

**Floating Pennywort, *Hydrocotyle ranunculoides* eradication programme
on Exminster Marshes, nr Exeter, Devon**

2000 – 2013

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Introduction

Exminster Marshes are 450ha of flat coastal grazing marshes with neutral lowland grass fields separated by ditches (wet fences). They are located to the west of the Exe estuary, from Countess Wear (A379) in the north to Powderham in the south. The marshes have multiple owners and as a component part of the Exe Estuary have National (SSSI), European (SPA) and International (Ramsar) nature conservation designations.

The site qualifies for the SSSI designation mainly for the ditch flora and fauna present at the time of designation, including several Devon rarities such as Parsley water-dropwort, *Oenanthe lachenalii*; Flowering rush, *Butomus umbellatus* and Frogbit, *Hydrocharis morsus-ranae* and a wide variety of dragonflies including the nationally uncommon Ruddy darter, *Sympetrum sanguineum* and Hairy dragonfly, *Brachytron pratense*. Exminster Marshes are also used by water birds at high tide and provide nesting and feeding habitats for other bird species.

The Exe Estuary is classified as a SPA due to supporting over-wintering waterbird assemblage and wintering populations of European importance of Avocet, *Recurvirostra avosetta*; Slavonian Grebe, *Podiceps auritus*; Dark-bellied Brent Goose, *Branta bernicla bernicla*; Eurasian oystercatcher, *Haematopus ostralegus*; Grey plover, *Pluvialis squatarola*; Dunlin, *Calidris alpina alpina*; Black-tailed godwit, *Limosa limosa islandica*.

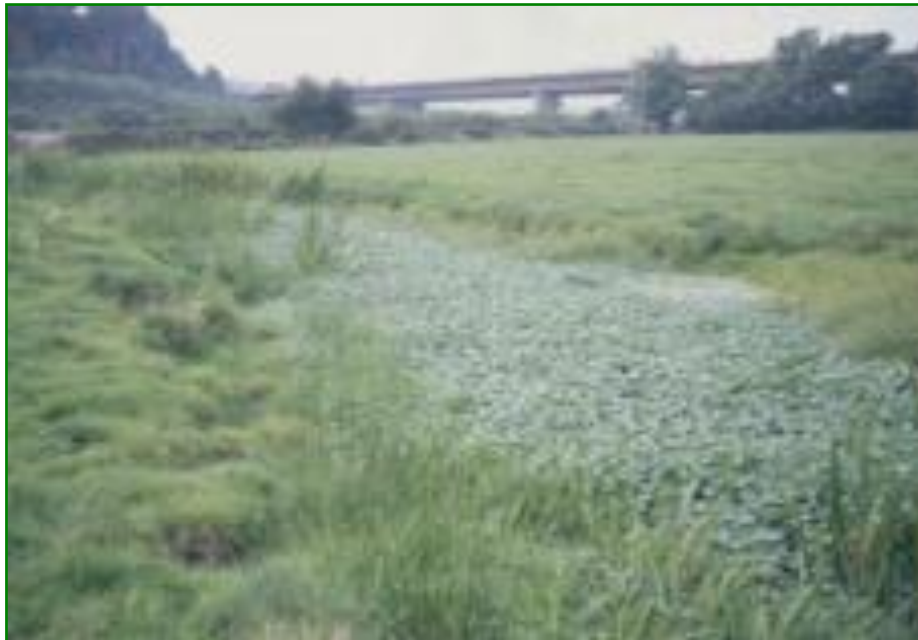
The qualifying features for classification as a Ramsar site are similar, with winter waterfowl peak counts of 20263 waterfowl (5 year peak mean 1998/99-2002/2003) and internationally important numbers of wintering Dark-bellied Brent Goose, *Branta bernicla bernicla*, 1509 individuals, representing an average of 1.5% of the GB population (5 year peak mean 1998/9-2002/3). Dark-bellied Brent geese occasionally use Exminster Marshes as feeding grounds.

A large area in the middle of the marsh is owned by RSPB and managed as a nature reserve. A Water Level Management Plan to balance the requirements of agriculture, flood risk management and nature conservation is in place.

Floating pennywort, *Hydrocotyle ranunculoides* is a North American species. It was brought to Britain in the 1980's by the aquatic nursery trade as an ornamental plant, but it soon became established in the wild. It is a highly invasive species that can grow up to 20cm a day, roots freely from nodes and can form extensive mats from the smallest root fragment, with maximum growth in late summer. The dense mats kill other aquatic species by starving the water body of light, nutrients and oxygen and can also increase the risk of flooding.

In September 1999 Floating pennywort was discovered just south of the M5, in ditches flowing from Exminster village. The ditches affected by Floating pennywort were in a triangular area bounded by the M5 to the north, the main Exeter-Penzance railway line to the west and the Exeter canal to the east. The majority of Floating pennywort was found to the north of Station Road.

Due to the major importance of Exminster Marshes for nature conservation it was imperative that the Floating pennywort was brought under control. The marshes act as a flood storage area for Exeter but even if the ditches were choked with vegetation (including Floating pennywort) it would not have a significant effect on the amount of water able to be stored. The floodwater would move overland as well. However, the Environment Agency carries out the regular ditch maintenance works, developed the Water Level Management Plan and so felt there was a moral responsibility to control the Floating pennywort.



1. Ditch choked with Floating pennywort, with M5 bridge in background 1999



2. Ditch choked with Floating pennywort

Removal and control

After Floating pennywort was discovered in September 1999 it was felt that mechanical control would be too disruptive and damaging for the ditch flora and fauna so while the problem was still confined to 6 ditches EA sprayed Diquat as Reglone. Although this was initially effective the plant soon recovered and continued to spread.



3. Spraying with Reglone



4. Ditch with sprayed Floating pennywort

A flood in December 1999 spread fragments further downstream. In 2000 the Environment Agency began a more co-ordinated removal and control project, with part funding by Natural England. However, repeated spraying with Reglone at a higher concentration than in 1999 left the apical buds unaffected and caused adverse publicity as well as health and safety issues. The cattle were excluded during the year.

Serious flooding across Devon during 2001 resulted in a backlog of flood defence work, restrictions due to the Foot and Mouth outbreak meant all EA operations were halted. The control programme was delayed but some removal took place during the routine maintenance.



5. Flooding spreading fragments of Floating pennywort downstream

In 2002 the removal programme was re-started with the floating carpets dredged by diggers, loaded into silage trailers, allowed to drain and then removed to a compost site.



6. Removal of floating mat



7. Loading into silage trailers prior to removal to compost site

The next stage was to remove the marginal plants which were rooted into the bank. These dredgings contained too much silt to be accepted for composting and it was too expensive to take to landfill (£30 per linear metre), therefore the plants were buried on site. The dredging resulted in widening of the ditches. Whilst dredging had an initial impact in removing the main mass of the weed many roots and fragments were left behind and these regrew.



8. Digger removing marginal plants and widening ditch

Kingcombe Aquacare started on a regime of hand-pulling in the autumn of 2003, with an Environment Agency surveyor producing a map with GPS grid references and notes. Kingcombe could then concentrate their resources on the removal by collecting floating plants, digging out rooted plants and by searching those ditches with limited visual access from the bank due to tall, dense vegetation (mainly reed) by donning dry suits and wading along the length. Stop-nets were not used due to the slow-flowing nature of the ditches and the time and expense needed to set and move them. Kingcombe revisited the areas where they had removed plants the next day to collect any fragments that had floated to the surface after the disturbance.

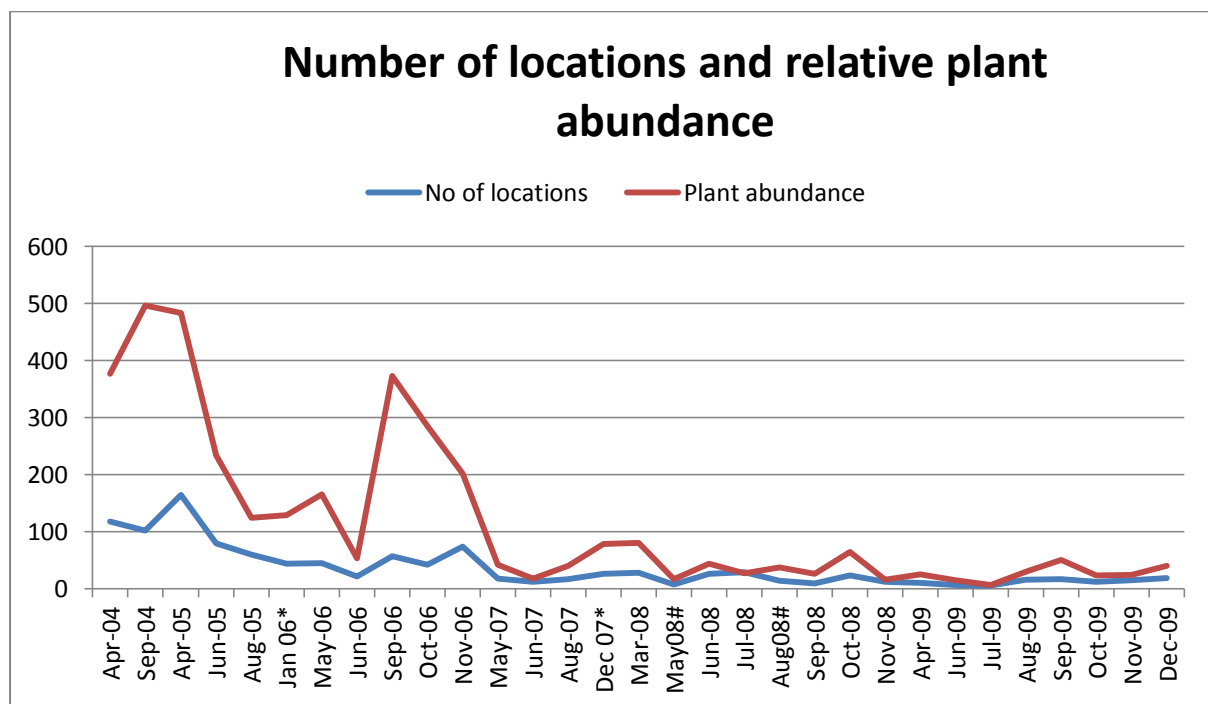
A more co-ordinated approach began in 2007 with Kingcombe Aquacare and the EA surveyor working closer together. Surveys and removals were carried out a minimum of 3 weeks apart during the growing season of May to October, with 6 visits in 2007, 8 in 2008 and 9 in 2009. This more intense effort reduced the number of locations where Floating pennywort was found and smaller fragments were removed before they had a chance to root or grow.

It appeared that Floating pennywort starts growing in May with an increase in leaf size and the plant starts to grow across the ditches. After the first one or two removals the plant abundance decreases in June and July before another growth spurt in August/September, as shown in Graph 1.



9. Plants starting to grow across a ditch in late May

Graph 1



Date of survey	No of locations	Plant abundance	Date of survey	No of locations	Plant abundance	Date of survey	No of locations	Plant abundance
Apr-04	118	377	Mar-08	28	80	Apr-10	0	0
Sep-04	102	496	May08#	7	17	May-10	0	0
Apr-05	164	483	Jun-08	26	44	Jun-10	0	0
Jun-05	79	234	Jul-08	29	27	Jul-10	0	0
Aug-05	60	124	Aug08#	14	37	Aug-10	0	0
Jan 06*	44	129	Sep-08	9	26	Sep-10	0	0
May-06	45	165	Oct-08	23	64	Oct-10	0	0
Jun-06	21	53	Nov-08	12	16	Nov-10	0	0
Sep-06	57	373	Apr-09	10	25	May-11	0	0
Oct-06	42	285	Jun-09	6	15	Jul-11	0	0
Nov-06	74	202	Jul-09	5	6	Oct-11	0	0
May-07	18	42	Aug-09	16	30	May-12	0	0
Jun-07	12	18	Sep-09	17	50	Oct-12	0	0
Aug-07	17	40	Oct-09	12	23	Sep-13	0	0
Dec 07*	26	78	Nov-09	15	24			
			Dec-09	19	40			

- Whole ditches recorded as being infested prior to 2004.
- Plant abundance is a subjective measure and only gives a relative indication of the decrease in biomass. The swamp area is not included here.
- * Partial surveys carried out only due to no access during winter months on RSPB land south of Station Road. This area is reserved for wintering wildfowl.
- # Partial surveys only as removal being carried out at the same time.

Problems

1. Ditch maintenance work

In September or October annual, rotational ditch clearance work is undertaken by EA with diggers removing the ditch vegetation and putting it on the bank. This work probably inadvertently spread fragments of Floating pennywort around the system. Small floating fragments were recorded in November 2006 after ditch clearance.

In 2008 and 2009 the surveyor was present to ensure any ditches which had patches of Floating pennywort were cleanly removed by the digger. The cleared ditches and slubbings were checked in November and Kingcombe removed any fragments which had re-grown.

2. Floods

Again winter flooding probably spread fragments around the system, with Floating pennywort appearing in new places downstream in the summer after flooding. These isolated patches were soon removed.

Flooding (as recorded by RSPB over 0.8m for more than 3 consecutive days)

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
		Jan	Jan	Jan		Jan			Jan	Jan	Jan
			Feb					Feb		Feb	
								Mar	Mar		
									May		
	Nov		Nov		Nov	Nov				Nov	
Dec	Dec					Dec			Dec		



10. Winter flood

3. Water-level changes

Occasionally patches were considered to be eradicated only to re-appear later when the water-level in the ditches changed or where cattle poached the banks. It is possible that a variation in water level causes any small dormant roots to grow as the water level drops and then rises again.

Specific areas (see locations on map 1)

1. Swamp

One of the most challenging areas for Floating pennywort control was in an area of *Typha* swamp. This area was regularly inundated in the winter and held 5-8cm of water during the summer, although occasionally no standing water was present, as in 2010.

The density of the *Typha* and reed stems made access to the area difficult and it was impossible to hand-pull the Floating pennywort stems as they often broke off leaving root fragments behind. It was then difficult to dig these out due to the mat of other roots. Spot-spraying with 2-4D Amine during 2005 had some effect in reducing the amount of Floating pennywort present but it soon regrew.



11. Swamp area after spraying 2005 showing sprayed and unsprayed plants



12. Plants in the swamp area before spraying in September 2007

In September 2007 transects were walked over the whole of the low-lying field and Floating pennywort was only found in the swamp area. This was sprayed with 2-4D Amine with the addition of 'Top Film' adjuvant. The untreated, clearly marked walkways through the stand were sprayed a week later, giving a total treatment with no overspray, which effectively reduced the biomass present. Only a few small plants with small leaves were located in December on the edges of the swamp area.



13. Spraying in the swamp area September 2007

The area was sprayed again in early September 2008 but it was not as successful as in 2007 and it proved impossible to effectively dig out the roots. Rain on the proposed spraying days prevented treatment during 2009 and there were still visible plants here during the survey in December 2009. However, the freezing conditions during the winter of 2009/2010 killed them and no plants have been seen in this area since. The swamp remained dry or damp throughout the growing period in 2010.

2. Willow carr

Floating pennywort was also present in a patch of mature willow carr, growing in shallow boggy pools amongst the willow roots. Spraying during 2005 was successful with a decrease from approximately 50 plants in April, to 12 in June and 5 very small-leaved plants in August. No plants were seen in this area until April 2009 when plants were recorded once again and these persisted as only 2 or 3 very small plants, despite hand-pulling and root-digging until December 2009. These were removed in December 2009 and no Floating pennywort plants have been seen here since. The willow carr remained relatively dry throughout 2010 until late October.

3. Pylon

No Floating pennywort had been recorded here until July 2008, and spraying during September 2008 was followed up with root-digging. The last plants were dug out in December 2009 and none have been seen since. The area beneath the pylon is poached by cattle and often holds water during the winter months. It is some 3-5m from the nearest ditch and was dry throughout the growing period in 2010.



14. Plants under pylon July 2008

4. Black Gulf

Black Gulf held persistent patches of Floating pennywort until 2010. It was a difficult ditch to survey and remove plants from due to the dense 2m tall fringe of reeds, which both obscured a view into the ditch from the bank and obstructed progress along the ditch in the water.



15. Plants in Black Gulf

Black Gulf ditch was dredged by Environment Agency in October 2009 and the surveyor was present to ensure the digger removed the Floating pennywort plants as cleanly as possible. The digger driver was very skilled but inevitably small fragments were left in the ditch. Follow-up visits by Kingcombe a week later and in December to remove both floating fragments and plants growing on the slubbings ensured no plants remained at the beginning of the winter.

Eradication

The southern marsh (south of Station Road) never had as much Floating pennywort (either in abundance or in number of locations) as the northern marsh. The plants that were present were probably washed downstream along the Berry Brook and they proved to be easier to eradicate by hand-pulling or simply lifting un-rooted fragments out of the ditches or where they had been caught in and started to grow in floating debris. The last patch was dug out in 2007 by a digger that was doing some work for RSPB.

Eradication was achieved rather unexpectedly. During 2009 plants remained at a low level, with persistent patches in the swamp and Black Gulf. Kingcombe carried out a late removal in December 2009 so that no plants remained but it was expected that plants would be present again in 2010. However the freezing winter of 2009 - 2010 apparently killed any remaining plants and none have been seen since. Temperatures in late December 2009 were well below the long-term average and January 2010 began very cold with hard overnight frosts and days when the temperature barely rose above freezing. There was also some snow. Nationally January 2010 was the coldest January since 1987. The summer in 2010 was generally dry with steady, unfluctuating low water levels on the marshes, which also possibly helped reduce any possibility of re-infestation. This dry summer was followed by another freezing winter.

Monitoring for any possible re-infestation was carried out 8 times in 2010 between April and November; in May, July and October in 2011; in May and October in 2012 and only in September in 2013, but no Floating pennywort plants or fragments were found.

Costs

Total costs from 2000-2013 were in the order of £200k. Mechanical removal and treatment cost about £60k a year but this cost reduced to around £10k a year for hand removal.

Conclusions

- Remove all plants as soon as they are identified
- Remove bulk of floating mat and marginal plants by digger and bury (or compost) but ensure that fragments do not remain or float downstream
- Hand-pull all fragments regularly (preferably at least every 6 weeks from May to November)
- Return to removal sites the next day to check for disturbed floating fragments. Also check downstream and for fragments caught in floating debris
- Ensure no plants or fragments remain at the beginning of the winter
- Spray areas that cannot be hand-pulled or dug out with 2-4D Amine with 'Top Film' adjuvant
- Hope for no flood events and for freezing winters followed by dry summers, with little or no fluctuation in water levels

- The fears that widening and clearing the ditches in 2002 would affect the ditch flora proved groundless. By 2009 the population of Flowering rush was higher than it had ever been and the floral diversity in the ditches recovered quickly.

Other invasive species present on Exminster Marshes

Water fern (*Azolla filiculoides*)



16. *Azolla*-choked ditch June 2007

This ditch was completely covered with *Azolla* during 2007 but with no treatment was clear in 2008 and just occasional plants have been seen since. *Azolla* does not appear to be a persistent problem here.

Water lettuce (*Pistia stratiotes*)

10 plants in a ditch were removed as soon as the surveyor saw them.

Fringed water-lily (*Nymphoides peltata*)

Fringed water-lily is present in some ditches but does not appear to be spreading. Rotational ditch clearance may be sufficient to keep this species under control.