The land was provided free of cost by a farmer.

■ To avoid any dissemination of water primrose to nearby rivers (200 metres), bunds were created around the storage area to trap any water running off of the mounds.

■ To avoid germination outside the storage area, the SMAGE carries out annual monitoring of both the mounds of plants and the bunds. The nearby rivers were included in the list of monitored areas in order to achieve early detection of invasive plants in the river basin (see below).

■ At some point, when the germination rates have fallen to a low level, the plants will be spread in ploughed fields lying outside floodable zones. The seeds in the sediment are regularly cultivated by the SMAGE in the framework of a simplified procedure and the germination rate is still between 80 and 90% after three years of storage.

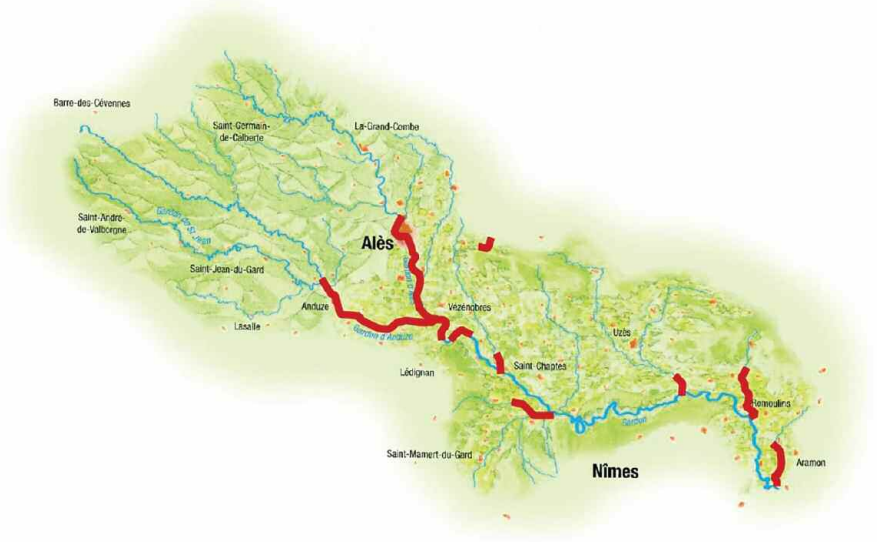
■ Monitoring, detection and rapid uprooting

■ The multi-year management plan includes monitoring and early detection work in rivers upstream of and near the zones already colonised. When water primrose is found in these areas, it is immediately uprooted.

■ In 2012, the work was done by SMAGE employees. However, due to a lack of time, only the downstream section of the Gardon d'Anduze and the Capelle Pond were inspected.

■ In 2013, consulting firms were assigned the mission of travelling along the rivers on foot to detect and map not only water primrose, but also the other species concerned by the multi-year management plan (parrot-feather watermilfoil, waterweeds, large-flowered waterweed, water cabbage, Japanese knotweed, desert false indigo and Japanese hop).

■ Each year since 2013, 60 kilometres of river have been inspected.
■ This work limits the risks of seeing the areas colonised by water primrose grow, while also ensuring the early detection of the other targeted species.



Map showing the river sections monitored annually.

■ The results are highly positive. In 2014, a new stand of water cabbage (*Pistia stratiotes*) was discovered in the town of Moussac, 60 km upstream of the known sectors, and in 2015, a square metre of water primrose was discovered along the river running through the town of Alès, 15 km upstream of the known sectors. The plants were immediately uprooted and no new regrowth has been observed.
■ On occasion, however, the plants are not discovered immediately. In 2014, a single large-flowered waterweed was found purely by chance along the Gardonnenque. In 2015, searches finally found the bed responsible for the dissemination downstream. It was approximately 1 000 square metres in size and in water 2 metres deep, in the town of Ners in an area that had not been previously inspected. Given the surface areas involved, it was decided to simply confine the plants to their present location.

■ Revised management strategy in 2015 (manual and mechanical uprooting)

■ All the work done in the framework of the management plan is assessed annually to determine whether the objectives are met and to modify the plan as needed. Concerning the management of water primrose, it became clear as early as 2010 that it would be impossible to completely eliminate the plants.
■ The objectives built into the management plan included a rapid and significant drop in the funds required for long-term management. The confirmation that the seeds were germinating, a mode of dissemination in addition to the cuttings, and the large surface areas covered by the plants on land meant that the overall objectives could not be met.
■ In spite of the highly positive technical results of the work (water primrose was no longer visible along 50 km of river) and the sums already invested, the failure to meet the economic objectives combined with the drops in available funding and the need to shift budget priorities meant that the project was no longer feasible. Consequently, the widespread uprooting was halted in 2015.
■ The work now addresses early detection, awareness raising, confining the species and locally reducing its economic and ecological impacts. Uprooting

is continued only on the upstream borders of colonisation and on the main tributaries (confinement), in closed wetlands and side channels of the Gardon in order to reduce the ecological impact. The main beaches and urban sections are also treated to limit the impacts on human activities.

- An annual photographic survey is now carried out on certain characteristic areas to estimate the speed of recolonisation on the treated sites and the utility of work to maintain certain areas of water free from the plants (this work is done less frequently, generally every three to five years).
- Given that water primrose is present in a large number of private ponds throughout the river basin, it must be assumed that it will spread to areas not currently monitored. By raising awareness, it should be possible to limit the risks of inadvertent dissemination and to increase the number of observers, thus improving detection and the possibilities of rapid intervention.

Results and costs

Technical results of manual uprooting

Table 1. Technical results

Note. The edges and the surface areas treated during work on such long distances of course vary from year to year, for example due to the discovery of colonised side channels. In order to enable comparisons from one year to the next, the table below does not include surface areas, often relatively large, added to certain sectors.

Technical results		Manual uprooting in 2012		Manual uprooting in 2013		Manual uprooting in 2014	
No.	Geographic sector	Surface area (sq. m) effectively uprooted	Volume harvested (cubic m) in one work period	Surface area (sq. m) effectively uprooted	Volume harvested (cubic m) in two work periods*	Surface area (sq. m) effectively uprooted**	Volume harvested (cubic m) in two work periods**
1-2012	Upstream of the Ners meander	71	0.1	Halted in 2013		Halted in 2013	
1-2013	2nd Ners gravel pit	340	22.5	250	8,0	Not applicable	2.0
2	Ners to Boucoiran	4 690	63.5	544	13.1	Not applicable	25.0
3	Boucoiran to Moussac	3 273	276	1 296	48.6	Not applicable	40.5
4	Moussac to St-Chaptes	3 796	155.8	1 927	310.0	Not applicable	66.3
5	St-Chaptes to Dions	490	14	108	3.2	Not applicable	7.8
6	Dions to Collias	515	5	0.1	1.3	Not applicable	5.1
7	Collias to Remoulins	1 775	56.6	935***	49.6	3 216.0***	106.4
8	Tributaries to the lower Gardon	680	6.3	Halted in 2013		Halted in 2013	
TOTAL		15 630	599.7	5 060	433.8	so	253.0

** The system was modified in 2013 to include two or three uprooting periods spread over four months. The volumes harvested in 2013 were therefore slightly greater.*
*** Following the work in 2012 and 2013, the water primrose was no longer present in dense beds, but only in random stands along the river banks. Calculations of surface areas were therefore halted.*
**** The company went bankrupt in 2013 and halted the work. A new call for tenders was launched in 2014, but the delay resulted in a rapid spread of the plants. This mishap demonstrates that in jobs of this size, the progress achieved can be rapidly lost.*

- Manual uprooting of water primrose in rivers turned out to be very different than in ponds, lakes and canals. The experience acquired by companies in the calmer waters (equipment, unit costs, work times) could not be easily transferred to running waters and this resulted in underestimating the financial costs.

■ The difficulties weighing on the work in rivers (running water, difficult access and removal of waste, regular discoveries of “hidden” side channels, etc.) make these jobs very hard to estimate and to manage by the responsible entity. Significant human resources must be brought into play and the teams must display great rigour and autonomy in their work, which implies a high level of confidence between the company and the managing entity.

■ The very small number of specialised companies and their heavy workloads constituted a major obstacle to projects over such large distances and made it difficult to set coherent “market prices”.

■ The discovery of new colonised areas, the failure of one company, a flood causing a massive dissemination, the renewed suspension and transport of seeds in the sediment, etc., make clear the uncertainty of the results of work done on rivers over large distances and surface areas. In areas with running water, compared to those with calm waters where the work conditions are better controlled, the management must foresee significant overruns in terms of the human resources and the overall funding. In some cases, it may be necessary to abandon certain heavily colonised sectors.

■ The time required by SMAGE personnel to organise and manage the uprooting work was considerable:

- 10 to 20% of an FTE (full-time equivalent) job from February to June (contacting the companies and preparing the contracts);
- 80% FTE from June to October (monitoring the work, amendments to the contracts, etc.);
- 20% FTE in November and December (writing reports, requesting subsidies).

■ Financial results of manual uprooting

Table 2. Financial results of manual uprooting

Note. Similar to the technical results, the prices were adjusted to enable comparisons between sectors from one year to the next. This table does not include surface areas added later to certain sectors.

		PRICE PAID (in euros incl. VAT)		
No.	**Sector / area**	**2012**	**2013**	**2014**
1-2012	Gardon upstream of the Ners meander	3 573		
1-2013	Gravel pit	6 099	3 137	2 970
2	River section	53 613	41 238	6 979
3	River section	37 269	53 127	19 612
4	River section	55 891	77 266	82 548
5	River section	8 721	7 375	3 984
6	River section	15 393	12 916	3 780
7	River section	28 274	11 565	59 388
8	River section	16 074		
	TOTAL	224 911	206 624	206 624

Table 3. Financial results of manual uprooting

Note. This table presents the amounts actually spent, taking into account major changes due to the discovery of small, heavily colonised ponds (reed beds, dense riparian vegetation) that had to be treated to avoid the risks of seed dissemination during floods.

	PRICE PAID (in euros incl. VAT)		
	2012	2013	2014
TOTAL	224 911	278 800	303 269

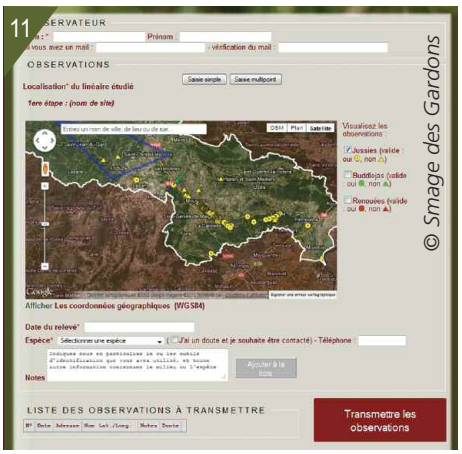
Information on the project

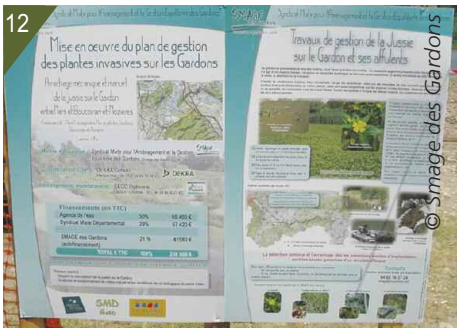
- An internet site using maps for early detection was created and made available in 2013 (http://invasives.les-gardons.com).
- The work done was used to illustrate various efforts to raise awareness, including TV reports, radio programmes, local meetings, brochures, posters and signs on the work sites, etc.

Outlook

- The work will be pursued in 2016 and 2017 according to the revised management plan set up in 2015.

Authors: Emmanuelle Sarat, IUCN French committee, Jean-Philippe Reygrobellet, SMAGE, and Alain Dutartre, independent expert.





11. Internet mapping site used for early detection.
12. Signs presenting the work on all the sites, intended to raise awareness.

For more information

- SMAGE internet site: http://www.les-gardons.com
- Site on invasive plants: http://invasives.les-gardons.com
- Smage des Gardons. 2011. Plan de gestion des espèces végétales invasives sur le bassin versant des Gardons. 72 pp. *
- Smage des Gardons. 2013. Bilan des actions menées en 2012 et 2013. 27 pp. *
- J-Ph Reygrobellet et A. Dutartre. 2013. Acte conférence ZNA à Toulouse. Plan de gestion des plantes aquatiques exotiques envahissantes à l'échelle du bassin versant. Mise en œuvre sur les Gardons (Gard-Lozère). 10 pp.*

** Available on request.*

SMAGE des Gardons
www.les-gardons.com

GT IBMA
FRENCH NATIONAL WORK GROUP
for biological invasions in aquatic environments

This management report was drafted in September 2016 by the work group for biological invasions in aquatic environments, set up by Onema and IUCN France, in addition to those already presented in the second volume of the book titled "Invasive alien species in aquatic environments, Practical knowledge and management insights", in the Knowledge for action series published by Onema.
http://www.onema.fr/sites/default/files/EN/EV/cat7a-thematic-issues.html