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Fen violet *Viola persicifolia* Schreber: A review of conservation work carried out under English Nature's Species Recovery Programme: 1993-2005

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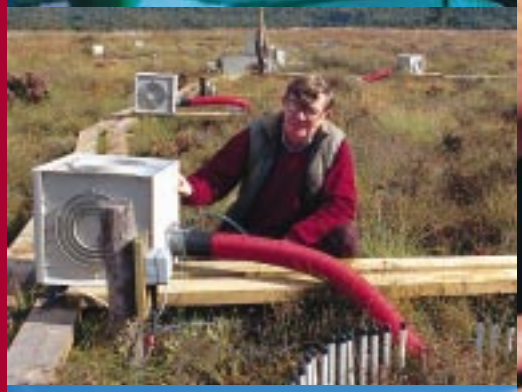

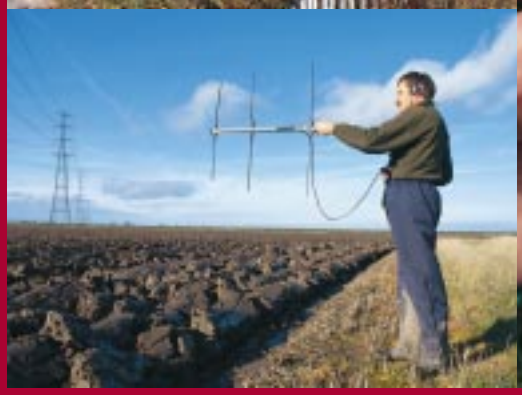

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Fen Violet *Viola persicifolia* Schreber: a review of conservation work carried out under English Nature's Species Recovery Programme 1993 to 2005

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Cover note

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Preface

Fen violet *Viola persicifolia* is regarded as Endangered in Britain (Cheffings & Farrell 2005) and is one of the plants covered by English Nature's Species Recovery Programme.

In 1993 the Institute of Terrestrial Ecology (ITE - later the Centre for Ecology and Hydrology, CEH) Monks Wood began research on *Viola persicifolia*, under contract to English Nature. At that time, the only extant UK sites were thought to be two fenland sites in Cambridgeshire and possibly a few lough margins in northern Ireland. The objectives of the three-year programme of work in England were:

- collation of existing data and information from previous studies;
- undertaking autecological studies to enable the definition of suitable germination and growth conditions;
- determination of specific habitat management requirements for the species at Woodwalton Fen and Wicken Fen and as a basis for a re-establishment strategy;
- assessment of the suitability of former sites for re-establishment of the species, with re-establishment in at least one former site.

The contract was extended after three years, and ITE/CEH continued research on the Cambridgeshire populations for a further five years, with Jane Croft becoming solely responsible for the contract in the last four years. The objectives for the second phase of the Action Plan, drawn up in 1996 in consultation with English Nature (Croft and others 1997), were to:

- maintain the existing populations;
- carry out further long-term observations on effective management and balancing of water levels;
- reinforce the declining and vulnerable population at Wicken Fen;
- set up disturbance experiments at historic sites which still have native semi-natural vegetation to recover plants from any seed bank which may persist.

On Jane's retirement from CEH, English Nature issued a contract to Tim Pankhurst to continue the work on monitoring *Viola persicifolia* at Wicken Fen and Woodwalton Fen.

Meanwhile, in 1997, *Viola persicifolia* was rediscovered at Otmoor, Oxfordshire, after an apparent absence from the area of three decades. The Rare Plants Group of the Ashmolean Natural History Society of Oxfordshire drew up an action plan for conserving *Viola persicifolia* in Oxfordshire (Annex 1) and began a detailed study of the Otmoor population. This initiative was supported financially under English Nature's Species Recovery Programme. The work was still ongoing in 2005. The objectives of the Oxfordshire action plan for *Viola persicifolia* were to:

- maintain and enhance the population at the known site;
- bring the plant into cultivation from the native population;
- investigate former sites and restore populations if appropriate.

This review spans the period 1993 to 2005. It is a summary of the work carried out on *Viola persicifolia* in Cambridgeshire and Oxfordshire, and includes information gathered during a visit by the ITE team to the Czech Republic, to investigate the requirements of the species in Europe. The main sources of information were:

- nine comprehensive annual reports to English Nature produced by ITE/CEH (Wells and others 1993 and 1995; Wells 1998; Croft & Preston 1996; Croft and others 1997; Croft 1998, 1999, 2000a, 2001);
- brief progress reports by Tim Pankhurst (Pankhurst 2001, 2003, 2004a, 2004b, 2005;
- accounts of the work in Oxfordshire by the Rare Plants Group (Lambrick 2001a, 2001b, 2002, 2003, 2004, 2005).

Acknowledgements

A large part of the information collated in this review was produced by Jane Croft and other members of the Monks Wood team (T.C.E. Wells, C.D. Preston, J.O. Mountford, R. Cox and V. Appleby), who carried out Species Recovery Programme work between 1993 and 2000. Tim Pankhurst took over the monitoring of sites in Cambridgeshire after 2000. The other half of the review covers work done by the Rare Plants Group of the Ashmolean Natural History Society of Oxfordshire, led by Camilla Lambrick. Other volunteers in the Rare Plants Group who helped in survey and monitoring at Otmoor are Frances Abraham, Robert Barber, Clare Coleman, Geoffrey Davey, Susan Erskine, Tom Fowler, Margot Godfrey, Sue Helm, Silvie Huijben, Anita Kikkert, Mark and Clare Kitchen, Shirley Leach, Lyn Matthews, Alison McDonald, Frances Watkins, Frank Penfold, John Presland, Sally Rankin, Dave Shute, Janet Welsh and Stan Woodell. I am particularly grateful to Jane Croft, Camilla Lambrick and Tim Pankhurst for providing copies of reports and answering queries. Camilla Lambrick produced Figure 5 of this review.

I would like to thank Alan Bowley and Adam Egglesfield, of English Nature, and Martin Lester, of the National Trust, for supplying me with site management details for Woodwalton Fen, Otmoor and Wicken Fen. Owen Mountford provided information about recent records of *Viola persicifolia* at Wicken Fen. Henry Arnold provided me with records and a distribution map from the Biological Records Centre, Monks Wood. Janet Terry, Royal Botanic Gardens, Kew, kindly sent me a report produced from the Millennium Seed Bank database, giving details of the holdings of *Viola persicifolia* seed. Richard Weyl, Environment and Heritage Service, Northern Ireland, and Naomi Kingston, National Parks and Wildlife Service, Republic of Ireland, provided information on *Viola persicifolia* in Northern Ireland and the Republic of Ireland. Chris Gerrard and Owen Mountford provided information on fen restoration projects in Cambridgeshire.

I am grateful to Jill Sutcliffe, English Nature, for giving me the opportunity to produce this review and for supervising the contract.

Summary

This review summarises the work carried out on fen violet *Viola persicifolia* in the period 1993 to 2005, under English Nature's Species Recovery Programme. The contractors were the Institute of Terrestrial Ecology (later the Centre for Ecology and Hydrology), Tim Pankhurst, and the Rare Plants Group of the Ashmolean Natural History Society of Oxfordshire. The sources of information for this review were reports produced by all these contractors.

Fen violet is Endangered in Britain and listed on Schedule 8 of the Wildlife and Countryside Act 1981. It has declined throughout western Europe and is rare in many countries. In Britain it is a plant of base-rich lowland fens and wet meadows. It has been recorded from over 20 sites in England, but its only remaining sites in 1993 were believed to be Woodwalton Fen and Wicken Fen National Nature Reserves, in Cambridgeshire. In 1997 it was rediscovered in Otmoor SSSI, Oxfordshire, in ground disturbed by the removal of willow two years earlier.

Populations of *Viola persicifolia* fluctuate widely in size and plants tend to appear in different locations from one year to the next, or to disappear from sites altogether for periods of years. Seeds can lie dormant for many years, germinating when conditions become favourable. During the period of the Recovery Programme, historic sites for *Viola persicifolia* in England were searched, but fen violet was not found. These sites were also assessed for their potential as re-introduction sites, but nowhere suitable was discovered.

Autecological work carried out in the field and on cultivated plants showed that in order to remain viable, populations of *Viola persicifolia* need very specific conditions.

- There must not be too much competition from other plants.
- Periodic disturbance of the soil is necessary to stimulate germination.
- Wet soil is needed in winter but waterlogging in spring and summer is detrimental.

The extant British populations of *Viola persicifolia* were monitored annually from 1993 to 2005 and the results are detailed here. At Wicken Fen, numbers of *Viola persicifolia* fell sharply in the late 1990s and the species has not been found there since 2003. At Woodwalton Fen, *Viola persicifolia* declined drastically after its population peaked in 1996 and 1997, and only one plant was found there in 2005. However, there may still be a large viable seed bank in the peat. An attempt to revitalise populations by disturbing the soil was temporarily successful, but experiments to reinforce populations by introducing young plants and seed met with no success. The Oxfordshire population appears to be self-sustaining.

The decline of *Viola persicifolia* in Cambridgeshire may be reversible with appropriate management, but climate change could render the sites permanently unsuitable. Unless the water table or the local topography at Wicken Fen and Woodwalton Fen can be manipulated to prevent the soil remaining waterlogged in spring, and a regime of regular disturbance is introduced, the species will remain very vulnerable to extinction there.

A reserve population of *Viola persicifolia* is established in cultivation in Cambridgeshire. Seed from Wicken Fen and Otmoor is stored in the Millennium Seed Bank, Royal Botanic Gardens, Kew.

Suggestions for the future direction of work on *Viola persicifolia* are made.

Contents

1 Morphology, identification, taxonomy and genetics

Fen violet *Viola persicifolia* Schreber is a low-growing herb, of the family Violaceae. It has a central tuft and creeping roots that send up stems at intervals. Its flowers are bluish-white to white, with a greenish spur that is less than twice as long as the sepal-appendages (Stace 1997). The pale flowers have given the plant its alternative name in some European countries: milk violet (Wigginton 1999). *Viola persicifolia* was formerly known as *Viola stagnina* Kit.

There are 15 British species in the genus *Viola. Viola persicifolia* is closely related to heath dog-violet *Viola canina*, which has all its stems arising from a central tuft, clear blue petals and a whitish-yellow spur that is over twice as long as the sepal-appendages (Stace 1997). *Viola canina* has two subspecies: *Viola canina canina* and *Viola canina montana.*

Viola persicifolia hybridises with both subspecies of *Viola canina*. The hybrid, *Viola* x *ritschliana* W. Becker (*Viola* x *gregoriae* Druce, *nom. nud., V.* x *stagninoides* Druce, *nom. nud.*), is closer to *Viola persicifolia* in its habit, but its flowers resemble those of *Viola canina* (Stace 1997). The hybrid is triploid and very vigorous, but so infertile that the possibility of back-crossing is very unlikely (Pankhurst 2004b, Lambrick 2001).

2 Distribution and current status

2.1 World

Viola persicifolia is largely confined to the cold temperate latitudes of Europe, but also occurs in western Russia and from central Siberia south to the Altai Mountains (Clapham and others 1962).

2.2 Europe

Viola persicifolia is widely distributed from western Ireland to Russia and from Scandinavia to northern Spain. It has declined throughout western Europe and is rare in many countries. A review of the status of the species in Europe in 1996 is given in Table 1 (from Croft and others 1997). The status of the plant may have changed in some countries over the last decade.

Table 1 The status of *Viola persicifolia* in European countries

Country	Status
Austria	No information
Belgium	No information
Britain	Endangered
Czech Republic	Rare
Denmark	Vulnerable
Estonia	Not threatened
Finland	Care demanding
France	No information
Germany	No information
Hungary	No information
Republic of Ireland	Rare

Country	Status
Italy	No information
Jugoslavia	No information
Latvia	Rare
Lithuania	Endangered
Netherlands	Endangered
Norway	Not threatened
Poland	Vulnerable
Romania	No information
Spain	No information
Sweden	Not threatened
Switzerland	Endangered

2.3 United Kingdom

In Britain, *Viola persicifolia* has been recorded from over twenty sites in fens and river valleys, mostly in eastern England. The species appears to have been lost from Norfolk, Suffolk, Yorkshire, Lincolnshire and Nottinghamshire. It has occurred since the start of the Recovery Programme in 1993 in only three places: Woodwalton Fen National Nature Reserve and Wicken Fen National Nature Reserve in Cambridgeshire, and Otmoor SSSI, a Ministry of Defence training area in the valley of the River Ray, Oxfordshire.

Viola persicifolia has been known from Woodwalton Fen since the early 1900s and was once widespread in the Reserve. It was recorded there sporadically up to the 1970s and the population peaked in 1980 at over 5,800, before declining again (Wells 1998).

Viola persicifolia was recorded as abundant at Wicken Fen in the nineteenth century, but declined in the early twentieth century. There is a record for 1916 (Wells and others 1995), but after that sightings ceased and the species was regarded as extinct at Wicken Fen for many decades. However, a single plant was discovered growing in a soil sample taken from the Fen in 1981 (Wells and others 1995). In the following year, two plants were found growing near a molehill and a large population appeared in the north western section of Wicken Fen, known as Verrall's Fen.

Viola persicifolia was recorded once in the nineteenth century at Otmoor, Oxfordshire, and was found again briefly in the 1960s. In 1997, it was discovered at Otmoor by the Rare Plants Group of the Ashmolean Natural History Society about half a mile from the area where it had last been recorded in the 1960s. The plant appears to be extinct at another site (Menmarsh) in Oxfordshire, where it occurred in the 1960s.

Viola canina ssp. *canina* is widespread and is present at Otmoor. *Viola canina* ssp. *montana* shows a close correlation of past and present distribution with *Viola persicifolia* (Pankhurst 2004b) but this subspecies is known with certainty only from Cambridgeshire. However, fertile violets resembling *Viola canina* ssp. *montana* have been found at Otmoor and require investigation (Lambrick 2004). The hybrid of *Viola persicifolia* with *Viola canina* ssp. *montana* is found at Woodwalton Fen. At Otmoor, hybrids are believed to be present, but their parentage has not yet been definitely established. Morphometric studies by Stephen Harris at the University of Oxford suggested that some plants thought to be hybrids were close to *Viola persicifolia* in form (Lambrick 2001).

Viola persicifolia is regarded as Endangered in Britain (Cheffings & Farrell 2005) and is one of the plants covered by English Nature's Species Recovery Programme.

In Northern Ireland *Viola persicifolia* occurred in the 1980s around the margins of Upper Lough Erne and a few turloughs in Fermanagh (Richard Weyl pers. com.). The species has also been found beside turloughs in the Republic of Ireland.

A summary of the British records for *Viola persicifolia*, held in the Biological Records Centre (BRC), Monks Wood, is given as Table 2.

Table 2 A summary of British records for *Viola persicifolia* held in BRC, Monks Wood

County (and vice-county number)	Site and 10 km square	Years of records				
		Pre-1900	1901-1950	1951-1970	1971-1990	Post-1990
Cambridgeshire (vc. 29 Cambs.)	Bottisham Fen TL56 (records for 5 years)	1851 to 1864				
	Near Clayhythe TL56	1832				
	Ely Fens/West Fen TL58	1880 1882 1894				
	Sutton Dole Fen TL47	1895				
	Wicken Fen TL56/TL57	1860 1875 1880 1883			1982	1992 1994
	Near Wicken Fen TL57				1982	
	Wimblington Fen TL49	1883				
Cambridgeshire (vc. 31 Hunts.)	Holme Fen TL28	1883				
	Whittlesey Mere TL29	1824				
	Woodwalton Fen TL28		1908 1942 1945	1950+	1980 1987+	1992
Lincolnshire (vc. 53 South Lincs.)	Boultham SK96		1933			
	Branston Fen TF06	1864 1897				
	Potterhamworth TF06	1853				
Lincolnshire (vc. 54 North Lincs.)	Fiskerton TF07		1936			
	Woodhall Spa TF16		1926			
Norfolk (vc. 28)	West Dereham Fen TL69		1936			
Nottinghamshire (vc. 56)	Near Bawtry SK69		1950			
	Misson-Misterton SK69	1840				
	Newington Misson SK69		1948			
Suffolk (vc. 26)	Lakenheath/Lakenheath Poors' Fen TL78			1953 1954 1968		
Oxfordshire (vc. 23)	Menmarsh SP51		1914	1956 1963 1964		
	Otmoor SP51	1821		1964		1997
	SP51				1987+	
Yorkshire (vc. 63)	Askern/near Askern SE51		1942 1946			
	Near Thorne Woods SE71		1942 1958			

Figure 1 illustrates the UK and Irish distribution of *Viola persicifolia*. The map was produced by the Biological Records Centre, CEH Monks Wood, using Dr Alan Morton's DMAP software, from records compiled by the Botanical Society of the British Isles.

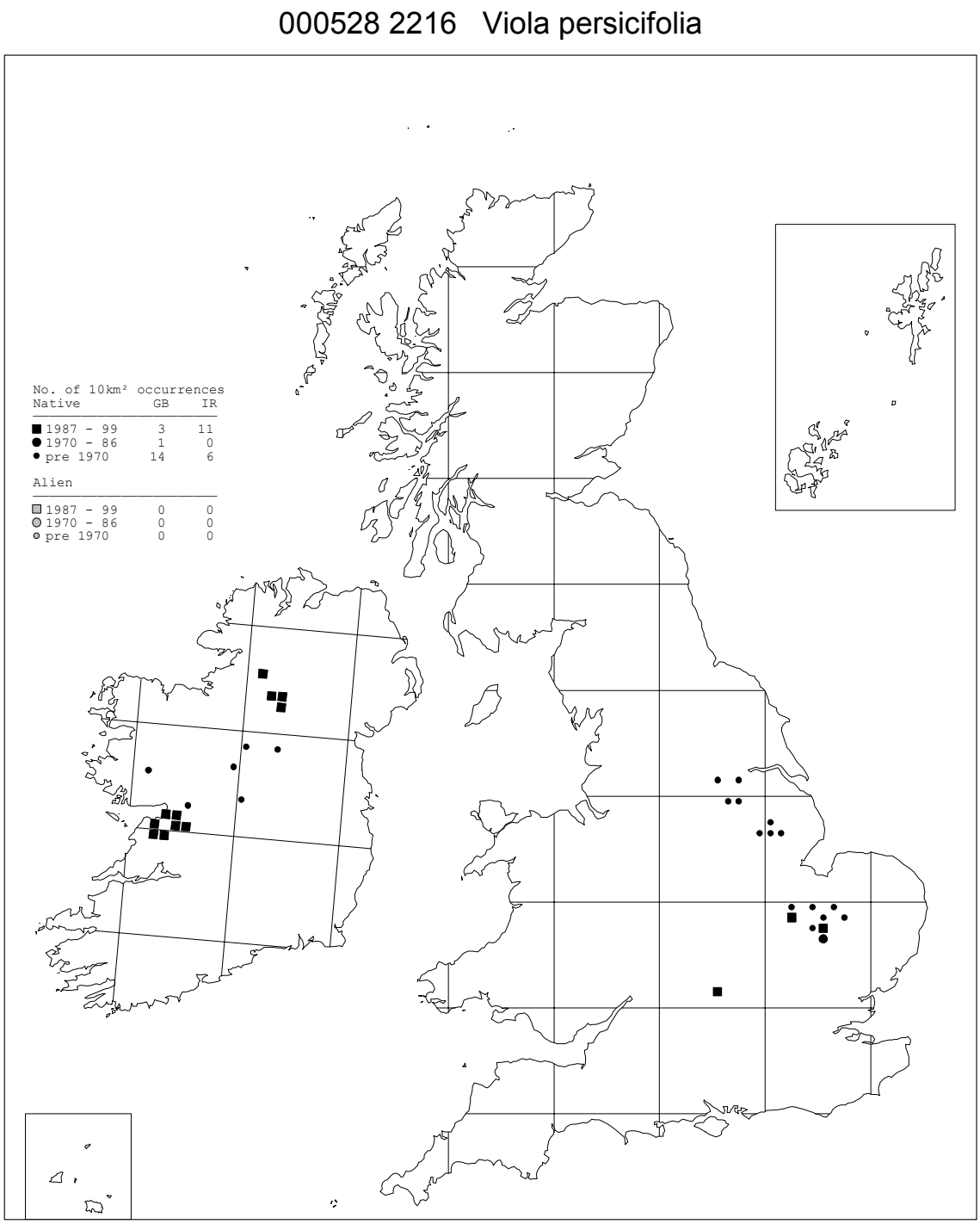

Figure 1 The distribution of *Viola persicifolia* in Britain and Ireland

3 Ecology and life cycle

Viola persicifolia is a perennial and is probably short-lived. Populations fluctuate wildly in size and plants tend to appear in different locations from one year to the next, or to disappear from sites altogether in some years. Seeds can lie dormant for many years, germinating when conditions become favourable. The plant flowers in May and June. Chastogamous flowers are pollinated by bees or, less often, by other insects, and apparently are never selfed in the wild, although they are self-fertile (Clapham and others 1962). Abundant seed is also produced later in cleistogamous flowers. *Viola persicifolia* spreads by means of its creeping roots, which produce shoots at intervals.

4 Habitat requirements

4.1 The landscape perspective

In England, *Viola persicifolia* is a plant of wet, base-rich soils in fens and unimproved fen-meadow, on peat (in Cambridgeshire) or clay (in Oxfordshire). The plant grows in relatively open vegetation, often with patches of bare soil. The species favours areas that are seasonally wet, rather than permanently waterlogged. All three sites in the UK are prone to flooding.

Viola persicifolia flourishes where the surface of the soil is periodically disturbed, as plants do not persist where the vegetation becomes dense (Wigginton 1999). When peat was still dug commercially in the Cambridgeshire fens, a show of *Viola persicifolia* often appeared in the wake of the peat diggers, growing on the baulks between the excavations (Gordon Mason, one-time Warden of Woodwalton Fen, pers. com.). During the 1960s and 1970s the plant appeared in abundance in various places in Woodwalton Fen in the years following the extraction of fen carr (Wells and others 1995) and disturbance caused by excavating clay for waterproofing the banks around the Reserve (see Section 7.1.2). It also reappeared at both Wicken Fen and Otmoor soon after scrub removal had disturbed the ground.

In Northern Ireland and the Republic of Ireland, *Viola persicifolia* is associated with grazed, calcareous grassland around turloughs (aquifer-fed pools with an annual dry period) and the margins of other loughs with fluctuating water levels. On the European mainland, the species is commonly found in grazed vegetation. Croft and Preston (1996) reported that in the Czech Republic they found the species in alluvial floodplain meadows that flooded annually

4.2 Communities and vegetation

4.2.1 Wicken Fen

At Wicken Fen, plants associated with *Viola persicifolia* in 17 quadrats were recorded (Wells and others 1995). The fen vegetation was 45 to 140 centimetres high. Species that scored 5 or more on the Domin scale in at least one of the quadrats are listed in Table 3.

Table 3 Some species associated with *Viola persicifolia* at Wicken Fen, 1994

Species	Range of Domin scores	No. of quadrats
Calystgia sepium hedge bindweed	1 - 5	5
Carex panicea carnation sedge	1 - 5	7
Cirsium palustre marsh thistle	1 - 9	14
Cladium mariscus saw-sedge	1 - 9	16
Epilobium hirsutum great willowherb	2 - 5	7
Juncus subnodulosus blunt-flowered rush	1 - 9	13
Mentha aquatica water mint	1 - 5	13
Phalaris arundinacea canary reed-grass	1 - 6	9
Phragmites australis common reed	1 - 5	14

The pH of the soil in these quadrats ranged from 6.50 to 6.95 (Croft & Preston 1996). The vegetation in the area of Wicken Fen that supports *Viola persicifolia* is classified (Mountford and others 2005) as National Vegetation Community M24 *Molinia-caerulea-Cirsium dissectum* fen-meadow (Rodwell 1991).

4.2.2 Woodwalton Fen

At Woodwalton Fen, *Viola persicifolia* grows in association with species such as *Agrostis stolonifera*, *Carex acutiformis*, *C. panicea*, *C. viridula*, *Hydrocotyle vulgaris*, *Juncus articulatus*, *J. effusus, J. subnodulosus* and *Ranunculus flammula* (Croft 1996). Pankhurst (1997) states that the vegetation in the area of the *Viola persicifolia* populations had most in common with MG10 *Holcus lanatus-Juncus effusus* rush-pasture (Rodwell 1993) and M22 *Juncus subnodulosus-Cirsium palustre* fen-meadow (Rodwell 1991). The plant was also associated with mosaics of atypical short sedge communities. As *Juncus effusus* became more dominant over time, the MG10 community tended to move towards M23 *Juncus effusus*/ *acutiflorus-Galium palustre* rush-pasture.

4.2.3 Otmoor

Lambrick (2002) states that the vegetation in the area of Otmoor supporting *Viola persicifolia* is very varied, with sedges abundant. It is closest to the National Vegetation Community M24 *Molinia-caerulea-Cirsium dissectum* fen-meadow (Rodwell 1991), although it is by no means typical of this community. Quadrat data for Otmoor is presented in annual reports to English Nature (Lambrick 2002, 2003, 2004). An Ellenberg analysis (Hill and others 1999) for vegetation at Otmoor indicates the presence of a number of species associated with *Viola persicifolia* that prefer low levels of nitrogen and a low pH (Lambrick 2002, 2003). These species include *Agrostis canina*, *Carex panicea*, *Cirsium dissectum* and *Molinia caerulea.*

4.3 Summary of habitat requirements

The habitat requirements of *Viola persicifolia* in the UK are summarised in Table 4.

Table 4 Habitat features important to *Viola persicifolia* in the UK

Type	Description
Physical and topographical	Lowland. On peat or clay. In base-rich fens and unimproved river valley fen meadow. In Ireland, around margins of lakes with fluctuating water levels. In waterlogged areas the plant occurs predominantly on slightly higher (better drained) ground.
Vegetational and structural	*Viola persicifolia* occurs in vegetation with *Phragmites australis*, *Cladium mariscus* and *Phalaris arundinacea* and in shorter rush-pasture and short sedge mire. Closest NVC communities: M24 *Molinea caerulea-Cirsium dissectum* fen-meadow (in Cambridgeshire and Oxfordshire) M22 *Juncus subnodulosus-Cirsium palustre* fen-meadow M23 *Juncus effusus/acutiflorus-Galium palustre* rush-pasture MG10 *Holcus lanatus-Juncus effusus* rush-pasture.
Processes	Seasonally wet but not permanently waterlogged ground. The species requires periodic disturbance of the soil. Plants do not persist where the vegetation becomes dense. Grazing or mowing benefits the species.
Chemical	Neutral to slightly acid soil. Nutrient enrichment probably not tolerated.

5 Threats / factors leading to loss or decline or limiting recovery

Viola persicifolia is thought to be rare in Britain primarily because it is associated with calcareous fen vegetation that has declined considerably in extent over the past few decades and is still under threat through lowering of water tables. However, populations have also declined at some protected sites. This is probably because site management has been inadequate to sustain viable populations (see Section 6). Hybridisation with *Viola canina* is a potential threat.

6 Management implications

Site management has to be finely tuned and cyclical in nature to provide conditions in which *Viola persicifolia* can flourish. Vegetation must be mown or grazed to prevent too much competition from other plants. As *Viola persicifolia* produces seeds from May up until the first frosts occur (Croft 2001), mowing is best done in autumn. Periodic disturbance of the soil is necessary. This can be achieved in a number of ways, for instance by scraping the surface, harrowing or grazing. The species is also demanding in its requirements for water, preferring wet conditions in winter but no waterlogging later in the season.

7 Conservation measures

7.1 *In situ* measures

7.1.1 Legislation

Viola persicifolia has been listed under Schedule 8 of Part I of the Wildlife and Countryside Act 1981 (as amended) since 1981. It is also listed on Schedule 8 of the wildlife (Northern Ireland) Order 1985. Woodwalton Fen, Wicken Fen and Otmoor are all Sites of Special Scientific Interest (SSSIs), and the two Cambridgeshire sites are also National Nature Reserves. Otmoor lies within an Environmentally Sensitive Area.

7.1.2 Site management

Wicken Fen

Between 1993 and 1999, the area in which *Viola persicifolia* grows was cut annually by machine and the cuttings were removed. The vegetation in the permanent quadrats set out in order to monitor *Viola persicifolia* was cut by hand and removed. Management outside the quadrats ceased for a year in 2000, but in 2001 a herd of small Konik Polski horses was introduced to the area. A programme of scrub clearance started in 2004 and will be completed in 2006 (Martin Lester pers. com.). Between 1987 and 1989 the northern boundary of Wicken Fen was waterproofed to retain water and to prevent outflow into surrounding ditches. This may subsequently have increased waterlogging in the area where *Viola persicifolia* grew. Several dip-wells have been installed to monitor water levels in the Reserve.

In Figure 2, the location of Compartment 2 Verrall's Fen, the area supporting the *Viola persicifolia* population, is arrowed.

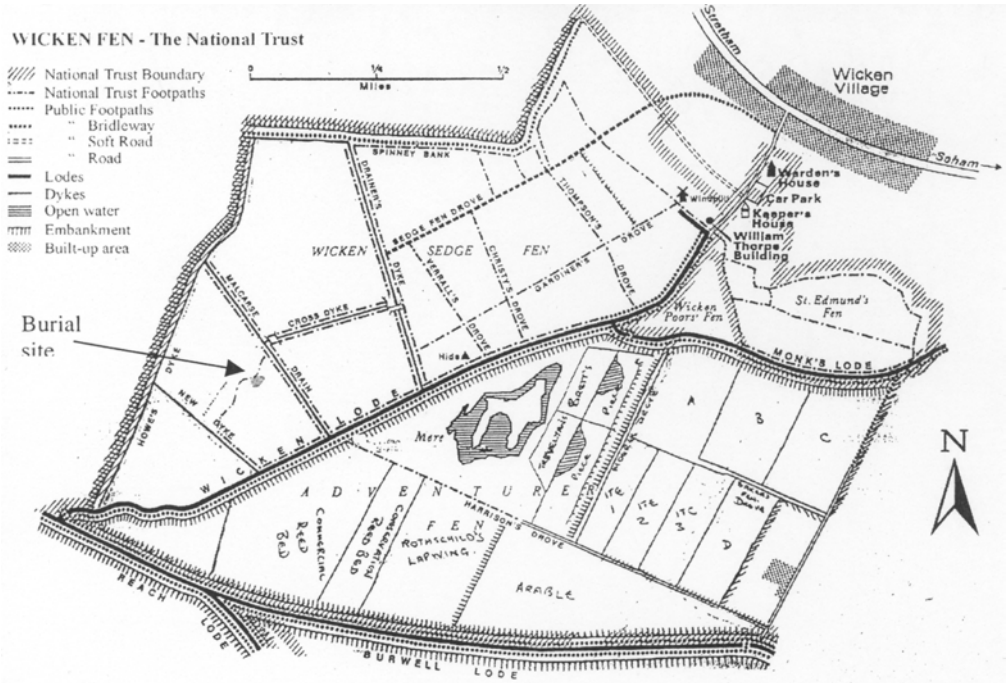

Figure 2 Map of Wicken Fen NNR showing the location of Compartment 2 Verrall's Fen and the population of *Viola persicifolia*

Woodwalton Fen

Much of Woodwalton Fen was cut over for peat in the nineteenth century, leaving behind a 'ridge and furrow' topography in some areas. A network of dykes was excavated to lower the water table in the peat diggings and to provide for the transport of peat and hay from the site by barge. In the first half of the twentieth century the fen dried out and scrub encroached, but following the designation of the site as a National Nature Reserve in 1954 a programme of scrub removal was begun, in an attempt to restore the fen vegetation. To prevent water draining out into the surrounding farmland, which is lower than the Reserve, leaking boundary banks were clay-cored. The excavation of clay for this purpose created meres within the Reserve. Boards were installed in internal dykes in an attempt to control local water levels within the Reserve, and dip-wells were sunk to monitor water levels in Compartments 42 and 55.

A map of Woodwalton Fen, indicating the location of the compartments, is given as Figure 3.

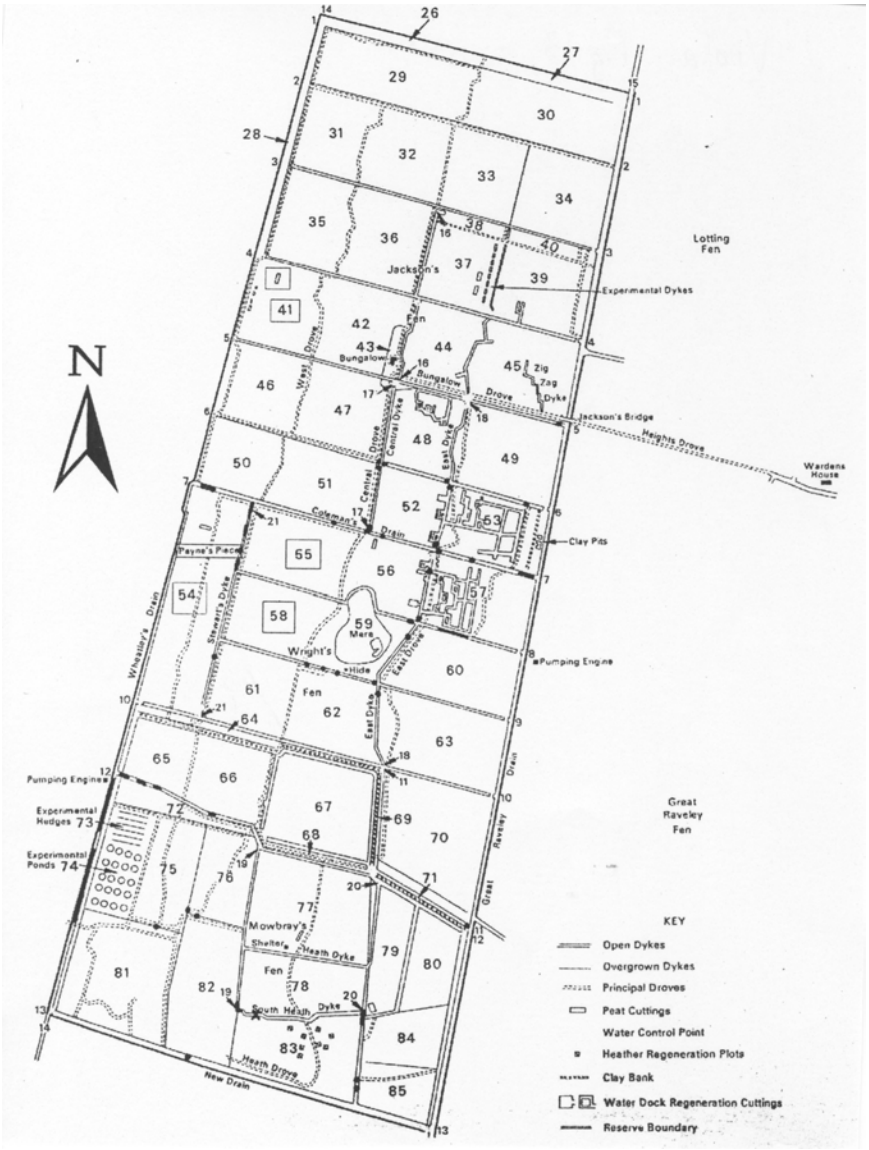

Figure 3 Map of Woodwalton Fen NNR showing the location of the compartments

A flood alleviation scheme for the surrounding farmland was created in the 1980s, with sluices to divert floodwater onto the Fen. The area of the fen where *Viola persicifolia* occurs most abundantly (centred around Compartment 55, the 'Violet Field') was for many years grazed with Galloway cattle and cut late in the season in an attempt to control *Juncus* and other coarse vegetation not eaten back by the cattle. However, since 2000 *Juncus* has been controlled using glyphosate weed-wipes. The Galloway cattle, being a heavy breed, created patches of disturbed ground.

Otmoor

The appearance of *Viola persicifolia* at Otmoor in 1997 followed sallow removal in 1995. In 2004, grey willow was pulled out on a section of the western boundary of the field ('Hayfield 1', SSSI Compartment 2) supporting fen violet. The Management Plan for Otmoor SSSI (English Nature 2000) prescribes hay cutting and aftermath grazing in the field where *Viola persicifolia* grows, to help maintain the herb-rich grassland communities and prevent the encroachment of coarse vegetation. The field where the plant grows is harrowed in the spring.

Otmoor is allowed to flood after heavy rain. Flooding is due partly to rainwater not soaking away on the heavy clay soil and partly to the river or internal ditches over-topping their banks. Water flow is controlled by the operation of a series of control structures inside and outside the SSSI, including bunds installed in 1996.

A map of part of Otmoor SSSI, indicating the location of Hayfield 1, is given as Figure 4.

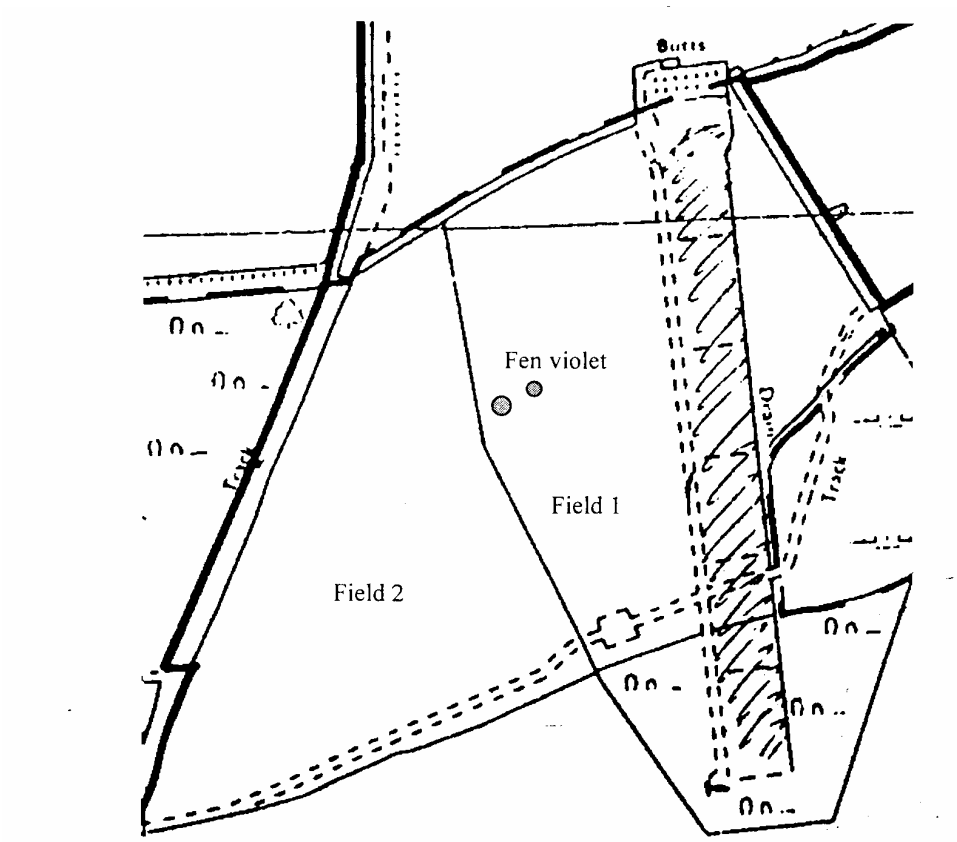

Figure 4 Map of part of Otmoor SSSI showing the location of Hayfield 1

7.1.3 Disturbance experiments

In 1994, field experiments were carried out to investigate the depth of the seed bank and the amount of disturbance needed to stimulate germination (Wells and others 1995). 2 x 10 metre plots in areas where *Viola persicifolia* had grown in the past at Wicken Fen (Verrall's Fen) and Woodwalton Fen (Compartments 55 and 58) were subjected to the following treatments:

- Control, no disturbance;
- Soil surface raked to a depth of one or two centimetres;
- Surface disturbed with a flail mower;
- Surface dug and the spit inverted to bring peat to the surface from a depth of 20 (Wicken) to 25 (Woodwalton) centimetres;
- Plots rotavated to a depth of about five centimetres (Woodwalton only).

The plots were subsequently mown annually and examined for young plants, until they became overgrown (Wells and others 1996; Croft and others 1997; Croft 1998, 1999, 2000a, 2001). In 1997 a further series of disturbance plots (2 x 5 metres) were created at Wicken Fen (Croft 1998). The results are shown in Table 5.

Table 5 Results of soil disturbance experiments at Wicken Fen and Woodwalton Fen

Site	Year	No. of plants	Location of plants Comments
Wicken Fen	1995	0	3 plants on the edge of the control plot, none in the disturbed areas
	1996	0	No plants seen; plots becoming overgrown
	1997	0	No plants seen; plots indistinguishable from the surroundings. New disturbance plots set up.
	1998	0	No plants found in either set of plots
	1999	10	10 plants + a few tiny seedlings in hand dug 1997 plot
	2000	6	6 small plants on hand dug 1997 plot
Wood-walton Fen	1995	658	No. of plants: control – 2 ; raked – 5; flailed – 66; hand-dug – 244; rotavated – 341
	1996	1079	No. of plants: control – 13; raked – 10; flailed – 69; hand dug – 559; rotavated - 428 plants
	1997	832	No. of plants: control – 3; raked – 14; flailed – 22; hand dug – 478; rotavated – 315 plants Plots difficult to distinguish from surrounding vegetation. Cattle allowed to graze plots in the autumn.
	1998	One group	All plants on rotavated plot. Vegetation on all plots dense.
	1999	86	Plots hardly discernible. 86 plants on hand dug and rotavated plots
	2000	0	No plants found
	2001	?	No monitoring because of foot and mouth epidemic
	2002	0	No plants found during visits in May or July
	2003	0	No plants found during visits in March. Plots becoming indistinguishable from the surrounding vegetation.

It was thought that *Viola persicifolia* did not appear at Wicken Fen in the plots set up in 1994 because there was no seed bank in this particular area. The results at Woodwalton Fen demonstrate that the more vigorous the treatment, the greater the likelihood of plants appearing.

7.1.4 Population reinforcement experiments

Because the native population of *Viola persicifolia* in the Verrall's Fen area of Wicken Fen was small and declining, it was decided to introduce a second population there in 1996 (Croft and others 1997). An area of old peat diggings in Compartment 18, between Gardiner's Drove and Wicken Lode (see Figure 2), with similar characteristics to Verrall's Fen, was chosen as the introduction site and mown. Fifty plants grown at Monks Wood from Wicken Fen seed were planted there at the end of July. By October, six of the plants were thought to have been lost, but many of the remaining plants had fruited. The results of monitoring these plants over the next nine years are given in Section 7.3.1.

In 1997, an attempt was made to establish a reinforcement population of *Viola persicifolia* in Compartment 45 of Woodwalton Fen, near the entrance to the Reserve. A small area was cleared and seed was collected from the disturbance plots in September. One hundred seeds were sown in the cleared site in October and their position was marked with canes. The seeds failed to germinate.

7.1.5 Seed longevity experiment

In 2000, *Viola persicifolia* seed collected from Wicken Fen was used to set up an experiment to investigate dormancy and viability over a period of years. A 'burial site' was chosen on Wicken Fen, near the existing colony on Verrall's Fen (see Figure 2). Fifty seeds were sown in each of 12 clay pots containing peat. A layer of gravel was placed on top and the whole was secured with plastic netting. Six pots were buried at a depth of 20 centimetres and six more at 40 centimetres. Large fence posts were erected to mark the plot and the position of the pots were marked with canes. The plan was to dig up some of the pots after five years and to test the seed for viability. Other pots would be left for a further five years so that seed could be tested for viability after being buried for ten years. In 2005, when the first set of pots was due to be raised, the cane markers could not be found because of disturbance by horses. However, because of the systematic way in which the experiment was laid out, it was thought that the buried plots might be located in the future.

7.1.6 Vegetation monitoring at Otmoor

The wisdom of a proposal to spread farmyard manure on the hayfields at Otmoor was called into question. The application of manure was suggested in order to increase the meagre hay crop, as an incentive to the tenant farmer to continue managing the site. In 2002, two 50 x 50 metre blocks were identified in Hayfield 1 (Compartment 2), one of which was due to be treated with manure. About twenty quadrats were recorded in each block. Because of the presence of a number of species that prefer low levels of nitrogen (Lambrick 2002, 2003) (see Section 4.2.3) it was recommended that manure application would not benefit the plant community in general, or *Viola persicifolia* in particular, so the proposal to use it in Hayfield 1 was dropped. However, in 2005 manure was applied to the neighbouring hayfield (Compartment 1). The effects are being monitored through quadrat recording.

7.2 *Ex-situ* measures

7.2.1 *Ex situ* cultivation and seed preservation

In 1994 onwards (Wells and others 1995, Croft & Preston 1996) *Viola persicifolia* plants were raised from Wicken Fen seed and cultivated in pots outside at ITE Monks Wood. Plants derived from this stock were used for the population reinforcement experiment at Wicken Fen (see Section 7.1.4). Later, Jane Croft cultivated plants in her garden in Cambridgeshire. These originated from a few individuals growing in a sod removed from Wicken Fen. By 2005 there were no plants remaining at Monks Wood, but plants were still doing well in Jane's garden.

In 1982 and 1983, seed of *Viola persicifolia* collected from Wicken Fen by staff of the Cambridge University Botanic Garden was deposited in the seed bank at Wakehurst Place, Royal Botanic Gardens, Kew (Janet Terry, pers. com.). More seed from Wicken Fen was donated in 1994 by the National Trust. The Millennium Seed Bank also holds seed from Otmoor, sent by the Oxfordshire Rare Plants Group in 1997 and 1998.

In 1997 seeds were collected from plants at Otmoor for cultivation in Oxford Botanic Gardens, but they did not germinate.

7.2.2 Experimental work

In 1993 and 1994 seed from Wicken Fen, made available from the Seed Bank at Kew, was used in experiments to investigate requirements for germination and subsequent development (Wells and others 1993, 1995). The following observations were made.

- Seed required cold treatment before it would germinate.
- Seed stored at low humidity and low temperature retained its viability for nine years, but seed stored at room temperature lost its ability to germinate.
- The depth of the water table below the soil surface did not affect germination.
- Subsequent development and performance of plants was significantly better in dry than in waterlogged conditions. This bore out field observations that prolonged flooding is unfavourable for *Viola persicifolia* (see Section 4.3).

In 1996 (Croft and others 1997) an experiment on seed dispersal was carried out, showing that seed forced out of the capsule on dehiscence could travel at least 173 centimetres.

In 1998, a DNA analysis of material from Woodwalton Fen, Wicken Fen, Otmoor and the Czech Republic was carried out by Dr. S. Harris at the Plant Sciences Department, Oxford University (Lambrick 2001). This was to investigate how closely the various *Viola persicifolia* populations matched and to determine whether any back-crosses or F2s were present, indicating possible endangerment of *Viola persicifolia* populations through hybridisation with *Viola canina*. Unfortunately, only two marker genes were found, which were an insufficient number to clarify the situation.

7.2.3 Investigation of historic sites for *Viola persicifolia*

Between 1840 and 1960, *Viola persicifolia* was recorded in three areas of the Humberside Levels in Nottinghamshire and south west Yorkshire, including SSSIs at Thorne and Hatfield Wastes. The records were investigated by the ITE team and in 1994 these sites were visited (Wells and others 1995) to search for the plant and to assess whether suitable habitat remained. No *Viola persicifolia* plants were found, although a few areas with potential for supporting small populations were discovered. The apparent demise of the species was attributed to various causes:

- ploughing of grassland and conversion to arable land;
- competition from more vigorous vegetation;
- water level too high or too low;
- removal and neglect of ditches;
- eutrophication caused by fertiliser run-off.

7.2.4 Proposed introduction at the RSPB reserve, Otmoor

There are records of *Viola persicifolia* in the 1960s in an area that is now within the RSPB reserve at Otmoor, close to the present site for the plant. To prepare for a planned attempt to reintroduce *Viola persicifolia* to the RSPB reserve, seed from hay taken from the fen violet field at Otmoor was scattered on the reserve in 1992, in the hope that vegetation associated with *Viola persicifolia* would become established (Lambrick 2002). This was not successful, probably because the thatch below the existing vegetation was too dense to allow establishment to take place. The introduction experiment has been postponed until more suitable conditions can be created.

7.3 Monitoring

Monitoring results for the native populations of *Viola persicifolia* at Wicken Fen, Woodwalton Fen and Otmoor are given in Wells and others (1993, 1995), Croft and Preston (1996), Croft and others (1997), Wells (1998), Croft (1998, 1999, 2000a, 2000b and 2001), Pankhurst (2001, 2003, 2004a) and Lambrick (2001a, 2001b, 2002, 2003, 2004, 2005). The reuslts are summarised in Sections 7.3.1, 7.3.2 and 7.3.3.

7.3.1 Wicken Fen

In 1994, eight metre square quadrats were set up at 'Site 1' near the disturbance experiment in Verrall's Fen (Compartment 2). Nine more quadrats were set up at 'Site 2' in an area of the same compartment where *Viola persicifolia* appeared in abundance that year, following scrub clearance in 1993.

The results of monitoring in Compartment 2 of Verralls' Fen from 1993 to 2005 are given in Table 6. There was a fairly steady decline in the population from 1994 to 2000, and thereafter no plants were found there. The results of monitoring the reinforcement population in Compartment 18, south of Gardiner's Drove, are shown in Table 7. The most recent record of *Viola persicifolia* at Wicken Fen was a single plant found in Compartment 18 in 2003 (Owen Mountford pers. com.).

Table 6 Results of monitoring *Viola persicifolia* at Verrall's Fen

Year	Total no. plants	No. plants in quadrats		Other observations
		Site 1	Site 2	
1993	0	-		Searches revealed no plants. Flooding and high water table because of heavy rainfall in winter and spring.
1994	>368 + seedlings	68	223	>300 plants at Site 2. All quadrats (except a control) cut with shears in autumn.
1995	>65 + seedlings	57	8	Fruiting performance in quadrats assessed. Plants present outside quadrats where scrub had been uprooted in 1994 and on a dry grassy area.
1996	39	34	5	A few new plants from shed seed or seed bank. Little bare peat in Site 2 and *Cladium* large. Plants not found outside quadrats. Standing water in the winter.
1997	67+	44	7	Many of the original plants in quadrats had gone but a few new ones had appeared. *Cladium* and *Juncus subnodulosus* dense. 16 plants found outside quadrats. No standing water, but dip-well measurements showed that water table had been high for much of the year.
1998	33+	11	2	>20 plants near path adjacent to Site 2. Area outside quadrats machine cut in September and cuttings removed. Quadrats hand-cut. Unusually wet spring and autumn.
1999	24 + a few seedlings	0	0	One group of 14 plants in drier area beside path in Compt. 2.10 plants + a few seedlings in the 1997 disturbance plots. Compt. cut by machine in autumn; vegetation in quadrats and round *Viola persicifolia* plants hand cut. Extensive scrub clearance in adjacent Compt. 5. Spring very wet.
2000	15	0	0	Group of 9 plants in drier area beside path. Vegetation in quadrats dense despite autumn hand-cutting. 6 plants in disturbance plots. Spring very wet.
2001	?	?	?	No monitoring because of foot and mouth epidemic.
2002	0	0	0	Fen very wet. Impact of horse grazing obvious. No plants found during visits in May or July.
2003	0	0	0	No plants found.
2004	0	0	0	No plants found.
2005	0	0	0	No plants found

Table 7 Results of monitoring the reinforcement population

Year	No. of plants	Other observations
1996	50	6 of the50 introduced plants thought to have died during the summer. Estimated seed production - 3,600.
1997	46 + 3 seedlings	Some of the original plants had died, but new plants present. Estimated seed production – 6390.
1998	20 + 31 seedlings	In September plants were thriving. Estimated seed production – 1080.
1999	12	Standing water in July. Vegetation about 1.5 metres tall. Area strimmed. Estimated seed production – 1314.
2000	11	Swamp conditions in May but area dried out later. Estimated seed production – 1260.
2001	?	No monitoring because of foot and mouth epidemic.
2002	0	Plots searched but no plants found.
2003	1	A single plant found by Owen Mountford.
2004	0	No plants found.
2005	0	No plants found. Vegetation tall and habitat appeared unsuitable for fen violet (Owen Mountford pers. com.)

7.3.2 Woodwalton Fen

During the 1980s, the total numbers of *Viola persicifolia* recorded at Woodwalton Fen varied from 135 to 5830; in 1991, 482 plants were counted; in 1992, just before the Species Recovery Programme began, only eight plants were found (Wells 1998). The results of monitoring the plant at Woodwalton Fen from 1993 to 2005 are shown in Table 8. Compartment 55 (the 'Violet Field'), where the main population occurred, was especially targeted for monitoring purposes.

It is clear from the observations that the peak years for the population (1996 and 1997), when over a thousand plants were counted, coincided with dry springs. When the ground was waterlogged, plants survived best on raised areas. This bears out the results of *ex situ* experiments (Section 7.2.2), which showed that performance of young plants was significantly better in dry than in waterlogged conditions.

Table 8 Results of monitoring *Viola persicifolia* at Woodwalton Fen

Year	Total no. of plants	Compt. 55	Other observations
1993	0	0	Compartments 41, 47, 54, 55 and 58 searched but no *Viola persicifolia* plants found. **Compt.** 55: 1 *Viola* plant found, possibly the hybrid. Standing water because of heavy rainfall.
1994	0	0	No plants found. Fen very wet in winter and spring.
1995	820	720	**Compts. 41 and 46** searched but no plants found. **Compt. 55**: 62 plants outside the disturbance plots, 658 inside plots. Plants avoided lower lying areas. Positions of 62 plants all marked. Comp. grazed by cattle. **Compt. 58**: 100 young plants found in August on cattle poached and bare areas. Electric fence installed.
1996	1449	1206	**Compt. 41**: 10 plants found. **Compt. 55**: 62 marked plants located. 1079 plants in and around disturbance plots and many flowering outside them. Dip well measurements showed low spring water table. **Compt. 58**: 233 vigorous plants. Grazing and mowing postponed until after seed shed in autumn.
1997	1123	1090	**Compt. 41**: 1 plant found **Compt. 55**: 29 of the marked plants not found, but 258 counted outside disturbance plots. 832 in disturbance plots. Vegetation varied and fen violet most abundant in fine-textured vegetation with *Carex* species. Compt. 55 cut in winter and cattle introduced in September. Dip well measurements showed low spring water table. **Compt. 58**: 32 plants. *Juncus effusus* invading. No plants found in Compts. 46, 47, 52 or 54.
1998	c.100	>6	**Compt 55**: section mown in March to control *Juncus subnodulosus.* 6 plants + 1 group inside disturbance plot. Other compts: no detailed information. A wet spring, water standing in depressions.
1999	109	86	**Compt. 41**: 6 flowering plants on drier ridges. **Compt. 54**: 15 plants where scrub had been removed in 1997. **Compt. 55**: no plants found outside disturbance plot but 86 inside it. Cattle grazing and machine cutting in May to control *Juncus subnodulosus.* **Compt. 58**: only 2 plants found in May; no search later. Spring very wet.
2000	16	0	**Compt. 41**: no plants found. **Compt. 54**: 15 plants where scrub had been removed in 1997. **Compt. 55**: no plants found; cattle grazing continued. **Compt. 58**: 1 plant found. Spring very wet.
2001	?	?	No monitoring because of foot and mouth epidemic.
2002	1	0	Winter was wet and water was lying in June. **Compt. 54:** 1 young plant found.
2003	1	0	Only 1 plant found.
2004	c. 50	c. 50	Area very wet and *Hydrocotyle vulgaris* was encroaching.
2005	1	0	1 plant found in **Compt. 51** in an area newly cleared of scrub.

7.3.3 Otmoor

The Species Recovery Programme for *Viola persicifolia* required investigation of the fields west of the rifle range at Otmoor because hybrids were known to occur there. A search in 1997 revealed numerous plants of *Viola persicifolia* in Hayfield 1 (Compartment 2 of the SSSI), most of which were in an area cleared of sallow in 1995/6. See Figure 4 for the location of Hayfield 1.

The main population in Hayfield 1 has been closely monitored by the Rare plants Group. The results are given in Table 9. The figures are not accurate, as numbers in patches of the plant were estimated and late-flowering plants may have been missed.

Table 9 Results of monitoring *Viola persicifolia* at Otmoor

Year	No. of plants counted	Other observations
1997	187	*Viola persicifolia* discovered, mainly in disturbed area. The 1960s site for the plant was searched but none found.
1998	330	Very heavy rainfall in April caused flooding. In the wettest area plants had disappeared. Flowering was late and leaves yellowish.
1999	122	
2000	136	Considerable fluctuation in where the plants are found.
2001	6	Monitoring late in the season because of foot and mouth epidemic. Spring cold and wet.
2002	170	Plant continued to move into new areas.
2003	192 + >500 seedlings	Seedlings not counted, nor plants in the north of the field Fewer plants in 10 metre strip along edge of field that is not cut. Wet autumn and dry spring.
2004	>248 + many seedlings	Plant continued to move into new areas and many seedlings seen. Small population in the north of the field not counted. *Viola persicifolia* almost lost from tall vegetation on western edge of field (this had been kept tall for the benefit of invertebrates).. Willow pulled out on part of western boundary.
2005	c. 108	No plants found where willow had been removed. Tall vegetation on western edge mown with the rest of the field in July.

The main population of *Viola persicifolia* occupies an area measuring about 100 x 60 metres. One of the interesting observations was that the distribution of the plants shifted markedly over the years, with the population showing a tendency to spread eastwards. The location of plants in the main population from 1998 to 2005 is shown in Figure 5, taken from Lambrick (2005). There have been a number of explanations suggested for this pattern of movement. It might have been due partly to inaccuracies in monitoring or to the plants behaving as annuals that germinate some way from the parent plant. The western strip of Hayfield 1 had, until 2005, been left unmown for the benefit of invertebrates and by 2004 it had grown tall and unsuitable for *Viola persicifolia*. The eastern side of the compartment is slightly higher than the western side, and the plant may have grown better in raised areas in wet years. Lastly, the shifting pattern may simply have been due to the direction of mowing and harrowing influencing the distribution of seed.

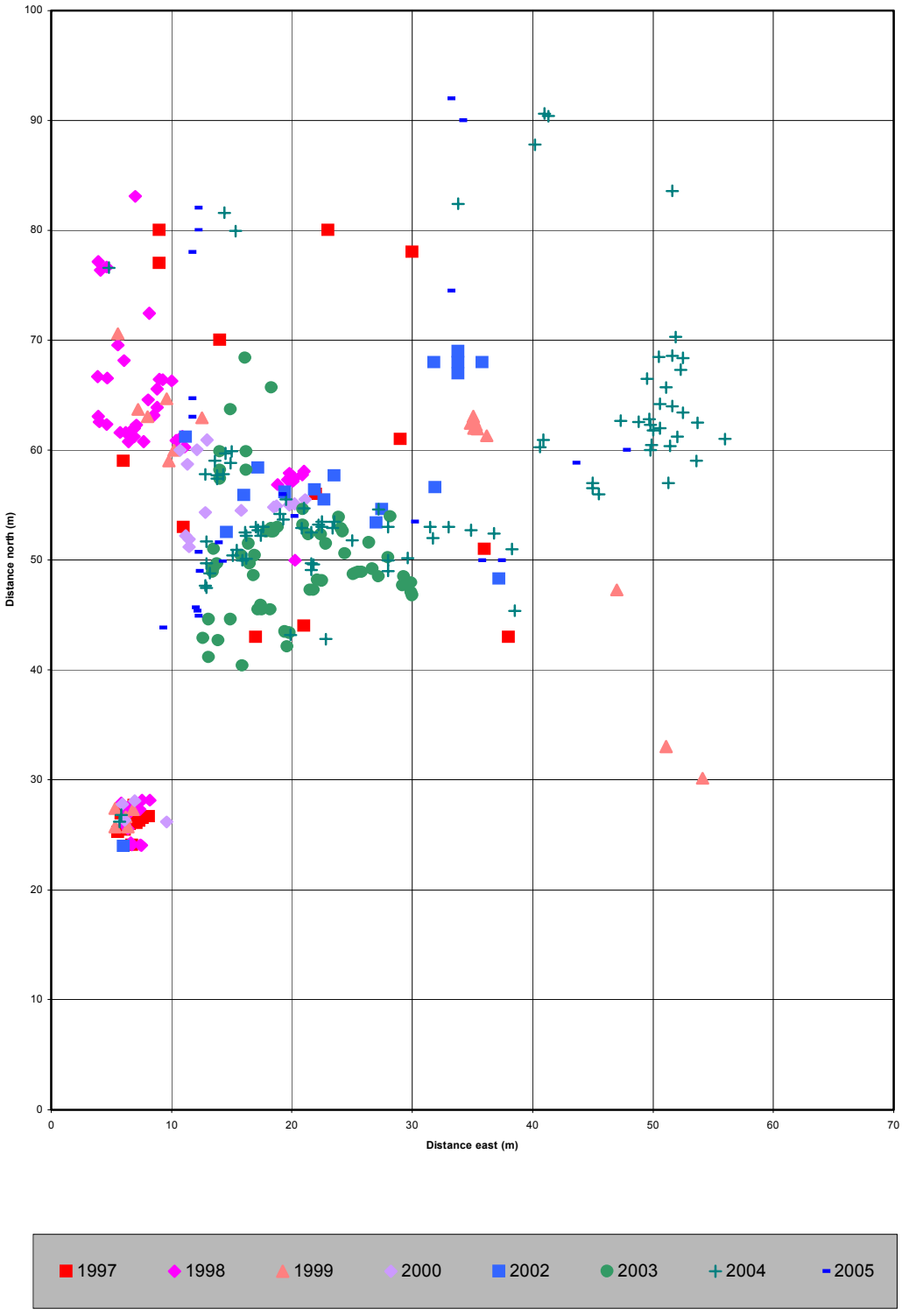

Figure 5 The location of *Viola persicifolia* plants in Hayfield 1 on Otmoor, 1997-2005 (from Lambrick 2005)

7.4 Investigations abroad

In 1995 Jane Croft and Chris Preston visited southern Moravia, in the Czech Republic, to study sites supporting *Viola persicifolia* (Croft & Preston 1996). Many of the sites were in alluvial floodplain meadows that were flooded annually for a period of two to six weeks. The soils in these sites were mainly clay or clay loam and were neutral or slightly acid. The meadows were not grazed, but mown in June when they had dried out sufficiently. Only minor disturbance was evident, where wild pigs had turned over the soil and ant hills were present.

Viola persicifolia populations were small and restricted to the wettest areas of the meadows where the vegetation was lush and up to 70 centimetres high. Croft and Preston recorded quadrats at 12 sites. The plants that occurred in more than half the 25 quadrats containing *Viola persicifolia* were:

	No. of quadrats
Alopecurus pratensis	19
Carex riparia	15
Cirsium arvense	19
Lysimachia nummularia	13
Phalaris arundinacea	17
Poa palustris	22
Poa pratensis	14
Potentilla anserina	13
Ranunculus repens	21

It was evident the *Viola persicifolia* populations in the Czech Republic, unlike those in Cambridgeshire, persisted amongst tall vegetation and in the absence of major disturbance.

8 Review of progress and suggestions for future work

The Recovery Programme for *Viola persicifolia* has produced a large amount of information about the behaviour and requirements of the species. Autecological studies have shown that in order to maintain a viable population in the Britain, very specific conditions are required.

- There must not be too much competition from other plants.
- Periodic disturbance of the soil is necessary to stimulate germination.
- Wet conditions are needed in winter but waterlogging later in the season is detrimental.

Despite an improved appreciation of the requirements of *Viola persicifolia*, it has not done well in Cambridgeshire over the last decade. Since 1997, the annual combined count for Woodwalton Fen and Wicken Fen has dropped from well over a thousand plants to one individual, and the species has not been seen at Wicken Fen since 2003. An attempt to revive a population from buried seed by disturbing the soil at the Cambridgeshire sites was temporarily successful, but experiments to reinforce populations met with no success. The seed bank may be extensive, so decline of *Viola persicifolia* may be temporary, provided

populations can be resuscitated by appropriate management. On the other hand, if climate change leads to wet winters and subsequent waterlogged conditions in spring, these sites may become permanently unsuitable for the species. Unless management of the water table at Woodwalton Fen and Wicken Fen can be more finely tuned to accommodate the requirements of *Viola persicifolia*, the species may die out in its native Cambridgeshire sites.

In Oxfordshire the situation is more hopeful. The first of the three objectives of the Recovery Programme for *Viola persicifolia*, to maintain and enhance the population at Otmoor, has been satisfied. However, the second and third objectives, to bring the plant into cultivation from the native population and to restore populations in appropriate former sites, have not been achieved.

No other sites suitable for introduction/reintroduction have been found anywhere within the previous range of *Viola persicifolia*. *Ex situ* cultivation has been successful, as a thriving population exists in a garden in Cambridgeshire.

The following suggestions are made for future work on *Viola persicifolia.*

Site management

- Continue efforts to maintain and enhance native populations of fen violet in Cambridgeshire and Oxfordshire.
- Attempt to provide low spring and summer water tables in compartments supporting the plants at Wicken Fen and Woodwalton Fen.
- Create areas of pronounced ridge and furrow in Wicken Fen and Woodwalton Fen, to provide dry refuges for the plant in wet springs and summers.
- Institute a cyclical regime of disturbance at Wicken Fen, Woodwalton Fen and Otmoor, in an attempt to revitalise and maintain populations.

***Ex situ* measures**

- Maintain the cultivated stock and the seed bank at Kew.
- Bring plants into cultivation in Oxfordshire.

Survey and monitoring

- Continue monitoring the existing native populations.
- Continue surveillance of former sites to see whether *Viola persicifolia* reappears.
-

Translocation

- Restore *Viola persicifolia* to some of its former sites, where appropriate. In particular, continue efforts to restore favourable conditions in the Otmoor RSPB reserve, with a view to introducing the species.

Research

- A detailed study is needed to relate annual performance of *Viola persicifolia* populations to records of rainfall and water table height at Woodwalton Fen and Wicken Fen. The information provided could be used to guide site management.
- Attempt to locate the buried pots of seed at Wicken Fen, in order to continue the longevity experiment.
- Make a detailed comparison between conditions at Otmoor, where *Viola persicifolia* appears to be mobile and opportunistic, and at the Cambridgeshire sites, where the species appears to be more static and in severe decline.
- To resolve taxonomic problems, carry out further genetic and morphological studies on *Viola canina* and the hybrid *Viola* x *ritschliana* at Otmoor.
- Make a comparison of seed production and viability in chastogamous and cleistogamous flowers, to indicate the period of maximum fertility in the life cycle. This knowledge would be of use in planning management regimes.

International cooperation

- Hold an international workshop involving botanists from the UK, Ireland and mainland Europe, to exchange knowledge about the ecology and conservation of *Viola persicifolia.*
- In particular, seek knowledge of the Irish populations, with a view to informing conservation measures in the UK.

UK Biodiversity Action Plan

- In view of the drastic recent decline of the species in two out of its three sites, include *Viola persicifolia* in the revised Biodiversity Action Plan priority species list.

Two long-term projects, the Great Fen Project (Anon, 2005) and the proposed expansion of Wicken Fen (Colston & Friday, 1999), could be the first steps in the restoration of large wetland complexes to Cambridgeshire. The Great Fen Project is an ambitious plan to revert 3700 hectares area of arable fenland to pre-drainage condition, thus linking Woodwalton Fen and Holme Fen and providing extensive fen habitat devoted to wildlife conservation. The National Trust has an equally ambitious plan to extend fen habitat at Wicken up to 4000 hectares. The potential for introducing and conserving *Viola persicifolia* should be borne in mind during the development of both these projects.

9 Links

There is no specific action plan for *Viola persicifolia* in the Local Biodiversity Action Plan for Cambridgeshire. However, reference is made to the protection of all Schedule 8 plants in Cambridgeshire County Council's Structure Plan (see www.Cambridgeshire.gov.uk). The Oxfordshire Wetlands Biodiversity Action Plan mentions *Viola persicifolia*, the target being to maintain its numbers at stable or increasing levels.

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Annex 1 Fen violet *Viola persicifolia*: proposed Species Action Plan for Oxfordshire

Prepared by the Rare Plants Group of the Ashmolean Natural History Society of Oxfordshire, in consultation with English Nature
C.R. Lambrick, April 1998

1 Current status

Rare in Europe. A probably short-lived perennial of calcareous fens in southern England, always rare, tending to appear after disturbance. In the UK now growing at two fens in East Anglia. In Oxfordshire it was found once in the 19th century and briefly in the 1960s, and appeared in 1997 about half a mile from the 1960s site. Also known from another Oxfordshire site (Menmarsh) in the 1960s. Sterile hybrids formed with *Viola canina* are present at the current Otmoor site.

Protection - on Schedule 8 of Wildlife and Countryside Act 1981. IUCN endangered, threatened in most of its European range. On UK Biodiversity Action Plan long list.

2 Factors causing decline

Loss of disturbed fen habitat.

3 Current action

The species is subject of an English Nature Species Recovery Plan, part of which required investigation of the fields just west of the Rifle Range at Otmoor because hybrids were known to exist there. A search in 1997 revealed that plants had come up following sallow removal in 1995. The 1960s Otmoor site was also searched and no plants found. Dry leaf material has been given to Dr S. Harris at the Plant Sciences Department, Oxford University, for DNA analysis. Seed and leaf material has been obtained from the Czech Republic. Seeds (c. 80) were collected from the Otmoor plants in July 1997 for Wakehurst Place and Oxford University Botanic Garden. They have been planted at OUBG but none germinated yet. The plant was mentioned to the FRCA as it is in the Upper Thames Tributaries ESA.

The steering group should include Heather Whetter (English Nature), Stan Woodell, Chris Preston or Jane Croft or Terry Wells, Camilla Lambrick (ANHSO), Kathy Warden (OUBG), Christine Bailey (BBONT), ? RSPB. To meet at least annually.

4 Action plan objectives

4.1 Maintain and enhance population at known site.

4.2 Bring into cultivation from native population.

4.3 Investigate former sites and restore populations if appropriate.

5 Actions

5.1 Policy and legislation

The current site is already an SSSI and is in the ESA scheme.

5.2 Site safeguard and management

5.2.1 Agree and implement a management plan for the current site with the owner. Annual hay cut in late July- August, grazing of aftermath. Rotational removal of sallows alongside the hedgeline? 10 year or longer, rotation

5.2.2 Discuss management of newly purchased RSPB site on Otmoor, which is adjacent to the Otmoor site known in the 1960s. Recommend ploughing followed by two years fallow with monitoring to allow time for buried seed to germinate.

5.2.3 Introduce fen violet to a demonstration area where it can be seen by the public. (Woodside Meadow, part of Wendelbury Mead SSSI, and Cothill Fen were considered not suitable for introduction). May be possible on part of the RSPB area at Otmoor.

5.2.4 Agree site management at former sites if appropriate to promote germination of buried seed.

5.3 Species management and protection

5.3.1 Germinate seed collected from Otmoor in 1997 (OUBG) .

5.3.2 Collect more seed for cultivation for Millennium Seed Bank, Wakehurst Place, and/or use plants at OUBG to bulk up seed for possible introductions.

5.3.3 Search former site at Menmarsh and establish whether the site is suitable for restoration.

5.3.4 Use DNA analysis to determine how closely the plants at Otmoor match those at Woodwalton and Wicken Fens and material from the Czech Republic. Also to determine whether any backcrosses or F2s are present. This will show whether the population is endangered by hybridization. The chromosome numbers suggest that the hybrids are sterile, and no fertile seed pods were found on the hybrid plants in 1997.

5.4 Monitoring

5.4.1 Place fenomarkers to fix the main population areas. Map plants in 1998.

5.4.2 Monitor RSPB area at Otmoor for germination.

6 Research

Investigation of the ecological requirements of the species is already in train under the English Nature Recovery Programme at Woodwalton and Wicken Fens.

6.1 Investigate water-table fluctuations at current site by recording the soild profile and monitoring monthly. Flooding in the late spring and summer can damage young seedlings.

7 Communications and publicity

An article has been prepared for Sanctuary, the army wildlife magazine by Dr S.R.J. Woodell. Publish a note in *Oxfordshire Nature Conservation Forum News*

8 Prepare report and review action plan at end of three years.

ENGLISH NATURE

Research Information Note

English Nature Research Reports, No. 676

Fen Violet *Viola persicifolia* Schreber: a reivew of conservation work carried out under English Nature's Species Recovery Programme 1993-2005

Report Authors: Edited by Margaret A Palmer. Date: November 2005
Keywords: Fen violet, SRP, review

Introduction

This review summarises the work carried out on fen violet *Viola persicifolia* in the period 1993 to 2005, under English Nature's Species Recovery Programme. The contractors were the Institute of Terrestrial Ecology (later the Centre for Ecology and Hydrology), Tim Pankhurst, and the Rare Plants Group of the Ashmolean Natural History Society of Oxfordshire. The sources of information for this review were reports produced by all these contractors.

What was done

Fen violet is Endangered in Britain and listed on Schedule 8 of the Wildlife and Countryside Act 1981. It has declined throughout western Europe and is rare in many countries. In Britain it is a plant of base-rich lowland fens and wet meadows. It has been recorded from over 20 sites in England, but its only remaining sites in 1993 were believed to be Woodwalton Fen and Wicken Fen National Nature Reserves, in Cambridgeshire. In 1997 it was rediscovered in Otmoor SSSI, Oxfordshire, in ground disturbed by the removal of willow two years ealier.

Populations of *Viola persicifolia* fluctuate widely in size and plants tend to appear in different locations from one year to the next, or to disappear from sites altogether for periods of years. Seeds can lie dormant for many years, germinating when conditions become favourable. During the period of the Recovery Programme, historic sites for *Viola persicifolia* in England were searched, but fen violet was not found. These sites were also assessed for their potential as re-introduction sites, but nowhere suitable was discovered.

Results and conclusions

Autecological work carried out in the field and on cultivated plants showed that in order to remain viable, populations of *Viola persicifolia* need very specific conditions.

- There must not be too much competition from other plants.
- Periodic disturbance of the soil is necessary to stimulate germination.
- Wet soil is needed in winter but waterlogging in spring and summer is detrimental.

Continued……

The decline of *Viola persicifolia* in Cambridgeshire may be reversible with appropriate management, but climate change could render the sites permanently unsuitable. Unless the water table or the local topography at Wicken Fen and Woodwalton Fen can be manipulated to prevent the soil remaining waterlogged in spring, and a regime of regular disturbance is introduced, the species will remain very vulnerable to extinction there.

A reserve population of *Viola persicifolia* is established in cultivation in Cambridgeshire. Seed from Wicken Fen and Otmoor is stored in the Millennium Seed Bank, Royal Botanic Gardens, Kew.

Suggestions for the future direction of work on *Viola persicifolia* are made.

The extant British populations of *Viola persicifolia* were monitored annually from 1993 to 2205 and the results are detailed here. At Wicken Fen, numbers of Viola persicifolia fell sharply in the late 1990s and the species has not been found there since 2003. At Woodwalton Fen, *Viola persicifolia* declined drastically after its population peaked in 1996 and 1997, and only one plant was found there in 2005. However, there may still be a large viable seed bank in the peat. An attempt to revitalise populations by disturbing the soil was temporarily successful, but experiments to reinforce populations by introducing young plants and seed met with no success. The Oxfordshire population appears to be self-sustaining.

English Nature's viewpoint

Fen violet is a rare plant in England and is the subject of a full conservation programme. This ENRR gives an excellent overview of the work undertaken and suggestions for future work.

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Further information

English Nature Research Reports and their *Research Information Notes* are available to download from our website: www.english-nature.org.uk

For a printed copy of the full report, or for information on other publications on this subject, please contact the Enquiry Service on 01733 455100/101/102 or e-mail enquiries@english-nature.org.uk

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Front cover photographs:
Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888