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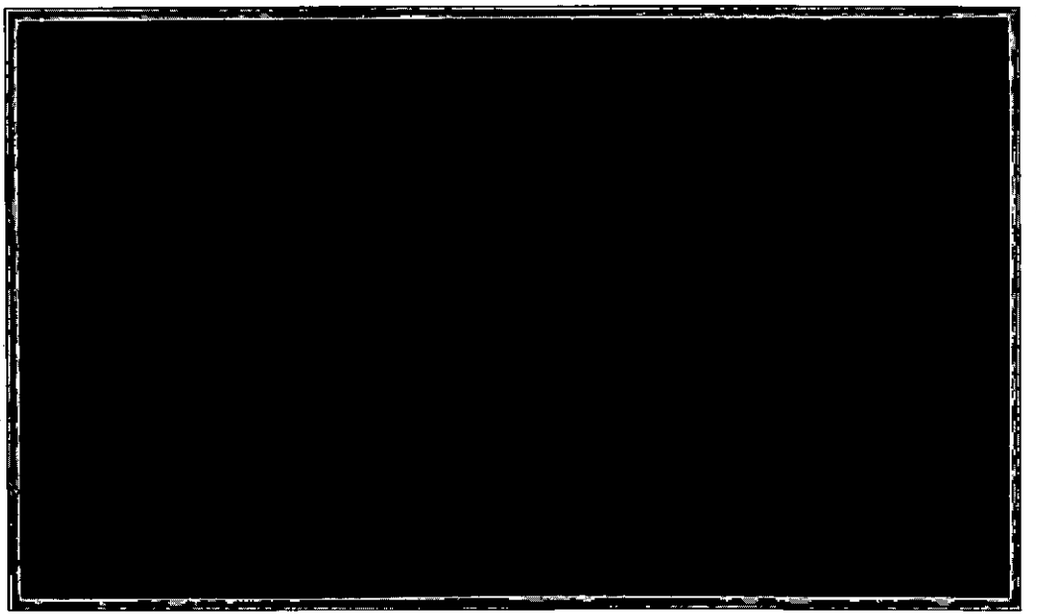

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An investigation of the control of *Crassula helmsii* by herbicidal chemicals (with interim guidelines on control) - final report

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Report date:	September 1989 (revised Feb 1991)
Report to:	Chief Scientist Directorate Nature Conservancy Council - nominated officer (P J Boon previously Mrs M Palmer)
Contract No:	HF3-03-374(38)
IFE Report Ref:	RL/T11053a1/2 revision
TFS Project No:	T11053g5 (T11053g1,T11003a1)

The Institute of Freshwater Ecology is part of the Terrestrial and Freshwater Sciences Directorate of the Natural Environment Research Council.

Summary

Crassula helmsii is an aggressive alien aquatic or 'amphibious' plant which has invaded Britain and is rapidly increasing its distribution. It grows both as tall underwater stands and in shallow water or on damp soil, as a short dense mono-specific sward which smothers out native flora and markedly affects the habitat for fauna. By January 1991 it had invaded *c* 270 aquatic areas with the frequency of new sites being invaded still doubling about every two years. Many factors have influenced the rate of recording but the continuing enthusiasm of local botanists and environmentalists is important and must be maintained. The type of sites invaded are predominantly small ponds, (about a third of which may dry down seasonally), in agricultural areas although many are in private estates and *c*. 40 in nature reserves, the remaining sites are lakes, ponds and canals.

Primary introductions probably resulted a wide range of human activities associated with water including water gardening and fishing whereas secondary or local introduction may also involve transfer by local wildlife; the mechanisms of transfer need further study if a successful control stratagy is to be developed.

Tank and field trials to control *C. helmsii* compared the effectiveness of all available Approved aquatic herbicides and showed the high herbicide resistance of drying turves and emergent stands, for which only glyphosate producing any noticeable degree of control. The growth of submerged stands were however rapidly suppressed using diquat or diquat-alginate although buds on separated shoots started to regrow over subsequent weeks before finally dying; these 'propagules' may enhance spread of the plant and be a source of 'reinfection' of control areas and should therefore be contained by eg. a mesh fence. The commercial chemical hydrogen peroxide were also tested because the absence of toxic or long-term residues made it suitable for nature reserves but only scorching of plant material occurred ie direct control, and growth was therefore unfortunately only suppressed temporarily. Other chemicals, trials with approved additives or new user trials with manufacturers, should be undertaken. Field observations of other techniques were made such as shading material which was very successful for small areas whereas for example flame-throwers were laborious, expensive, and not effective. Suggested provisional guidelines have been produced for the control of *Crassula helmsii* at sites with differing degrees of dominance.

Proposals are given for improvements in control of emergent stands, for further full field trials on the elimination of this plant from sites at which it currently dominates, on the strategy for further monitoring and controlling invasive plants in nature reserves, on the development of herbicidal chemicals with minimal and non persistent by-products, but most importantly the assessment of the vulnerability of estuaries to invasion by this plant and an advisory leaflet. Firm measures are considered necessary to halt its further spread, particularly to vulnerable northern regions.

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1. INTRODUCTION

1.1. Background

Crassula helmsii (T. Kirk) Cockayne, is expanding its distribution very rapidly in the UK but particularly from the South East half of the country. It is generally available from aquatic centres as an 'oxygenator plant' for ponds. It appears to be easily distributed to natural areas where it grows vigorously without an overwinter period of rest or die-back. It is found in a wide range of habitats from acid to alkaline waters of ponds and lakes; experimentally, it will grow well in flowing waters, and it is known from semi-saline sites and will tolerate intermittent or half- saline conditions. Its occurrence in the UK has been recorded in *c.* 25 sites in 14 nature reserves or national parks. It does not appear to be just another invading aquatic plant because its vigorous growth, as a short dense sward, rapidly dominates aquatic areas. It has been recorded to date growing both on damp ground to 0.5 m above water levels and to depths of over 3 m depending upon conditions. Detailed data from one study site suggest that within four years of its invasion, 80% of native species are out-competed whilst another suggests that within ten years, all other species can be lost. No site once dominated has yet returned from near total domination, as would be expected by comparison to the invasion of previous aquatic species. From this evidence it is important that the spread of this plant should be restricted and stopped as soon as possible before it becomes a universal problem of nature reserves.

A full investigation of this plant would probably

1. confirm the distributional status, extent of invasion and suppression of native flora and fauna;
2. establish the dispersal mechanisms and vulnerability of sites at the local and regional level;
3. determine the potential habitat range, genetic variation and seasonal cycle through extending the study of its biology;
4. develop effective control techniques and programmes compatible with the aims of nature conservation.

However with its continuing rapid expansion, it was thought necessary that extreme measures of control should be immediately considered, ie the use of herbicides in nature reserves, and that guidelines on control should be developed.

1.2. Objectives

The objectives of this report are to:

1. investigate a control technique using herbicidal chemicals,
2. make recommendations for their use in nature reserves and
3. to produce a preliminary version of guidelines for the general control of this plant.

The methods, experimental design and work programme include:

(a) undertaking tank-trials on the control of emergent and submerged stands of *C. helmsii* using proprietary approved aquatic herbicides and other suitable herbicidal compounds;

(b) undertaking field trials over a wide geographic range of sites and water levels (-3 m to +0.7 m) using the most suitable chemical(s) above;

(c) coordinating control attempts by other field personnel (marked 'a' in Appendix II), synthesizing results and producing general control recommendations.

(d) maintaining records of plant distribution and continuing to assess both the rate of expansion and the type of sites invaded.

Several field sites (*c.* 8) over a wide geographic and habitat range (Table 4.), were proposed for appraisal visits to assess their suitability for herbicide field trials. These took place after discussion with local NCC representative (eg. ARO), owner and, as necessary, with permission from the relevant Regional Water Authority (now the National Rivers Authority).

In fulfilment of the contract, the output included an interim report (in December 1988 (Dawson 1988a) and this final report which includes:

(a) Results of tank and field herbicide trials with proposals for control recommendations and further studies.

(b) A synthesis of results of field trials with current best recommendations (interim guidelines) for control. Verbal advice on control would continue to be given during the contract period.

(c) Current distribution of plant occurrences, NGR site references, current status of plant at sites and possible year of invasion or first record i.e. records and an assessment of the rate of expansion to July 1989 (updated to January 1991).

In addition this commission is being supported by:

1. continuing the production of the short bulletins 'Crassula Watch' (Appendix IV) and circulating it to those interested
2. to maintaining distribution records and the scientific publication of results.

2. METHODS AND MATERIALS

2.1. Tank trials

Emergent (7) and submerged (7) stands of *C. helmsii* were grown in large domestic water tanks (0.6 x 1.0 x 0.55 m deep, 300 l). The latter were set out in an east to west line on grass in a light 'quadrangle' away from normal access and without direct drainage towards any water body. Plant material was collected as turves from shallow (emergent form) and deeper (submerged form) water in Mockbeggar Pond just outside the New Forest, Hampshire, in June 1988, January 1989 and Summer 1989. Turves were transported sealed in suitably sized thick polythene bags and placed in pairs in each of the tanks. Turves of the 'shallow water' or emergent stands were placed on wooden boards fitted half way down the tank and filled with 'hard' tap water to three quarters to create shallow water but not shaded conditions. Turves of 'deep water' or submerged stands were placed upon the beds of tanks which were then completely filled with water. Water levels were maintained weekly at the above levels by addition of tap water as necessary. Plant nutrients and total hardness were monitored and replenished to maintain good plant growth by the addition of c. 10 ml of a commercial general 8-4-4 fertilizer (Liquinure, Fisons, Ipswich) every ten days following additions of 'hard' tap water. Herbicides and chemicals were applied in an appropriate manner at the maximum permitted dose rates after growing for 6 - 20 weeks from collection from the field site (Tables 1, 2, 3, Appendix I). An additional tank trial using glyphosate at the increased dose rates of x5 and x10 were also undertaken.The dose rates were either calculated according to individual tank volumes i.e. 0.23 m^3 and 0.3 m^3 or surface areas of tank i.e. 0.58-0.62 m^2 and 0.60-0.65 m^2 for emergent and submerged plants respectively; this was necessary due to sagging of the 'deep water' tanks which were filled to above their normal working level, i.e. completely full.

Assessments of the effectiveness of herbicides were made regularly both visually and recorded photographically. Chemical characterization of the water from nutrient release in particular was initially undertaken every two days but subsequently at less frequent intervals (see field data collection techniques and Appendix III).

Plant material was carefully removed for assessment of fresh and dry weight (105^0C); samples were sorted, by hand, to remove any stones, etc. originating from field collection sites. Water from the tanks was disposed of in a specially-constructed soakaway.

Table 1. The use and normal application time of chemicals and approved herbicides for the tank (T) or field (F) trials for the control of *Crassula helmsii* (see relevant data from product labels, Appendix 1)

Key

/ = additional months to MAFF Guidelines - see label

? = months not included in label but in MAFF Guidelines

. = additional months in special circumstances eg 'off-label' use (this may to apply to other herbicides

Chemical	Use						Month of Application												Trial (Tank or Field)
	Terrestrial	Marginal		Aquatic															
Herbicides	bracken	mono dock	dicot	free floating	sub-merged	Algae	J	F	M	A	M	J	J	A	S	O	N	D	
asulam	x									x	x	x	x						T
2,4-D amine (not oil based)		x	x							/	x	x	x	x					T F
dalapon		x								x	x	x	x	x	x				T
dichlobenil					x				x	x	x	?							T F
diquat				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	T F
diquat-alginate					x		x	x	x	x	x	x	x	x	x	x	x	x	T F
glyphosate	x	x	x				.	.	.	.	.	.	x	x	x	.	.	.	T F
terbutryne				x	x	x				x	x								T F
Chemicals																			
hydrogen peroxide		(x)		(x)	(x)	(x)													T F

Footnotes

1. The herbicide chlorthiamid is no longer available.
2. Fosamine ammonium was considered unsuitable being used only for control of deciduous trees and shrubs near water.
3. Maleic hydrazide was considered inappropriate and is used as a growth retardant for bank side grasses.

Table 2. Dose rates of active ingredient and product for those approved herbicides and chemicals used in hand applicators in various trials for control of *Crassula helmsii* (see also relevant data from product label - Appendix 1)

(1 g m-3 = 1 mg L = 1 ppm) (* = see Dawson & Warman 1987)

Herbicides with dose rate of active ingredient and maximum in water	**Product Used** Manufacturers formulation (% as weight of active ingredient per volume or weight)	**Dose Rates for Product** (Large area) (Small area)	**Water Dilution Range**
asulam 4.5 kg ha^{-1} < 1 g m^{-3}	Asulox May & Baker 40% aqueous solution	11 l ha^{-1} 1.1 ml m^{-2}	4.5-18
2,4-D amine 2.2-4.5 kg ha^{-1} < 5 g m^{-3}	2,4-D Atlas 38% aqueous solution	4.5-9 l ha^{-1} 0.4-0.9 ml m^{-2}	11-22
dalapon 19-47 kg ha^{-1} < 30 g m^{-3}	Dalapon (85?) Atlas 85% soluble powder	20-66 kg ha^{-1} 2-6.6 g m^{-2}	Not applicable
dichlobenil 1-2 g m^{-3} < 3 g m^{-3}	Casoron GSR ICI 20% in granules	28 kg (ha 0.6 m)$^{-1}$ -50 kg ha^{-1} 3-5 g m^{-2}	Not applicable
diquat 0.5-1 g m^{-3} < 2 g m^{-3}	Reglone ICI 20% in aqueous solution	25-50 l (ha.m)$^{-1}$ 2.5-5 ml m^{-3}	> 0
diquat alginate 0.5-1 g m^{-3} < 2 g m^{-3}	Midstream ICI 10% in viscous gel	< 100 l ha^{-1} < 10 ml m^{-3}	Not diluted
glyphosate 1.8-2.2 kg ha^{-1} < 0.2 g m^{-3}	Roundup Monsanto 36% water soluble	5-6 l ha^{-1} 0.5-0.6 ml m^{-2}	18-55
terbutryne 0.05-0.1 g m^{-3} < 0.1 g m^{-3}	Clarosan Ciba Geigy 1% in granules	50-100 kg (ha.m)$^{-1}$ 10 g m^{-3}	Not applicable
Chemicals			
hydrogen peroxide *20-250 g m^{-3}	commercial -	670-3350 l (ha.m)$^{-1}$	5-10
-	100 volume or c . 30% w.v.	67 ml m^{-3} -335 ml m^{-3}	

Table 3. Maximum permitted dose rates and dilution ranges for those herbicides and chemicals used in tank and field trials for control of emergent and submerged stands of *Crassula helmsii*.

Emergent	Tanks	Field Tests 4 m^2
Asulam	0.66 ml in 3-12 ml (20 ml)	4.4 ml in 20-80 ml (50 ml)
2,4-D amine	0.54 ml in 6-12 ml (20 ml)	3.6 ml in 40-80 ml (30 ml)
dalapon	4 g	26 g (10% aqueous!)
glyphosate	.36 ml in 6-20 ml (20 ml)	2.4 ml in 43-130 ml (100 ml)
hydrogen peroxide		
20 g m^{-3}	15 ml in 75-150 ml (100 ml)	270 ml in 1.4-2.7 l (2 l)
100 g m^{-3}	77 ml in 0.38-0.77 l (0.5 l)	1.3 l in 6.7-13 l (10 l)

Submerged	Tanks	Field tests (4 m^2 by 0.5 m deep)	(4 m^2 by 1 m deep)
dichlobenil	1.9 g	12 g	20 g
diquat	1.5 ml in 20 ml	10 ml in 20 ml	20 ml in 50 ml
diquat alginate	3 ml	20 ml	40 ml
terbutryne	3 g	20 g	40 g
hydrogen peroxide			
20 g m^{-3}	20 ml in 100-200 ml (150 ml)	134 ml in 0.67-1.3 l	270 ml in 1.4-2.7 l
100 g m^{-3}	100 ml in 0.5-1 l	670 ml 3.3-6.7 l	1.3 l in 6.7-13 l

2.2. Site survey and field trials

Sites were selected and agreed upon with the NCC on the basis of a wide geographic spread and to cover the habitat range particularly of water depth and water chemistry (Table 4).

2.2.1. Site selection and appraisal visits

Site visits. Data on the area, relevant physical, chemical, and morphological features together with flora, were collected from a range of sites; previous management or changes in flora etc were assessed as far as possible from available data or verbal reports, for use in guidelines.

Field trials. Three types of site covering the habitat range of this plant were selected for the field control trials, firstly, on the basis of uniformity of plant stand and secondly, on permission being available from the landowner:

(i) **drying stands** of *C. helmsii* growing as a short turf were selected at
Holmesley NR, Hampshire; and
Corfe Common, Dorset
(single plots each of 2 m x 2m in area);

(ii) **emergent stand** at the margins of a lake at Stalbridge, Dorset from 0.2 m depth of water to the moist margins
(single plots each of 10 m x 10 m in area); and on

(iii) **submerged stands** at water depths of *c* 1 m also in the above lake
(single plots each of 10 m x 10 m in area).

The herbicides were applied in September 1988 to these plots in a similar manner to the tank trials Table 1,2,3 & Appendix I).
Results were assessed by regular observation over the subsequent months.

Table 4. List of sites or areas visited as potential field control trials for *Crassula helmsii* or to assist in making preliminary guidelines, together with the original reasons for selection of the site. (NR = Nature Reserve; NNR = National NR).

	Site	reason for selection
1.	pool, Gunver Head N. Cornwall	(a) possible semi-saline condition (b) adjacent to stream (c) geographic
2.	Decoy pond, Newton Abbot Devon	(a) geographic (b) adjacent to NR (c) deep water
3.	Townsend Pond, Corfe, Dorset	(a) suitable local seasonal pond (b) previously studied (- on National Trust land)
4.	Lake, Stalbridge Dorset	(a) permission for range of field trials (b) variety of growth habits (c) studied previously
5.	Shallow ponds, New Forest, Hampshire	(a) variety of sites with developed or developing dominance by *C. helmsii* (b) nationally important sites
6.	drainage channel Sandown, IOW	(a) a flowing channel (b) possible semi-saline conditions (c) geographic (d) possible second introduction site from Australia (see Newtown site)
7.	Trout pond, Fingeringhoe Wick NR, Colchester	(a) resurgence following apparent decline (b) geographic
8.	pond, Ynyslas NNR, N. Dyfed, Wales	(a) possible dune slack ponds (b) introduction and rapid spread possibly related to control
9.	La Hague Reservoir St Peter's Valley, Jersey	(a) annually drained and dried for 2 months (b) geographic
10.	Hooper Pool, Coverham W. Gloucestershire	(a) shaded pond (b) geographic

2.3. Current distribution and expansion rate

Records of the occurrence of *Crassula helmsii* continued to be collected from vice-county recorders, interested botanists, attendees at presentations on this plant and as a result of the continued production of the Bulletin 'Crassula Watch' (Appendix II & IV). Records obtained were classified according to the type of site and also by the date of their occurrence at sites. Predictions of the continued rate of expansion or its potential decline were made by linear and semi-logarithmic extrapolation from these data.

3 RESULTS

3.1 Tank trials

3.1.1. The environment of the tanks

The temperature of the water in the shallow and 'deep water' tanks varied through the day and with the seasons. For example in July 1988 the surface water of the deep-water tanks rose by 10-15°C from morning to late afternoon on full sun days whereas the water at the bottom of the tanks only rose by *c* 5°C; the average morning temperatures were 15-20°C. No plants died as a result of heat stress. Water chemistry was normally monitored before and after water changes or replenishment. Both pH and conductivity changed daily by up to c. 0.5 pH unit from *c* pH 8.5 to 50 μS from 600 μS respectively but these parameters also drifted as the plants grew actively between water changes by a rise of 1-2 pH units and a fall in conductivity of *c* 200 μS. Nitrate was also monitored but was generally elevated to give 20 mg l^{-1} on the day following water changes but then allowed to fall in order to avoid algal growth which could inhibit the growth of underwater shoots.

3.1.2. Autumn Trial 1988. Regular observations of the submerged growth of *C. helmsii* in the tanks following the herbicide application in autumn 1988, were confirmed in biomass measurements after the ten week trial (Tables 5 and 6). Diquat and diquat-alginate were immediately effective in killing the submerged form of the plant whereas dichlobenil and terbutryne were considerably slower as might be expected by their mode of action at this time of the year; at the completion of the trial submerged material treated with dichlobenil was brittle, easily fragmented and had a poor root system. Observation of the emergent material showed little lasting control, apart from direct scorching which rapidly regenerated; this confirmed observations at various field sites. However the final biomass in several of the treated tanks was lower than the control, particularly with glyphosate, indicating some degree of reduction in growth rates and therefore some control.

3.1.3. Spring 1989 Trial. Similar results were found for underwater stands in this trial to the previous autumn one ie that emergent stands were not in general effectively controlled. A pre-treatment weighing showed that plant biomasses changed and that an erroneous result may have previously been obtained for the partial effectiveness of some herbicides but this must be balanced against the disruption caused to stands by removal for weighing as shown by the control.

3.1.4. Autumn Trial 1990.

A further autumn trial was undertaken in autumn 1990 using only glyphosate at normal and higher concentrations. Results indicate that the biomass could be more reliably reduced by nearly two-thirds at these higher concentrations than the normal application rate; this assumed that the biomasses in each tank were equal prior to treatment (Table 6). Further attempts at increasing herbicide concentration to match the ratio of biomass to herbicide during normal application were not undertaken as this ratio was already twice that normally applied for full control.

Table 5. Observation of the state of growth of *C. helmsii* grown in tanks and treated with aquatic herbicides, September to December 1988.

Emergent stands

Time days	asulam	2,4-D	dalapon	glyphosate	Hydrogen peroxide 20 g m^{-2}	Hydrogen peroxide 100 g m^{-2}	control
+4	no change	shoots less erect			white spots developing		green, stems pinkish
+10	" "	flattened stems, reddish		leaves pale	brown and dark green areas		
+20	3% brown	10% dead and decaying, some new buds	little further change	leaves pinkish, submerged leaves pale green	brown leaves now dead, some new growth		no chang
+65	good growth especially submerged shoots			some brown tips to shoots	some brown tips, remainder healthy		no change
percentage reduction in biomass from control	66	55	51	82	*c* 0	*c* 0	-

Submerged stands

Time days	dichlobenil	diquat	diquat-alginate	Terbutryne	Hydrogen peroxide	control
+4	no change	looks dead	looks unhealthy	no change	no change	no chang
+10	emerging stems reddish	95% brown some new shoots green	looks dead	little change	as control	
+20	leaves dead tips regrowing	shoots mainly dead, some buds green, ('oily' bacterial film?)		as control	as control (some reddening of stems)	
+65	shoots healthy near surface	mainly dead decaying stems		many short green shoots	as control	
percentage reduction in biomass from control	66	100	97	48	*c* 0	*c* 0	-

Table 6. The biomass of *C. helmsii* in December 1988, June 1989 and October 1990, following tank trials of the application of Approved herbicides and herbicidal chemicals.

	Autumn Trial 1988			Late Spring Trial 1989					Autumn Trial 1990			
	post-treatment, December			pre-treatment (July)	post-treatment (August)				Post treatment			
Emergent	fresh wt kg	dry wt kg	reduction %	fresh wt kg	fresh wt kg	dry wt kg	change in weight actual %	growth corrected %	fresh wt kg	dry wt kg	reduction fresh wt %	dry wt** %
asulam	3.2	.22	66	5.5	6.0	.61	+9	-3				
2,4-D amine	6.0	.29	55	2.8	3.0	.30	+7	-4				
dalapon	5.9	.32	51	4.4	4.9	.51	+11	-1				
glyphosate dose												
x1	1.6	.12	82	5.7	5.6	.60	-2	-14	17.5	.86	-25	-31
x3				7.1	6.4	.71	-11	-20				
x5									7.5	.44	-68	-65
x10									9.8	.52	-58	-58
hydrogen peroxide												
20 g m^{-2}	10.6	.77	n.e.									
100 g m^{-2}	8.9	.56	n.e.									
250 g m^{-2}	-	-	-	6.2	5.4	.61	-13	-24				
Untreated control	9.3	.65	0	7.2	8.2	1.19	+14	n.e.	23.3	-	0	0
Submerged												
dichlobenil	1.6	.10	66	2.8	1.0	.11	-65	-20				
diquat	0	0	100	3.7	0.5	.11	-86	-72				
diquat alginate a	0.1	.01	97	2.0	0.2	.02	-90	-80				
b	-	-	-	4.6	0.1	.01	-97	-95				
terbutryne	2.6	.15	48	1.9	0.75	.07	-60	-18				
hydrogen peroxide												
20 g m^{-2}	3.9	.24	n.e.	-	-		-	-				
100 g m^{-2}	4.0	.32	n.e.	-	-		-	-				
250 g m^{-2}	-	-	-	2.8	1.95	.18	-30	+45				
Untreated control	4.7	.29	0	2.5	1.2	.13	-48	0				

Key n.e. no effect

* The pretreatment weighing adversely affected the growth of submerged plant stands.

** assumes a 0.053 ratio of fresh to dry weight for the untreated control.

3.2 Site survey

A wide geographic and habitat range of sites with *Crassula helmsii* were visited to assess their suitability for field control trials (site reports 1-10, see below). During these field surveys *C. helmsii* was found at a variety of sites with a wide range of habitat, size of water body, water depth, water chemistry and flora (Figure 1, Tables 7 and 8). The dominance achieved at sites was variable but high nutrient and alkaline water sites were often those most dominated by *C. helmsii*. The rate of expansion of plant stands following invasion differed, however, and it was therefore difficult at some sites to assess the actual date of the initial invasion. It was apparent that the probability of further spread of the plant at some sites to adjacent water bodies was high and inevitable without control measures.

Water chemistry. *C. helmsii* was found to be more dominant over a wide range of sites with water of medium to high 'potential' productivity, i.e. those with significant levels of carbonate (Table 7). Plant macro-nutrients were not in general high but this was probably the result of the growth of water plants. One site was found to have an elevated salinity level (x 4-7) but other water plants were present in abundance; however, the water in this small pond was also the most acidic of the sites.

Flora. The variety of flora at sites at which *C. helmsii* became dominant, decreased significantly when the sites were uniform and shallow (0.5 to 1-2 m in depth, Table 8). *C. helmsii* did not invade deeper water sites but few other plants were present. The dominance of *C. helmsii* was lower in sites with clay bed or banks but it was apparent that the biomass of other aquatic plants was similarly low; this may relate to macro-nutrient capture, especially phosphate, by clay particles.

Table 7. Physical and chemical parameters of sites visited to assess their suitability as field control sites for *Crassula* or as helpful to the development strategy for guidelines (Site numbers as Table 4, c = *Crassula* being controlled by time of visit; () = percentage cover following control ie regrowth)

	Site number																
	1	2	3	4	5a	5b	5c	6a	6b	6c	7i	7ii	8i	8ii	9	10i	10ii
Dimension																	
Water area (estimated)																	
length m	2	280	25	400	30	25	250	3	20	30	80	200	30	300	300	20	30
width m	2	170	15	250	20	20	150	3	20	20	25	100	15	1	60	10	30
depth m	1	30	0.4	3	1.2	1	0.8	0.5	1		1	1-3	(1)	.3	-4	1	2
Crassula cover																	
% of water	20	3	99	95	99	(3)	15	20	(5)	2	95	5	c	c	3	20	1
% of margin	10	20	99	95	99	(3)	15	10	(5)	5	90	(5)	c	c	20	30	1
Water - physical																	
temperature at visit ^{o}C	17	20	-	17	20	-	25	20	22	27	20	25	-	-	18	9.3	11.8
pH	6.8	8.1	-	7.9	8.4	-	8.6	7.7	8.6	7.8	8.3	9.1	9.2	8.0	6.7	7.5	8.8
conductivity µS	1200	350	-	310	454	-	280	560	538	495	384	350	475	405	623	142	173
Water - chemistry																	
Anions																	
carbonate hardness, mmol	2.6	0.6	-	2.3	0.3	-	.7	2.2	1.5	1.5	-	-	1.5	1.5	-	.42	.5
" as $CaCO_3$, mg l^{-1}	260	60	-	230	30	-	70	-	-	-	-	-	150	150	-	42	50
nitrate, mg l^{-1}	3	<3	-	0-3	<2	-	<3	<2	-	<2	<1	0	<2	<2	25	<3	<2
nitrite, mg l^{-1}	0	0	-	0	0	-	0	0	-	0	0	0	0	0	0	0	0
chloride, mg l^{-1}	280	34	-		42	-	45	50	75	55	75	72	64	39	70	-	-
Cations																	
Alkaline earth ions, mmol	2.9	0.7	-		0.9	-	0.9	-	-	-							
= as calcium mg l^{-1}	115	28	-		35	-	35	-	-	-							
= as calcium carbonate mg l^{-1}	290	70	-		90	-	90	215	-	170	107	107	100	100	125	35	63
calcium, mg l^{-1}	71.8	36.2	-	55	-	-		95	42	40						23	22
magnesium, mg l^{-1}	27.0	4.45	-	7	-	-										4.1	5.0
sodium, mg l^{-1}	90	14.4	-	11	-	-		40	20							6.3	4.4
potassium, mg l^{-1}	0.86	12.3	-	4.4	-	-										3.8	8.9

Table 8. General flora list with relative abundance of marginal (M) and aquatic (A) plants within whole site at sites visited for assessment of suitable sites for field control or as helpful to guidelines
(a = abundant (ie dominant or codominant) *c* 70%; c = common *c* 40%; f = frequent *c* 20%; o = occasional *c* 5%; i = infrequent *c* 1%)

Plant genera	Site 1		2		3		4		5a		5b		5c		6a		6b		6c		7		8		9		10	
	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A	M	A
Alnus			c																									
Alisma					i								o						f									
Apium	a	f											o															
Azolla		o																										
Callitriche																					f				f			
Carex							i																					
Eleocharis		c									o																o	o
Elodea			o								o																	f
Epilobium	f	o					i						o															
Equisetum																			o									
Eupatorium	o		o																									
Galium	i						i				o																	
Glyceria					c																							
Iris	f																										o	o
Juncus							i						c						f		f							
Lemna		f			o																							
Lythrum	o				i								o												f			
Medicago	i																											
Mentha	o	i											o															
Myosotis		o																										
Myriophyllum			i										o								o							
Nuphar			o								o				f													
Oenanthe	f																											
Phalaris							i																					
Phragmites							f																					
Potamogeton													f						o								f	
Ranunculus									i	i			o														f	
Rumex							i																					
Salix			c												f						f		f				f	
Solanum													o															
Sparganium							i						o															
Typha			o				f						c	o					f	o	o	o					o	o
Urtica							i																					
Viccia	i																											
Other species	4	-	-	-	7*	-			1	1	9	-	5	2	1(3)				2	3	-	-			1			
Relative Abundance of																												
C. helmsii	o	f	f	i	a	a	a	a	a	a	o	i	f	o	o	f			(o)	(o)	a	a	-	-	f	o	f	f

Notes
* see table 10.

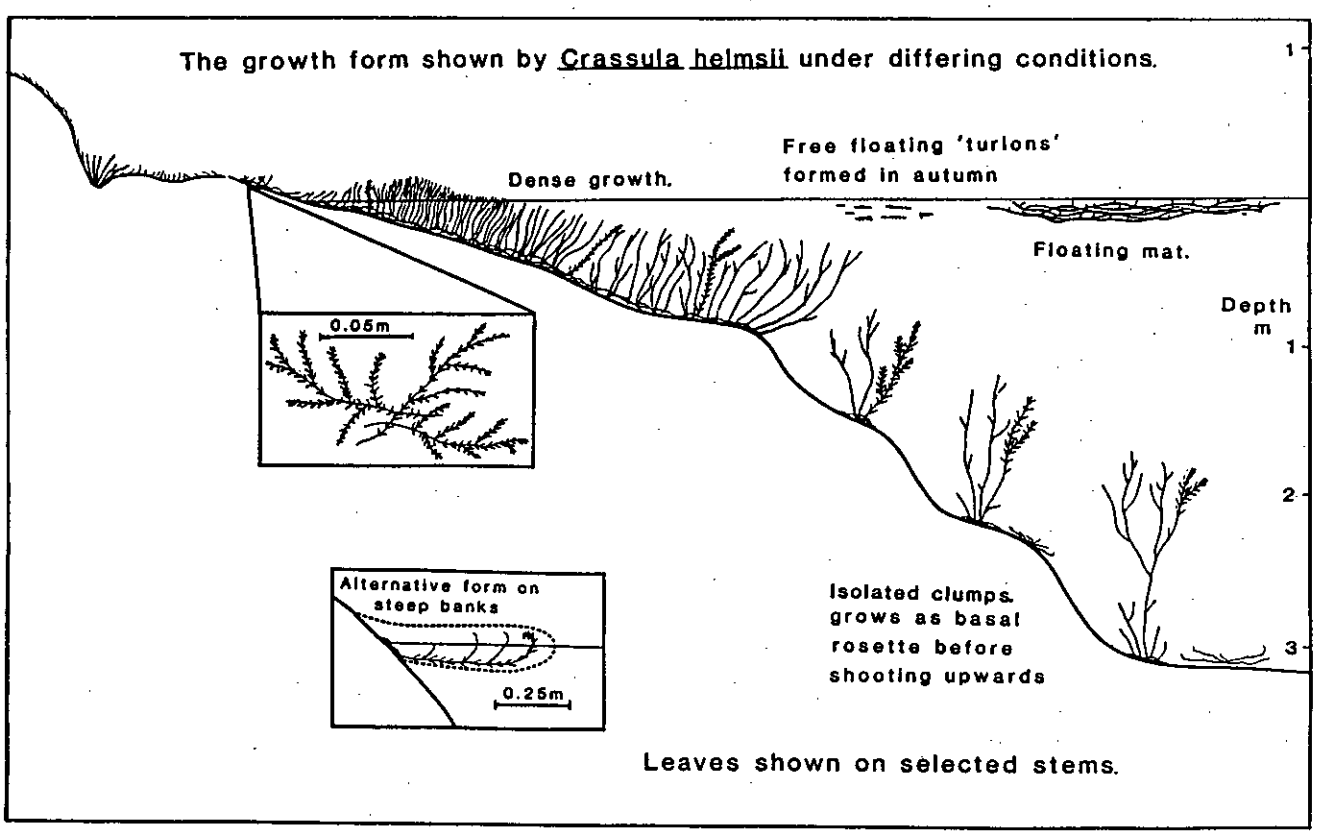

Figure 1. The habit of *C. helmsii* in relation to water depth based upon forms found at Site 4, Priors Down Lake, Stalbridge, Dorset 1986-1988.

Site 1. **Pool (Treguddah Gorge), Gunver Head, Padstow, Cornwall.**

10.8.88
Owner: Mr A L Olver, Trethillick Farm, Padstow.
Contact: Dr J E Oliver, Lockeridge, Wilts.
First recorded: 1988

A very small pool at the base of a small granite rock face situated one quarter the way down the shallowly sloping upper part of a gorge through which an adjacent small stream flowed to the sea. Emergent vegetation particularly species of *Oenanthe, Iris and Apium* dominated the outflow of the pond and the wet slope to the stream; free floating plant were present in the pool whilst deeper-water emergent plants surrounded it. The water- depth in the pool was fairly shallow but there was an underlying very deep layer of decaying vegetation; hydrogen sulphide could be smelt upon disturbance. The levels of sodium, chloride and conductivity were elevated above normal fresh waters. This could have resulted from either as a concentration effect through evaporation or by sea-spray which could be received directly on north-westerly winds. These levels are approximately equivalent to salinities of 2.3 ppth., 3.3 ppth. and 1 ppth. respectively and indicate a range from 3% to 9% of average seawater.

Source of plant. Inexplicable.
The plant is unlikely to have been introduced accidentally as the nearest recorded occurrence is 50 km away. However it is also unlikely to have been deliberately introduced as it is a long way from nearest houses (2 km) and not in an area designated of particular biological interest being surrounded by farm land; there is a National Coast Path within 200 m but this runs several kilometres from other fresh waters.

Status. Originally thought to be increasing but currently only a relatively small area exists.

Recommended control. None, monitor annually as interesting slightly saline pool.

Site 2. Decoy Pond, Recreation Ground, Newton Abbot, Devon.

10.8.88.
Owner: Teignbridge District Council
Contact: Andrew North, Planning Dept. T.D.C.
First recorded: 1986

A clay pit disused since 1967 and filled with water; it is currently used for recreational purposes e.g. sailing, diving, fishing, within a local authority park. Adjacent, to the south west, is an area of particular botanical interest (SSSI?/Nature Reserve?). The pond itself is c. 4.5 ha in area, oval in shape with the longer axis north-south; there is a narrow and shallow marginal zone (2-4 m) which rapidly slopes to a depth of c. 30 m. The vegetation was observed to be limited to these shallow margins and consisted of stands of a cultivated variety of water lily and *Typha* spp in the north east corner; weed growth was not excessive and no management has been undertaken. *Crassula helmsii* was mixed throughout these plants and scattered around the remaining shallower areas. Another alien aquatic *Myriophyllum aquaticum* (formerly referred to as *M. brasiliense)* was also present on the west bank by an iron-rich seepage. The conductivity, nitrate content and hardness were fairly low but the water was not as acidic as expected from this; a further analysis for cations is necessary. Submerged vegetation near the slip in particular was covered in a layer of fine particles probably clays; this may be a result of wind action but would chemically affect the ion balance of the water. A large quantity of decaying bread was observed by the boat slip.

Source of plant. The lake is used for many activities and *C. helmsii* could have been introduced in many ways eg during stocking with fish, by fishermen or by transfer of boats etc.; the presence of another alien plant suggests that it has been planted.

Status. This plant is probably increasing but may be nutrient limited. It is unlikely to become a general problem but could easily dominate the margins and therefore control is recommended. The depth to which *C. helmsii* has colonized is worth further investigation by divers (local club or IFE).

Recommended control. Herbicides.

Site 3. Seasonal pond, Higher pond, Corfe Castle, Dorset.

regular visits and 19.9.88.
Owner: National Trust
Contact: A W Jones
First recorded: 1984

A shallow seasonal pond situated adjacent to main Corfe Castle to Swanage road and on National Trust land. This land is grazed by locally-owned ponies and horses but is also at the end of the town of Corfe Castle and therefore has easy access for many people. The maximum water depth in winter is 0.4 m but the pond dries to <0.1 m or damp ground by late summer. The pond itself is currently almost totally dominated by *C. helmsii* although to the south of its centre there are bushes of *Salix* spp. There has been a significant reduction in the numbers of plant species present since the 1930s (-43%) and again since 1982 (-66%) following the invasion of *C. helmsii* (Table 9).

Source of plant. A pond with open public access at the southeastern limit of the town, a direct introduction is likely.

Status. Dominant in both margins and pool.

Recommended control. Removal and on-site composting or shade-material, followed by herbicide applications.

An open level area parallel to the main road was selected as a site for comparative herbicide field trials on emergent stands.

Table 9. A comparison of aquatic bank and submerged flora for Higher Pond, Corfe, before and after invasion by *C. helmsii* (1936 by R. Good; 1982 = part of list A.E. Newton & I. Cross, Dorset Environmental Record Centre (pers. comm.); 1986 = F.H. Dawson & E. Warman)

	Higher Pond, Corfe		
	1936	1982	1986
Alisma plantago-aquatica	x		x
Anagallis tenuis	x		
Apium nodiflorum	x	x	
Baldellia ranunculoides	x	x	x?
Callitriche agg.	x	x	
C. obtusangula			x
C. stagnalis			x
Caltha palustris	x		
Equisetum palustre			x
Glyceria fluitans	x		x
Groenlandia densa			x?
Hydrocotyle vulgaris	x	x	
Hypericum eloides	x	x	
Juncus articulata	x	x	
J. bufonius	x	x	
J. bulbosus	x	x	
J. effusus	x	x	
Lemna minor			x
Lythrum portula	x		x
Mentha aquatica	x	x	
Menyanthes trifoliatus	x		
Potamogeton natans			x?
P. polygonifolius	x		
Ranunculus aquatilis			x?
R. flammula	x	x	
R. hederaceus			x?
Sparganium erectum	x		
Sphagnum spp		x	
Triglochin palustris L.	x		
Typha spp.			
Veronica anagallis-aquatica	x		
	21	12	7 (12?)
	100	51	33-57
		-49	-66?

Site 4. small lake, Priors Down, Stalbridge, Dorset.

regular visits since 1986 and 1.11.88 and subsequently for herbicide field trial assessments
Owner and contact: N.G. Robinson of Priors Down
First recorded: 1985 but known to exist since 1976

A 1 ha artificial fishing lake with two ornamental islands and clay lined; it was constructed in 1970s. Although the average depth is *c.* 2 m, there are areas of the lake which are relatively shallow *c.* 1-1.5 m and others which are *c.* 3 m in depth. Three quarters of the margins are steep sided whereas the remainder are shallow sloped and vegetated by *Phragmites* and *Typha*. A variety of forms of *C. helmsii* have been found at this site (Figure 1) (Dawson and Warman 1987). Apart from rain, the source of water was drainage from an adjacent wooded area. The chemistry of the water was approximately half the alkalinity of local waters; plant nutrients were generally low despite the presence of tens of Canada geese but this may be related to the year-round presence of *C. helmsii* with the associated continuous uptake of nutrients (and clays in suspension?).

Source of plant. Not known but may have been introduced with aquatic plants into an adjacent ornamental pond and escaped to the main pool. *Elodea* spp. had previously been the dominant species but within 18 months of the initial appearance of *C. helmsii* it had become the dominant species. A regular and continual programme of management by both physical and herbicide techniques have not controlled *C. helmsii* at this site.

Status. Dominant in both margins and pool; the use of herbicides at less than recommended overall levels is considered to have resulted in maintaining the dominance of *C. helmsii* and not its eradication.

Recommended control. Intensive herbicide control programme with shade-material in shallow marginal areas. Replanting with less vigorous species is probably desirable.

The open bay to the north was selected as a site for comparative herbicide trials on submerged stands and the margins of the east end of the lake were used for trials on emergent growth.

Area 5. **Lakes and ponds within the New Forest and its perambulation, Hampshire.**

Owner: under control of the Verderers of the New Forest and the Forestry Commission.

Contact: Andrew Byfield, Nature Conservancy Council, County Officer for mid and north Hampshire.

Background. The Forestry Commission has accepted the principle of using chemical control for *Crassula helmsii*, provided that areas were temporarily fenced, but required that alternative methods be tested first.

Trials on

(1) mechanical removal were resisted because it was ineffective, labour-intensive and if the material was not composted on site then there was a high risk of further spread of the plant;

(2) use of a flame thrower by NCC was monitored and assessed;

(3) the use of shade material was advocated wherever possible, but in view of its non-aesthetic appearance, the time required for effective control and the perceived need to fence off areas to avoid problems with grazing ponies, the technique was rejected.

(Subsequently some herbicide trials are believed to have been undertaken.)

Site 5a. **Mockbeggar pond, Ibsley, Ringwood (on west margin of New Forest).**

regular visits since 1986 and control trial on 20.8.88 with subsequent assessments for assessment of control.
Owner: at cottage, adjacent Ibsley Garage, Ibsley.
Contact: above and also Mr P Webster, Nut tree Cottage, Mockbeggar Lane, Ibsley.
First recorded: 1982 but probably much earlier.

A shallow drying pond of 0.1 ha at the corner of open field grazed mainly by ponies, but shaded by trees to the North and East sides. The pond was last dredged to base gravel in mid-1970's and a small central island was formed; the bed is overlain by a thin layer of organic mud. In winter the maximum depth of the water is 1.2 m but it can dry to only 0.6 m in late summer. The pond and its broad margins are almost totally dominated by *C. helmsii* which grows in a variety of forms related to water depth or drying (see Figure 1). The flora includes *Ranunculus flammula* and occasional agricultural weeds.

Source of the plant. Not known but the site has open access and is well-visited. It could have been transferred from (and to) adjacent well ditches and ponds by ponies etc.

Status: totally dominated at all seasons by *C. helmsii*.

Recommended control. Shade material eg rick sheet secured by pegs to the ground or by ropes through the eyelets.

Control Trials. Control of the plant around the drying pond margins was attempted in August 1988 by NCC staff using three-burner gas flame-throwers. Based upon the work rate achieved (1 m^2 in 5 min.), it was estimated that 3 person-weeks of effort would be required which, in addition to the gas used, would make a cost of £1000-1500 for this pond; this equates to £10-15 000 per hectare at direct cost. The rapid regrowth of unburned lower shoots (assisted by release of nutrients from the ash?) together with the adventitious spread of stems across the moist mud led to the 'fired' areas becoming latticed by regrowing stems within a month. This method of control for marginal areas was not considered further as it was not possible in practice to kill stems buried in the moist mud particularly at the bottom of hoof marks.

Mockbeggar Lake - a former airfield site from which gravel had been extensively removed. *Crassula helmsii* was found in the N.E. corner (the closest to Mockbeggar pond) in shallow sloping margins. Other vegetation includes *Elodea nuttallii* with species of *Mentha, Lycopus, Alisma, Juncus* and *Potamogeton* growing on the gravel substratum.

[Contact: Patrick Webster, at Mockbeggar, Ringwood 4722079.]

Site 5b. **Little Hatchet Pond, East Boldre**

regular visits since 1986 and 4.8.88
Owner
Contact: A. Byfield, NCC Lyndhurst, New Forest
First recorded 1978

Pond with adjacent shallow pools and wet depressions within a sunken area formerly a site of gravel extraction (?) and bounded by a triangle of minor roads raised on gorse-covered banks. The main pond c. 0.1 ha is open and has shallow wet margins with the rare plants *Ludwigia palustris*, *Galium debile*, *Pilularia globulifera*, *Cicendia filiformis*, *Illecebrum verticillatum* and other less common species such as *Littorella uniflora*, *Eleocharis acicularis*, *Baldellia ranunculoides*, *Apium inundatum*, *Menyanthes trifoliata* and *Hypericum elodes*; in deeper areas of the pond, (c. 1 m) stands of *Nuphar* are common. The substratum is mainly soft organic silts and muds, the margins show signs of trampling by ponies over the last 3 years. *Crassula helmsii* has gradually spread from the main pool to other areas in a sporadic manner.

Source of the plant: unknown but other aquatic plants have been introduced into ponds in this area e.g. *Pontederia* and the northern Floating Bur-reed *Sparganium angustifolium*.

Status: increasing despite control attempts and it is considered to be in direct competition with the rare *Galium debile*, but *C. helmsii* could out-compete many other species especially *Ludwigia palustris*, if the nutrient status became higher.

Recommended control. Attempts had previously been made to control *C. helmsii* by rolling up the plant stands as a carpet. This material was then composted on raised areas up to 1.3 m above the water level but although this was successful in reducing bulk, there were many shoots still growing from the top of the heaps even after many months. There was unfortunately regrowth from fragments of *C. helmsii* which remained in the margins.

Shading material applied in autumn combined with restricting all access to the site may be the only acceptable moderation of the growth of *C. helmsii* at this site. Trials on the use of the recommended herbicides may also need to be conducted in parallel to this.

Site 5c. gravel pit lake, Holmesley Nature Reserve, near Bransgore

visited 8.8.88 (and subsequently for herbicide trials)
Owner: Hampshire and Isle of Wight Naturalists Trust Ltd (?)
Contact: R. Tyler, Field Officer, Hampshire and Isle of Wight Naturalists Trust Ltd, Romsey, Hants

A shallow lake of c. 3 ha, formerly the site of gravel extraction and in which islands have been constructed to encourage nesting of water birds. *Crassula helmsii* has spread rapidly around the shallow and drying margins to form a sparse to dense short turf particularly on the south margins and the bay to the south west. It is the dominant vegetation in most of the gently sloping stony or sandy margins, but is currently less common on the steeper banks and amongst the tall emergent plants; the sandy central regions of the lake are dominated by *Potamogeton* spp. and filamentous algae. A variety of other aquatic vegetation was present including to the south *Lycopus europaeus, Lythrum portula, Potentilla anserina, Epilobium hirsutum; Alisma plantago-aquatica, Lysimachia vulgaris, Typha angustifolia, T. latifolia* and *Juncus* spp.; to the west a large stand of *Typha* together with *C. helmsii* both amongst it and in the adjacent water; in the main lake species of *Myriophyllum, Chara, Littorella* (?) and *Ranunculus*; in the north, meadows were vegetated by different but near- featureless plants including *Eleocharis acicularis* (?), and on the margins small broad leaved willow (*S. caprea*?), Gorse with *Solarium dulcameria.*

In addition, a local botanist and vice-county recorder, R.P. Bowman reports *Typha glauca, Eleocharis palustris, Apium inundatum, A. nodiflorum, Mentha aquatica, Nasturtium officinale, Potamogeton natans, P. berchtoldii, Sparganium emersum* and R. Tyler, Hampshire & Isle of Wight Naturalists Trust, also reports *Littorella uniflora.*

Source of plant. unknown; the site is just outside the New Forest Perambulation zone and is not open to grazing.
Status: widespread and increasing to new wet areas (1-3 per year).

Recommended control: The nutrient concentrations were low which, combined with the relatively small amount of organic silts (except in the south west), suggest that dense stands of *C. helmsii* are unlikely to develop. However, the plant is likely to increase and become the dominant plant in the population. Control of the plant in the south and south west margin of the lake has been attempted firstly by manual removal and twice subsequently using glyphosate (1987, 1988) but the plant has always regrown and is spreading.
An area to the south east of this site was selected for comparative herbicide field trials and for a follow-up large-scale trial.

Area 6. Ponds on the Isle of Wight

Background. Ponds at the west end of the island have been reported verbally as the site of another introduction of the plant possibly in association with sheep imports from Australia, also around the 1920's. However, the presence of the plant at the earliest site on the island was only confirmed in 1965. The plant was reported growing in drainage channels and in the River East Yar at the east end of the island but these sites were not located.

Site 6a. Small pond, Marsh Farm House, Newtown

Owner and contact: Mr & Mrs Seabrook
First recorded 1965 but could have been present since 1930's

A small nutrient-rich shaded pond formerly a stock-watering pond near a former farmhouse. *Crassula helmsii* was seen together with other plants introduced to the pond including *Stratiotes*, *Menyanthes* and *Nuphar*. The water level was maintained high during summer by the addition of chalk rich top water. *C. helmsii* was seen to be growing abundantly and required regular control to reduce its invasion of the pond.

An adjacent site, a pond in an adjoining field and from which the plant had previously been reported, was dry.

Source of plant: as above.

Status: the plant is regularly controlled by hand but could rapidly increase. There is an estuarine nature reserve within 300 m but without stream or ditches leading to it.

Recommended control: none, if present owner remains and no biota is transferred from the pool; otherwise herbicide control. The adjacent area must be regularly monitored for spread of the plant; the site is however within an area suitable for study of the plant's invasion of estuaries.

[Contact: Nature Reserve Warden, Richard Grogan, for access to reserve and especially Brickfield and East Point]

Site 6b. Pond, Army Range, Locksgreen, Newtown

Owner: Ministry of Defence
Contact: T.G. Rolf, Range Warden
First recorded 1985

A small lunate pond excavated in *c.* 1984. *Crassula helmsii* had been found to be increasing in the margins amongst *Typha* but had recently been removed by mechanical scraper and dumped near banks of estuary (*c.* 10 m). It was advised that light should be excluded from the fragments of plant remaining viable and that the site be monitored for signs of regrowth.
A wet scrape dug for amphibians, in an adjacent wood but very close to the estuary was found to be dominated by a short emergent turf of *C. helmsii*.

Source of plant: not known, but could have been introduced with other native aquatic plants when pond was 'planted'. The scrape in the wood is of concern and indicates the ease of transfer within adjacent wetland sites.

Control: shade material suggested as trust managers want to avoid herbicides.

Site 6c. Pond, Shanklin and Sandown Golf Club, Sandown

Owner: Shanklin and Sandown Golf Club
Contact: G.A. Wormold, Club Secretary/Manager
First recorded: 1976

A former turbine-pump balancing-pond richly vegetated with many aquatics including *Potamogeton natans*, *Menyanthes*, *Stratiotes* and *Equisetum* in water and surrounded by *Typha* and grasses on the banks. *Crassula helmsii* was noted as beginning to spread and thicken along one margin in association with *Hydrocotyle*.

Source of plant: not known.

Status: apparently increasing but reported as present for a decade; the extent of management of the pond was not investigated.

Recommended control: herbicide.

Site 7. **Trout pond and others, Fingeringhoe Wick Nature Reserve**

visited 21.6.88
Owner: The Essex Naturalists' Trust Ltd, Fingeringhoe, Colchester
Contact: Chris Miles
First recorded 1976

(i) Trout Pool (0.3 ha) a small shaded lake of interest for its dragonflies was dominated (90% cover) by *Crassula helmsii* as rooted stands in the c .1.2 m of water to emergent stands just above the water level. One stand of *Typha angustifolia* (?) was present at one margin but this was co-dominated by a large floating mat of *C. helmsii*, whilst in the water there were occasional stands of *Myriophyllum spicatum* (1%), and filamentous algal mats. Species of *Juncus* and *Carex* previously dominated the margins.

(ii) Adjacent connecting ponds also contained stands of *C.helmsii* the largest 'main lake' of which was deeper than Trout Pool and still contained many other species. A small pool surrounded by trees, was found to have a dense raised emergent mound of *C. helmsii* growing in the central less shaded area in the moist conditions.

Source of plant not known; initially noted following the drying down of pool in 1976.

Status: dominant. This site has previously been hand-cleared (1986) and supposedly totally removed but regrowth was rapid.

Recommended control: shade material, but in view of the concern it was proposed as a site for comparative herbicide trials, using only some of approved herbicides (Appendix V). This was rejected by Conservation Committee on grounds that their 'show piece' site should not be used for experiments until proven elsewhere.

Site 8. Small pond, Ynyslas Dunes, Dyfi National Nature Reserve, River Dovey Estuary
Visited 23.8.1988
Owner: NCC
Contact: Paul Burnham, Reserve Warden
First recorded 1986

(i) Paul Burnham reports:

'*Crassula helmsii* was found growing in 1986 in a small pond (and later in adjacent ditches), approximately 18 m x 6 m, situated in the eastern dune slacks. This pond had been excavated in 1978 to retain an area of open water during the summer period. In the winter months the pond fills with water and joins up with the flooded dune slacks creating a potentially larger area for the plant to colonize.'

Glyphosate was used to spot treat (21.9.87) *C. helmsii* on the northern bank of the pond (1-1.5 x 18 m). A month later (19.10.87) and with falling water levels, a clear division was observable between the dead plant material previously out of water and that previously in the water; this clear division did not seem to apply to plants in the shade of willow bushes. Diquat alginate was then applied (19.10.87) but although much was killed, floating and viable (?) fragments were still present in the pond. A further treatment was made in winter which killed almost all the remaining *C. helmsii* although very careful examination yielded a few diminutive live shoots.

(ii) *C. helmsii* was effectively controlled in the adjacent ditches by using weighted sheets of black polythene to cover the plants for several months.

Source of plant unknown, but 11 miles downstream of aquatic centre with *C. helmsii* but line of sites near or suggests introduction by man and/or followed by spread during winter flooding of dune slacks (the plant is known to have a tolerance to half sea water).

Status: probably eliminated, but requires monitoring at least still twice more, Spring 1989, Autumn 1989.

Site 9. **small water supply reservoir, St Peter's Valley, Jersey**

visited: 25.10.88
Owner: Jersey New Water Works Co.
Contact: F. Le Sueur of Jersey National Trust
First recorded 1985

An annually drained and dried water-storage supply reservoir of *c.* 1 ha in valley with maintained grass banks and surrounded by woods. The marginal aquatic vegetation is limited to a short turf of aquatic herbs including *Crassula helmsii* but also, *Lythrum portula*, *Callitriche stagnalis* and *Montia fontana*.

Source of plant not known, site downstream of stream site previously containing *C. helmsii* which was probably an escape from an ornamental pond (?).

Status: co-dominant, seem to be controlled by annual drying down of the reservoir.

Recommended control: extended period of desiccation followed by use of shade fabric to avoid herbicide contamination of potable water supply (or take reservoir out of service and treat with herbicide and flush before re-use as water supply.

Site 10. **Hoopers Pool, Coverham Enclosure, Coleford, West Gloucestershire**

visited 3.10.1989
Owner: Forestry Commission (Site of Biological Interest of G.T.N.C.).
Contact: Mrs S Holland, Gloucester Trust for Nature Conservation
M A Wilkinson, ARO Gloucestershire, NCC West Midlands
First recorded: 1983

(i) A small lunate shaped forest pool shaded mainly by oak trees and bushes of willow.

The aquatic vegetation included *Potamogeton natans*, *Elodea nutalli* (?), *Ranunculus flammula* and species of *Iris*, *Typha* and large a *Eleocharis* in addition to *C. helmsii* which was well distributed within the pond and in apparently increasing abundance.

(ii) Another open clay pond in the area, **Jugshole Pool**, Broadwell, near Coleford Dean, also contained a small quantity of *C. helmsii* in its shallow margins and *Lagarosiphon major* in addition to the above species. Characterization of the water chemistry shows a low level of macro-nutrients which in combination with the turbid clay water is likely to limit aquatic plant growth in general.

Source of plant: adjacent school?

Status: increasing and probable source of plant to adjacent sites.

Recommended control: Initially by use of shade material.

3.3 Field Control Trials

Field trials on small plots were inconclusive especially in the short drying turves at Corfe common and Holmesley and the emergent growth at Stalbridge (Table 10). Stands of *Crassula helmsii* were, however, killed in the deeper water trials at the latter site, but it was unclear if movement of the herbicides in the water had occurred and confused the result by creating a herbicide 'cocktail' (table 11).

Table 10. Observation of the state of growth of emergent stands of *C. helmsii* at the field herbicide trial sites Corfe Common and Holmesley N.R. September 1988 to April 1989.

Emergent drying turf - Corfe

time days	herbicide asulam	2,4-D	Dalapon	glyphosate	hydrogen peroxide 20 ppm	hydrogen peroxide 100 ppm	Control
+6	no change	30% dead	40% dead	50% dead but new growth	little effect	scorched	no change
+30	pale shoots	shoots regrowing		pale shoots	shoots regrowing		no change
+105	no difference						
+180	no difference, shoots greener in hoof marks than on raised tussocks by .1m						

Emergent drying turf - Holmesley

+6	scorch lines	some scorching yellow green	scorched lines	slight scorching 60% pink but regrowing	little change	some scorching tips green	no change
+30	scorch lines some regrowth brown			pink stems and some dead shoots	little change	no change	no change
+105	many shoots regrowing			poor growth	little change		
+180	all marking sticks removed - but only one small area showing poor growth (probably glyphosate area)						

Table 11. Observation of the state of growth of submerged and submerged stands of *C. helmsii* at the field site Priors Down, Stalbridge, September 1988 to April 1989.

Submerged stands

time days	herbicide dichlobenil	diquat	diquat-alginate	terbutryne	hydrogen peroxide 20 ppm	hydrogen peroxide 100 ppm	control
+20	red brown stems	looks unhealthy	looks nearly dead	little change	little change (some scorching)	little change	no change
+65	little bottom growth	dead many live floating fragments	dead many live floating fragments	little change some dead stems?	no change		no change
+92	bed near clear much floating debris	dead, some live rosettes on bed patchy	dead bed clear many floating live fragments	live roots some stems many live fragments	no change		no change

Emergent stands

time days	herbicide asulam	2,4-D	Dalapon	glyphosate	hydrogen peroxide 20 ppm	hydrogen peroxide 100 ppm	Control
+7					browned all over		
+20	no change	looks unhealthy	some unhealthy	pale pinkish leaves	brown patches		no change
+65	no change	no change	stems	some brown tips, leaves pale	some brown tips areas of dead leaves		no change
+92	no change	no change	little change	little change	little change		no change some frost damage

3.4 Current distribution and expansion rate

Crassula helmsii has rapidly expanded its range in natural and semi-natural sites across Britain consolidating in the central south east. The plant which had been found in only a dozen sites by the end of the 1960's increased its abundance to *c*. 210 sites by September 1989 and is currently found in *c* 270 sites (late-1990); this total includes at least 40 nature reserves of varying status (Appendix II). The rate of invasion of new sites continues to double about every two years with little sign of any decrease in its rate (Figure 2, 3 and 4). There is a slight dip for 1988-89 in the histogram of new sites records,and this follows the effects of a year which included direct mailing to vice-county recorders, regular exhibitions, pamphlets and publicity in the various media requesting information and anticipating records normally delayed. The underlying trend in the cumulative graphs however shows a continuing near-exponential rise in the linear data and linear rise in the logarithmic graph assuming that those records attributable to only decades and not specific years was evenly distributed within those decades. This data trend suggests that *c* 1000 sites will be found to have been invaded by the year 2000 AD.

The **true annual rate of increase** relies to a major extent on the interest of botanists and recorders and, there are several factors which must be taken into account in determining this rate. Factors ensuring that records of the plant are notified include: the increased interest, particularly in the south during the 1970's, for a new plant and the associated interest in producing new vice-county records; concern expressed by particular recorders, and also pond owners, that the adverse effects of the plant were becoming evident; the availability of description and drawings for identification; and, the continuing publicity on the consequences of this plant to various habitats. Whereas on the negative side: reduced interest following the reporting of the first and second vice-county occurrences; the perception that invasions were not as bad as forecast particularly for deeper waters and for those with low nutrient levels; and, also the false optimism of loss of the plant from sites following supposed clearance; but also, difficulties of identification and confusion particularly with *Callitriche* spp.

Further **investigation of records** reveals several effects. For example, although it has been suggested in some reports that *C. helmsii* has been lost at some sites, investigation suggests that this is rare. Of the sites investigated, one pool had been filled in, whereas at another 'loss' resulted from three herbicide treatments within 12 months. A cautious approach is considered necessary as this plant has been reported lost from several other

sites but has recovered and rapidly reinvaded to cover even larger areas than previously reported. Considerable variation was found in the definition of occurrence at a 'site' eg from a single small patch to an area of several hectares with six ponds, a lake and the interconnecting channels; it was therefore necessary to define presence in a standard manner, thus presence of the plant in a 1km square was taken as a single occurrence.

Analysis of the types of site invaded indicates that the majority are small ponds of which about one third may dry-down; the majority of these are located in agricultural areas although there are many in private estates and nature reserves (Table 12). Such an analysis does not fully indicate the area of stands and thus some reservoirs in the south east of England have extensive areas but due to the large fluctuations in water level these are not the highest biomass: the latter are to be found in seasonal ponds particularly in the south (Table 12). No extensive analysis of the water chemistry of sites invaded has been undertaken although it would appear from a selection of *c* 25 sites that biomass is highest in slightly alkaline and nutrient-rich waters; although the plant grows better than nearly all native species in all but true acid waters ie.less than pH 5.5. (Table 7).

Following the finding of the first naturalized site in Essex in the mid-1950s there were several records for deliberate and accidental plantings during the 1960s and early 1970s in various types of pond mainly in the south of England but with two in Scotland although none in Wales (Figure 2). The plant was not recorded as becoming naturalized until the late 1970s. Subsequently there have been two main types of invasion: firstly that of new sites to a region or super county and secondly more local spread from established sites. This local or secondary invasion initially seems to take about 5-10 years to occur. Sites at which such spread is clearly seen include the New Forest in Hampshire in which *c* 17 pools of the *c* 200 potential sites have been invaded with increasing rapidity in *c* 25 years. In addition, spread or drift along the Basingstoke Canal has occurred, as has the transfer around the parks and commons around Greater London. Aquarists and aquatic plant suppliers have and continue to supply the plant both directly by name, or indirectly as an unnamed 'oxygenator', but more importantly passively with many named species of marsh plants native such as *Typha spp.*or introductions, eg *Myriophyllum aquatica* (*M. braziliense*), *Scirpus zebraius*. Observation indicates that other activities have caused the continued expansion of this plant including human activities such as associated with nets used for transfer of fish or other equipment (baskets and boots), emptying aquaria, biologists, pond clearance and replanting, and also by wildlife including ponies, but also passive drift along canals and drains.

Table 12. Occurrence of *Crassula helmsii* in sites in Britain by (a) type of water body and (b) adjacent land use for sites, in the years to mid 1988 (190 sites) and to Nov 1990 (270 sites)

(a) Occurrence by water body	Percentage occurrence mid '88	mid '90		Public Access
small ponds (30% temporary or drying)	70	62	*	variable
tanks		4		restricted
shallow gravel sand or clay lakes	6	7		variable
large lakes or reservoirs	11	9		open/closed
Linear watercourses near static	5	10	*	open
Linear watercourses, flowing (or on banks)	5	4		open
damp ground, marsh	1	2		variable
in cultivation	2	2		closed

(b) Occurrence by adjacent land use	Percentage occurrence mid '88	mid '90	Public Access
Nature reserves, SSSIs, etc	15	16	restricted
Natural or semi natural areas	55		open
Common land (& woodland)		12	open
Parks, estates, country houses, moats	28	16	restricted
Agricultural land		21	restricted
Private gardens		12	closed
Industrial, extraction of gravel, clay		11	closed
Reservoirs, large tanks		6	closed
Fish & ornamental ponds		4	variable
in cultivation	2	2	closed

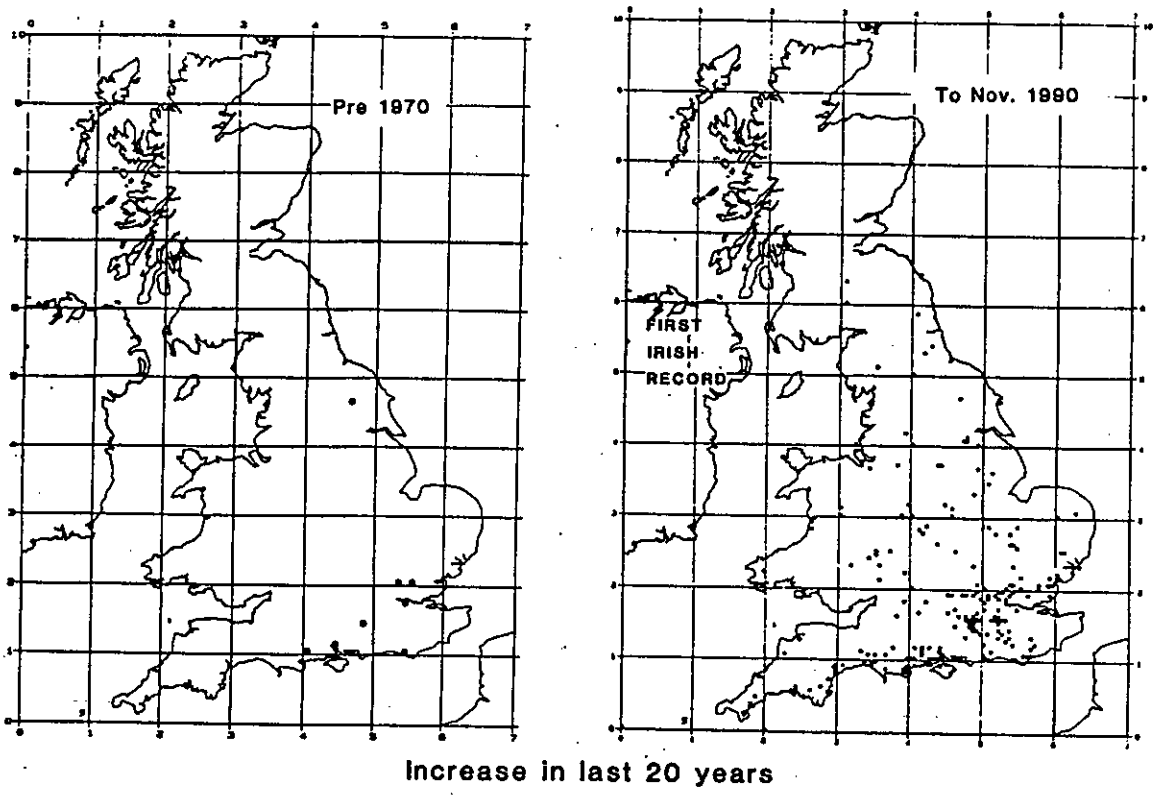

Figure 2. A comparison of the distribution of *C. helmsii* between the twenty year period 1970 and 1990, for the British Isles.

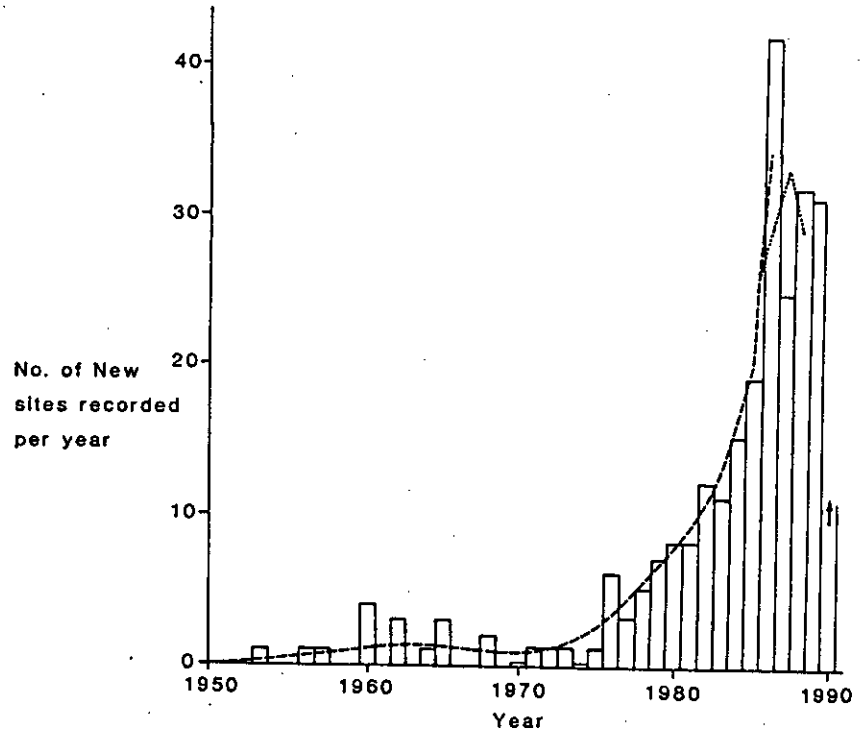

Figure 3. The rate of increase of new occurrences of *Crassula helmsii*, with year, to July 1990 in Britain.

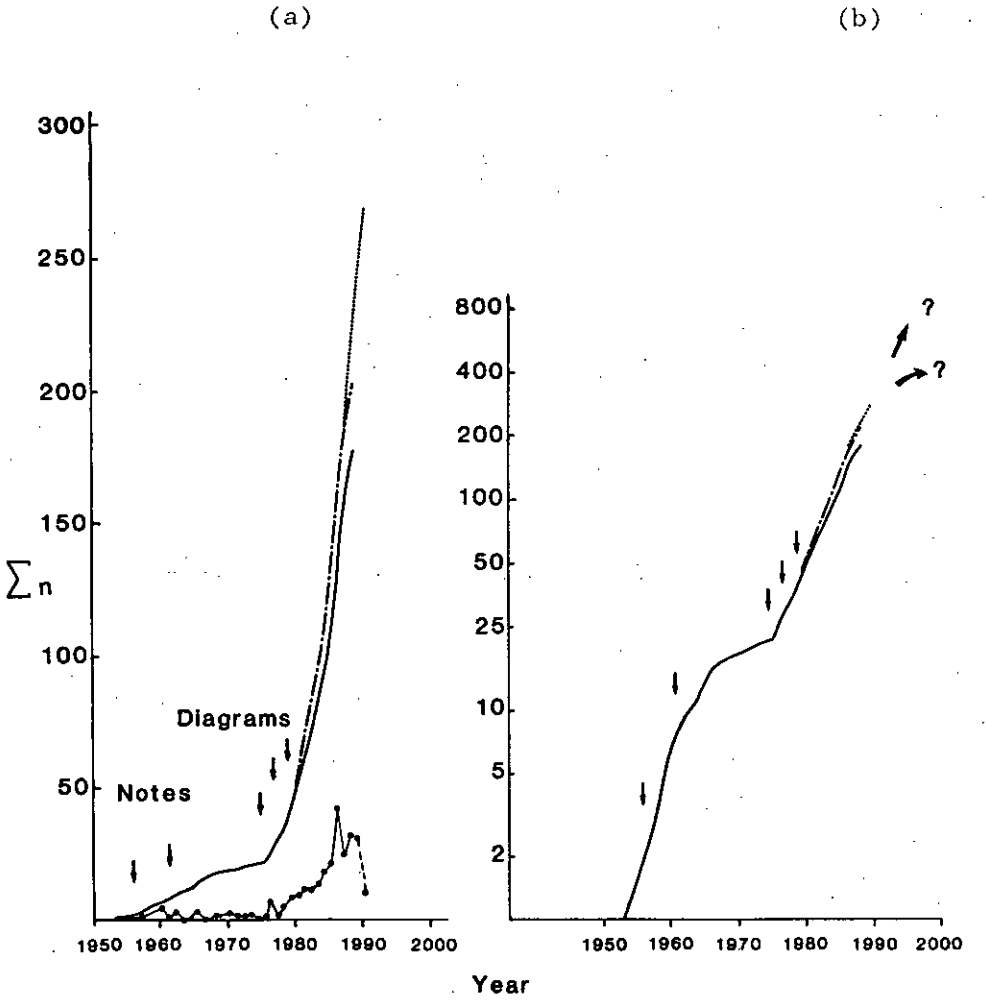

Figure 4. The (a) arithmetic and (b) logarithmic number of actual year of new occurrences (solid line) of *Crassula helmsii* in Britain to July 1990 together with correction for those sites with only approximate year (dashed lines) eg. as 1980's. The possible rates of continued new occurrences are indicated by the extrapolation (bold arrows) on the logarithmic diagram (b).
(key - ↓↓ notes = approximate date of notes on the presence of *Crassula helmsii* published in house journals, see Dawson and Warman, 1987; ↓↓ Diagrams = approximate date of publishing of diagnostic figures of *C. helmsii*, see above; Irl = First Irish record)

4. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

The objectives of the work reported were to:

1. investigate a control technique for *Crassula helmsii* by comparing herbicides and a herbicidal chemical both in tank and field trials at suitable selected sites;
2. synthesize tank and field trials with observations of other control attempts at sites over a wide geographical and morphological range, to produce some guidelines for the control of this plant;
3. assess the current status, distribution and increase of this plant in Britain.

The first objective of comparing the effectiveness of different aquatic herbicides was successful in tank trials but not in field trials on emergent stands. Comparison of both untreated emergent and underwater stands showed that the degree of control varied with herbicide. Underwater stands of *Crassula helmsii* were well controlled by diquat and diquat-alginate whereas emergent stands were only partially susceptible to one herbicide glyphosate. Hydrogen peroxide was apparently quite effective initially but was limited to a direct kill or scorching effect. By comparison with the normal requirements of weed control there are two problems in the attempted elimination of this plant;

1. the typical biomass of *Crassula helmsii* is considerably higher during the approved application period (eg 17 kg m^{-2} fresh weight for emergent growth, Table 6) than normal weeds, thus giving an unusually low ratio of herbicide to 'weed' biomass, and,
2. elimination is desired not merely the firm control as required for most aquatic sites.

These problems are exemplified by the field trials on both drying turves and emergent stands, in which a single application at the approved dose produced little significant effect; underwater stands of typically lower biomass were for more successful. Multiple applications (eg 3 in 15 months) of herbicide at the approved dose rates seem to be required but this may not be possible because of the approved application periods and other constraints. The questions of dose rate and timing have been investigated with tank trials on glyphosate as part of 'off-label' trials at concentrations up to ten times the normal maximum dose but these were insufficient to give more than two-thirds control in a single application. Multiple applications were not attempted and both this and the effects of the addition of Mixture B, an approved mixture of two non-ionic surfactants, should be tested in further tank and field trials if eradication of this plant from nature reserves is to

be achieved; the plant may in addition be much more resistant than many others and further comparative trials may be required.

The **second objective**, to synthesize the results of herbicide tank and field trials with the variety of requirements and susceptibility of a range of sites to prevent or moderate the further continuing spread of *Crassula helmsii*, indicated that guidelines were required for sites with differing degrees of dominance or area of site invaded and that some techniques were ineffective or counter-productive. Manual or mechanical control was an example of the latter as it led to the increase in the number of viable fragments within the wet area, loss of local flora and an increase in the risk of spread to other sites on operators or machinery. The use of flame throwers was simply ineffective, laborious and expensive. Herbicides should be applied as effectively as possible on the first application as reduced or further applications only cause the loss of other more susceptible species and enhance the dominance of *C. helmsii* . Application of herbicide in winter when native species are less common may cause less effect and the natural seed bank can help to regenerate the local flora. The efficacy of diquat-alginate has often been suggested as suspect when calcium levels exceed 10 mg l-1 due to competitive action at the cell surface. However no such effect was observed despite a variety of calcium levels in the trials.

The **third objective** of assessing the current status and any change, confirm that the previous assessments and predictions were correct ie the doubling rate for new sites reported is about every 2 years and the geographic distribution is increasing particularly for the south east of Britain. The current number of sites at which *C. helmsii* occurs is c. 270, of which 16% (c. 40 sites) are in nature reserves or SSSIs; there are, also, a number of sites (c. 18) in close proximity to nature reserves and to which the plant may spread in the near future. The definition of a site adopted by each recorder varied but is taken to mean presence within a one kilometre square in this report. Unfortunately, this definition has included up to seven ponds or wet areas as a single site in some localities; the number of site occurrences (c. 270) is therefore an underestimate. The dispersal of the plant between sites probably occurs by many mechanisms and although accidental transference with animals or plants (particularly amphibians to 'scrapes') and also directly by animals, was suspected, no convincing evidence was found. Other mechanisms compatible with the known tolerances and biology of the plant are likely to include transfer on equipment such as fishing nets, baskets, boats, boots. Thus it would appear that most British

British freshwaters are susceptible to invasion by this plant. Preliminary analysis of data collected in Australia indicates that Britain lies within the range of requirements for this plant when considered in terms of water chemistry, rainfall, dryness, altitude, frost and snow conditions, in addition to which the plant was found in protected estuaries within 0.05-0.1m above the sea water surface; the interpretation of the latter in a European context is difficult due to the reduced tidal range in the Southern Australia. There is an increase in the number of sites with elevated concentrations of salt and also in the number of sites near or on the banks of rivers. The extent to which the plant can grow in semi-saline water eg estuaries, salt marshes etc is not yet established but recent experiments indicate that shoots will both survive half sea water for some weeks and will recover from inundation by normal sea water (Dawson, Brock & Henville, in prep.).

Recommendations for further work on the control of *Crassula helmsii*

1. Improvements in the control of emergent stands of *Crassula helmsii* either by using glyphosate in an off-label way or optimizing the concentration of surfactant additive *or* to undertake new user trials with the manufacturers of Glyphosate, to determine appropriate off-label dose rates and surfactant/adjuvent concentrations. Alternatively, further research to assess the herbicidal properties and by-products of simple chemical compounds for use in nature reserves (*or* by the use of other herbicides) could be undertaken. The use of hydrogen peroxide in these trials resulted in some control but this was not fully exploited and further investigation of 'peroxygen' generating compounds, in particular, is suggested.

2. Undertake or monitor whole site trials using the guidelines to test efficacy in eliminating *C. helmsii* from nature reserves and to determine floristic or faunal changes.

3. Formulate a strategy for monitoring and controlling the invasion of nature reserves by introduced plants including *C. helmsii* to wetlands. This would involve a study of the secondary or local invasion of sites and could result in a policy of containment to the South East of England with a policy of eradication elsewhere. This should reduce the chance of invasion of Scottish sites to which this plant is seemingly well adapted; the current trend of increasing eutrophication of freshwater lochs by fish ranching activities, etc, may well prove an ideal take off point for this plant especially in the absence of a native flora with both the potential to exist and to take full advantage of elevated nutrient levels.

4. Assess the vulnerability of semi-saline reserves (especially estuaries) to invasion by *C. helmsii*. Research funded in part by TERF and NERC indicates that this plant will tolerate saline conditions up to half sea water by a combination of tolerance and growth strategy.

5. Produce an advisory leaflet on the biology and control of *C. helmsii* with recommendations for notification of new introductions and monitoring.

6. Organize a central register to collect and collate records of the presence of *C. helmsii* and attempts at control.

5. SUGGESTED PROVISIONAL GUIDELINES FOR THE CONTROL OF *Crassula helmsii*

Crassula helmsii (Tillaea recurva to the water gardener or aquatic supplier) is identifiable in the field growing on damp soil near or in water by its short dense stands and mid- to yellowish-green succulent-like appearance. The pairs of unstalked opposite leaves (4-24mm) borne on rigid stems which also bear small white 4-petaled ariel flowers on short stalks singly singly in their axils in summer. The joining of the leaf bases into a *c* 1mm collar is a distinctive character and allows the plant to be readily distinguished from other species, such as, *Callitriche spp*, especially in their underwater forms. The leaf shape is simple and varies from a long narrow near-parallel to very slightly elliptical with sharp or bluntish tip. The leaf tip allows the underwater form of the plant to be readily distinguished from *Callitriche spp* in particular which has notched leaf tips.

1. Identify and obtain confirmation of the plant together with its associated flora. Occurrences should be notified to a central register (eg Biological Record Centre, Monkswood or to F H Dawson, Institute of Freshwater Ecology). (Confirmation samples should be dried and stored on herbarium-style sheets.)

2. Obtain permission for access and control from the owner, discuss control strategy with local NCC office and inform the local National Rivers Authority as necessary that herbicidal control is to be undertaken.

Small areas - up to areas of 20 m^2 or larger if a drying turf (400 m^{-2}).
Cover with an opaque material eg geotextile, black polythene, rick sheet, old carpet etc, for 6-10 weeks as soon as possible following identification of plant. Such material may require to be weighted at corners and elsewhere, to keep it in position. (or spot treat with herbicides as below)

Medium sized areas - 20 to 1000 m^{-2}
Apply the following herbicides
diquat alginate to water at the rate on the label
(ie 0.5 litre per 100 m^2 of Midstream if less than 0.3m in depth
or 1 litre per 100m^2 if greater than 0.3m)
at anytime but avoid times when water conditions are turbid.
glyphosate to emergent stands or drying turves at the rate on the label
(ie 5 litres per ha of Roundup, 0.5-2% of Mixture B may also be added)
'when plants are actively growing with a full emergence at the flowering and up to dieback stage'
Other Approved aquatic herbicides are less or not effective and should be avoided (asulam, 2,4-D amine, dalapon, dichlobenil and terbutryne).

Sections of the pond or margins should be enclosed by a fence of fine wire mesh surrounding an area of about twice that of the plant stand to entrap pieces of shoot released following herbicide application. The contained area should be monitored before removal of the fence or reapplication of herbicide (possibly to a significantly decreased area).

Large areas - greater than 1000 m^{-2} or 25% of water body as margin or area.

1. Remove as much *C. helmsii* to bank as possible, stack and compost under light proof cover eg rick sheet, 20 cm of soil close to the site
   - do not transport material from affected site.
2. Apply herbicide, as above.
3. Monitor 6 monthly and reapply herbicides to (possibly reduced) areas of regrowth of *C. helmsii*.
4. Reintroduce native flora from unaffected part of water body or adjacent area.

The time of application of the herbicide may be adjusted to suit regrowth of local flora from rhizomes or seeds. During the autumn, normal application in accordance with the label is legally acceptable for diquat-alginate but not after 'mid September' for glyphosate, however, as *C. helmsii* continues 'active growth' during this period and for the majority of the year 'off label use' should be considered. Care must be taken to avoid causing the death of autumn germinating seedlings of some temporary pool plant species which then rest overwinter before active spring growth.

A balance must also be determined between the use of the more effective herbicide recommended for underwater use (diquat) versus the reduced dispersion of that recommended for use on emergent stands of *C. helmsii* (glyphosate) during times of maintained high or low water level.

ALL AREAS

Remove fragments from boots and other equipment before leaving a site.

All areas must be carefully monitored by carefully examining several small areas for developing shoots or small buried rhizomes within the area previously occupied by the plant and also adjacent areas; this should be continued at quarterly intervals for up to 5 years following apparent elimination of *C. helmsii*.

Note. Pesticides may only legally be applied by operators with an appropriate certificate of competence (or by persons in their direct control) issued by the National Proficiency Test Council for Agriculture and Horticulture, under the Control of Pesticide Regulations, 1986 and in accordance with the appropriate Code of Practice under Food and Environmental Protection Act 1985, to avoid complications involving ownership and control of the land.

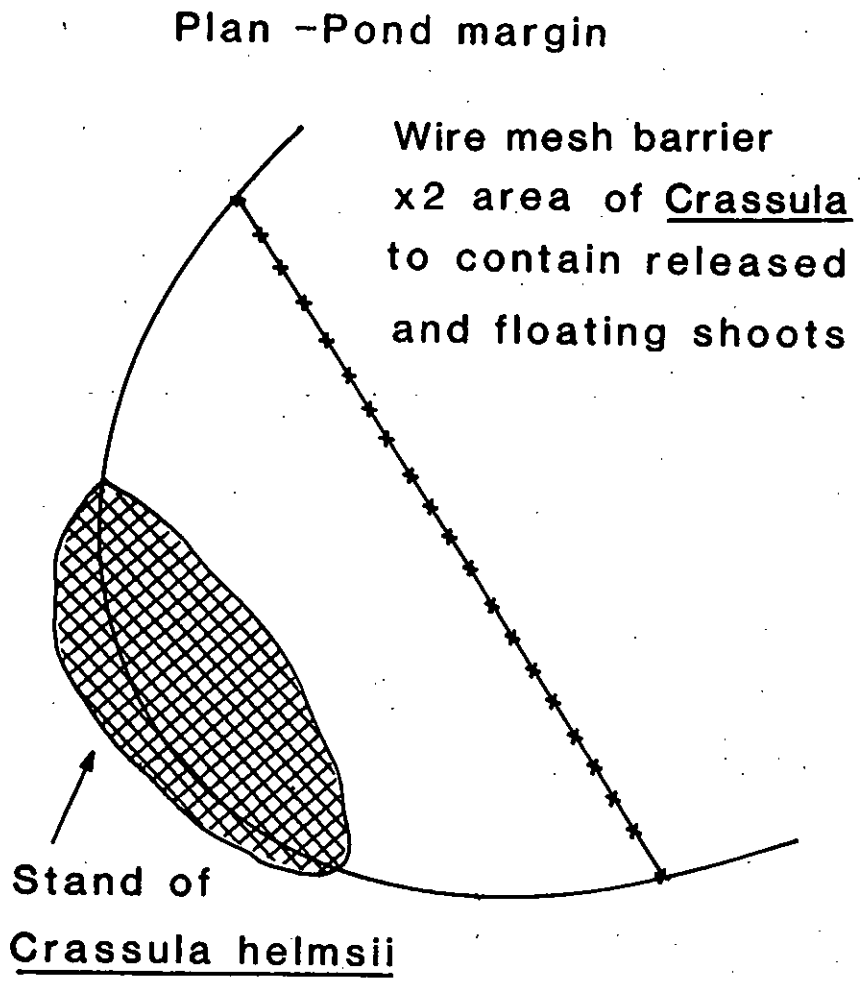

Figure 5. The preliminary proposal for containing fragments in the treatment of the smaller areas of *C. helmsii* in medium- to large-sized water bodies.

6. ACKNOWLEDGEMENTS

The chemicals diquat alginate ('Midstream') and diquat ('Reglone') were donated by ICI Agrochemicals and glyphosate ('Roundup') by Monsanto Agricultural Company for use in these trials; the remainder were purchased.

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Dawson F.H., Brock M.E. & Henville P. (in prep) The responses to salinity of the alien aquatic *Crassula helmsii* (T. Kirk) Cockayne and its potential for invasion of estuaries. (Abstract in *BSBI News* 45, 38-39, April 1987)

also (see Appendix IV)

Crassula Watch 1, Nov. 1987 4 pp,
Crassula Watch 2, Nov. 1988 4 pp,
Crassula Watch 3, Nov. 1990 4 pp

APPENDIX I

Photocopies of the labels of Approved aquatic herbicides and some product safety sheets as used in trials.
(appropriate aquatic sections marked by vertical bars)

Asulox

BRACKEN CONTROL

TIMING

Bracken should be treated IN FULL FROND. Spray on a dry day when fronds are fully expanded, soft and bright green and before the onset of senescence. Normally this will be within the period early July to late August (early August in N. Britain). Senescence begins with the fronds turning a darker green, becoming glossy and hard to the touch with subsequent bronzing.

DIRECTIONS FOR USE

For bracken control, ASULOX may be applied in water with or without "Agral" or in mixture with "Actipron". These additives increase the rate of uptake of ASULOX by the bracken fronds thereby improving reliability under adverse climatic conditions. Additives should not be used in forestry situations.

Preparation

(a) ASULOX and water: Half fill the spray tank or container with water and then pour in the required amount of ASULOX. Top up with water then add "Agral" where this is being used. Ensure thorough mixing before commencing to spray.

(b) ASULOX and "Actipron". Mix ASULOX and "Actipron" thoroughly before filling the spray tank.

Always adjust the sprayer or direct the appliance to give uniform coverage of the bracken fronds.

1. HILL LAND, AGRICULTURAL LAND AND NON-CROP AREAS

APPLICATION RATES AND METHODS

(i) Aerial application by helicopter.
Conventional water based system.
With water and "Agral". Mix 11 litres of ASULOX with 44 L/ha water (8 pt with 4 gal/ac) and "Agral" at a rate of 100 ml per 100 L of spray solution.
Application can be made with either conventional or Delavan "Raindrop" nozzles.
"Raindrop" nozzles give larger droplets which lessen the risk of drift evaporation.
Low volume oil based system:
With water and "Actipron": mix 11 litres of ASLULOX with 7 litres of "Actiron" and 2 L/ha of water (8 pt with 5pt and 1 ½ pt/ac).
Delavan "Raindrop" nozzles are necessary.
In both cases it is essential to determine swath width before spraying.
Ground markers should be used to aid swath matching.
Fixed wing aircraft are not recommended for the application of ASULOX to bracken.

(ii) Tractor mounted sprayer – use ASULOX at 11 L/ha in 400 to 500 L/ha of water. (8 pt with 35 to 45 gal/ac).

(iii) Hand-operated knapsack sprayer or motorised mist-blower – mix 11 L/ha of ASULOX with 50 to 200 L/ha of water. (8 pt with 4 ½ to 18 gal/ac) and "Agral" at the rate of 10 ml per 10 L of spray solution.
Do not use where bracken exceeds waist height, as coverage and ultimately control will be impaired.

(iv) Spot treatment with knapsack or hand-lance – mix 10 parts ASULOX and 1 part Agral with 1000 parts water (see Guide to Dilution Rates). Apply to the point of run-off.
Extra care is required with lower volume application to ensure coverage is complete and even.

(v) Low volume drift-spraying with "Micron Ulva" – use ASULOX at 11 L/ha with "Actipron" at 7 L/ha (8 pt with 5 pt/ac). A total of 18 L/ha (13 pt/ac).

Spraying Procedure for the "Micron Ulva"

Spraying with a "Micron Ulva" requires close attention to detail and the method of spraying. The best results will be obtained when the work is carried out carefully, methodically and accurately.

In order to drift the spray mixture onto the bracken there must be a steady wind of 5 to 25 km/hr (3 to 15 mph) over the area to be sprayed. DO NOT treat when the wind is gusty or changeable in direction. For ease of spraying on steep hills spray along the contours. Therefore, the wind should be blowing up or down the slope.

Accurate marking of the swaths with brightly coloured canes or flags should be carried out in every case. If the bracken is dense, it may be necessary to walk along the swath lines before spraying to establish a relatively free path.

Start spraying 3 metres (3 yards or 3 paces) inside the downwind edge of the bracken to be cleared. Walk through the bracken at right angles to the wind holding the head of the "Micron Ulva" approximately one metre above the top of the bracken. The spray head should always be held downwind of the operator with the face away from the operator. The feed bottle should be held vertical. The operator should walk at 1 metre (1 yard or 1 pace) every 3 seconds when using the grey feed nozzle and 1 metre (1 yard or 1 pace) every 1 ½ seconds when using the green feed nozzle.

On reaching the far edge of the bracken move 3 metres (3 yards or 3 paces) into the wind and return across the area. Continue spraying in this manner using passes every 3 metres (3 yards or 3 paces) through the bracken and using the canes or flags as swath markers until the area to be sprayed has been covered.

Feed Nozzle Colour	Nominal Flow Rate of Mixture (ml/sec)	Required Walking Speed using a 3m swath		Time Taken to spray	
		metres/minute	seconds/pace	1 acre	1 hectare
Grey	2.0	22	3	1 hour	2½ hours
Green	4.0	44	1½	30 mins	1¼ hours

DO NOT USE the red feed nozzle for non-forestry application–

Note: 1 metre approx. equals 1 yard or 1 pace.

As a check on applications ½ bottle should be emptied in about 90 metres or paces.

One full "Micron Ulva" bottle (1 litre or 1¾ pt) will treat approximately 550 square metres (approx. 1/8th acre).

After use, the feed nozzle should always be washed out with water to prevent subsequent blockage.

Batteries for the "Micron Ulva" should be replaced after five hours use.

FOLLOW-UP TREATMENTS

Because of the nature of bracken growth and the difficulty of spraying sheltered or uneven terrain, 100% control is rarely achieved. Any bracken surviving should be sprayed as soon as it recovers to full green frond, (which may be the year following initial application but more likely the second year following initial application).

IF NO FOLLOW-UP TREATMENT OR LAND IMPROVEMENT PROGRAMME IS CARRIED OUT RESPRAYING MAY BE NECESSARY WITHIN 5 YEARS

AFTER CARE

DO NOT cut the bracken or admit stock for at least 14 days after spraying and preferably leave it undisturbed until late autumn.

In order to qualify for A.H.G.S. or A.D.G.S. grants it may be necessary to undertake some form of aftercare involving one or all of follow-up bracken treatments: liming, fertilizing or re-seeding. The requirements for grant aid vary locally therefore contact either your local A.D.A.S. or D.A.F.S. office about eligibility and requirements for grant aid before commencing work.

A21/17/2

EFFECT ON SWARD

Some grasses and herbs will be damaged by the full dose in practice however, the bracken canopy protects the sward. Any check to these species is only temporary. The more sensitive species include Yorkshire-fog, Timothy, Cock's-foot, bents, annual meadow-grass, daisy, docks, plantains and saxifrage.

EFFECTS ON TREES AND SHRUBS

Most species are unaffected however, young specimens of the following may exhibit chlorosis and a slight check in growth if sprayed directly while actively growing:-

Beech	Grand fir	Scots pine
Birch	Japanese larch	Bilberry
Corsican pine	Norway spruce	Gorse
Douglas fir	Poplar	Heathers
Elm	Sitka spruce	

Mature specimens of the above, as well as Hawthorn, Holly and Rowan will be unharmed.

Western hemlock and Willows are more susceptible and thus should not be sprayed.

2. BRACKEN – IN FORESTRY AREAS

There are three main situations in which ASULOX may be used in forestry:-

(i) Areas to be used for new plantings should be treated during the summer prior to planting, and then planted up in accordance with normal practice for the district.

(ii) In areas to be replanted it is preferable for spraying to be carried out in standing timber before clearing. If clear felling is carried out in the spring the cleared areas can be sprayed in the summer as for new plantings. However, possible damage to emerging bracken from clear felling operations may lead to variable long-term control and some regrowth in the following year is likely.

(iii) Newly-planted areas. Two methods of use may be employed
The bracken may be "whipped" or cut early in the season and the ASULOX applied to regrowth later. This effectively means by the time the spraying is carried out growth has ceased on most tree species and the risk of any check removed
Alternatively, ASULOX may be applied overall to the undisturbed canopy.
In either case, due to the relatively insignificant effect of ASULOX on the frond growth during the season of application, the bracken will inevitably have to be cut before the end of the season to prevent collapse on to the young trees. An interval of at least fourteen days should elapse between spraying and cutting.

APPLICATION RATES AND METHODS: FORESTRY ONLY

The rate of ASULOX applied will depend upon the period of protection or release from bracken required. No additives are recommended.

(i) Tractor mounted sprayer – apply 5 to 10 L/ha of ASULOX in 200 to 300 L/ha of water. (3½ to 7 pt in 20 to 30 gal/ac).

(ii) Hand-operated knapsack – apply 5 to 10 L/ha of ASULOX in 90 to 175 L/ha of water (3½ to 7 pt in 9 to 17 gal/ac).

(iii) Spot treatment with knapsack or hand-lance – mix 1 part ASULOX with 100 parts water (see Guide to Dilution Rates).

(iv) Low volume drift spraying with the "Micron Ulva" – apply neat ASULOX at 5 to 10 L/ha using the red feed-nozzle and a walking speed of 1 pace per second. Use a swath of not more than 3 metres wide, or direct the spray cloud over the three rows.

(v) Aerial: helicopter – apply 5 to 10 L/ha of ASULOX in a total volume, including water, of 55 L/ha (3½ to 7 pt in total volume of 5 gal/ac). Use either Delavan "Raindrop" or conventional nozzles.

Planting Programmes

Pre-planting: Leave bracken undisturbed until it dies back, then plant up in accordance with normal forestry practice.

Post-planting: See (EFFECT ON TREES AND SHRUBS) above. Allow at least 14 days between application and cutting or clearing bracken from small trees.

CAUTIONS

Spray ASULOX at or just before full frond extension (minimum 3 'pairs' of 'leaves') and before senescence.

Do make sure the bracken is actively growing, light green and soft to the touch before spraying.

Do not apply during or immediately after drought periods or in conditions of high temperature and low humidity.

The use of the red feed nozzle for "Micron Ulva" application is restricted to forestry use where only bracken suppression is required.

The fronds must not be damaged by stock, frost or by cutting before treatment. Do not treat bracken affected by late frosts (bronzed and stunted fronds).

Herbicidal symptoms are virtually absent in the year of spraying but in the following season there is little or no frond re-growth.

At least 6 weeks should elapse between applying ASULOX and sowing or planting any subsequent crop.

TANK MIXING

The use of products other than those adjuvants or wetters listed for the various methods of application is not recommended.

GUIDE TO DILUTION RATES

FOR BRACKEN – 1 PART ASULOX TO 100 PARTS WATER

KNAPSACK SPRAYER

SPRAYER CAPACITY L	AMOUNT OF ASULOX PER FILLING ml	SPRAYER CAPACITY gal.	AMOUNT OF ASULOX PER FILLING fl. oz.
5	50	1	1½
7	70	1½	2½
10	100	2	3¼
12	120	2½	4
20	200	4	6½

STANDARD SPRAYER WITH HAND-LANCE

SPRAYER CAPACITY L	AMOUNT OF ASULOX PER FILLING L	SPRAYER CAPACITY gal	AMOUNT OF ASULOX PER FILLING pt
200	2.0	40	3¼
250	2.5	50	4
300	3.0	60	4¾
400	4.0	80	6½
500	5.0	100	8

DOCK CONTROL (broad-leaved and curled)

Docks (broad leaved and curled)

For best results against established docks, treat when the plants are actively growing and in full leaf but before any signs of emergence of flower stems. If cutting, grazing or poaching has taken place, the docks must be allowed to recover adequate foliage before ASULOX is applied so as to ensure the ASULOX is completely absorbed into the plant system. DO NOT graze or mow for at least one week after spraying.

DIRECTIONS FOR USE

Preparation

Half fill the spray tank or container with water and then pour in the required amount of ASULOX. Top up with water. Ensure thorough mixing before commencing spraying.

Always adjust the spray machine or direct the appliance to give uniform coverage at the height of the docks.

APPLICATION RATES, METHODS AND TIMING

Crops	Method	Timing
Permanent pasture and established leys. (Do not treat grassland or leys in the year of establishment)	STANDARD CROP SPRAYER: Apply 2.8 L/ha ASULOX in 200 L/ha of water (2 pt in 18 gal/ac). Take care that the sprayed swaths do not overlap. KNAPSACK SPRAYER (Spot treatment) -- See Guide to Dilution Rates. Use a standard dilution of 1 part ASULOX in 200 parts of water. Avoid spraying to "run off".	Apply ASULOX between April and September providing the docks are growing well are IN FULL LEAF and when grassland management permits (see below). Treat before the flowering shoots emerge or mow them off and treat the leafy re-growth. **Light infestations of recently established docks.** A single application of ASULOX may be sufficient. **Heavy or long established infestations of docks.** TWO SPRAYS are recommended. There may be some recovery of docks after the first treatment. The interval between the first and second sprays must be at least 10 MONTHS. Always carry out the second treatment in the season following the initial treatment.
Hayfields	As above.	**Do not use ASULOX before mowing for hay.** ASULOX does not impart toxic properties to hay. However there may be a short term loss of bulk due to control of the docks and the presence of sensitive grass species. These include Bents (Agrostis spp), meadow grass (Poa spp), Yorkshire fog, creeping soft-grass (Holcus spp), and the Brome grasses (Bromus spp)
Silage leys	As above.	Spray fields destined for silage production within 7 to 10 days prior to a cut -- provided the cutting date can be predetermined with accuracy. If not, spray 3 weeks after the final cut. Having allowed adequate regrowth of the docks, but in any event not later than mid-August. This avoids loss of bulk of treated grasses which would occur if cutting were delayed until after spraying, or alternatively, avoids sward damage from spraying too soon after cutting for silage.
Established orchards (Apple, Pear, Plum, Cherry).	Use ASULOX as a directed spray around the base of the plants where treatment adjacent to a crop is required.	
Established Blackcurrants and Hops.	Do not treat blackcurrant cuttings, hop sets or 'weak' hills.	
Roadside verges, waste ground, amenity areas (excluding fine turf).	STANDARD CROP SPRAYER: Apply 4.2 L/ha ASULOX in 200 to 400 L/ha of water (3 pt in 18 to 36 gal/ac). KNAPSACK SPRAYER or Standard Crop Sprayer fitted with hand-lance attachment (See Guide to Dilution Rates): use a standard dilution of 1 part of ASULOX to 200 parts of water. Avoid spraying to "run-off".	Apply ASULOX at any time between April and September provided that the docks are growing well and are in FULL-LEAF (not flowering). Always allow at least 3 weeks between mowing and application. Do not mow until one week has elapsed after spraying. Grasses may be temporarily retarded, but very few broad leaved plants (except docks) are affected.

EFFECT ON GRASSES AND CLOVERS

Established rye grasses can safely be treated with ASULOX. When ASULOX is used on bents, fescues, meadow grasses and Timothy swards, with or without rye grasses, yellowing may occur and a temporary check to growth. Cock's-foot and Yorkshire fog may be severely checked. Established clovers are practically unaffected by ASULOX but seedlings may be damaged.

GRASSLAND MANAGEMENT

Pre spray: Allow a recovery of 3 weeks or more between grazing or mowing and application of ASULOX.

Post spray: DO NOT GRAZE OR MOW UNTIL AT LEAST ONE WEEK AFTER SPRAYING to allow the herbicide to be translocated to the dock roots.

PROVIDED DOCKS ARE IN THE CORRECT STAGE FOR SPRAY TREATMENT (as described above) ASULOX application may be best integrated with management systems in the following ways:-

	SYSTEM	WHEN TO TREAT
GRASS FOR GRAZING	General systems	TREAT AT ANY TIME BETWEEN April AND September. Close mowing is advisable after stock removal, three weeks before spraying. Re stocking may commence seven days after treatment.
	Intensive systems or (if animals cannot be removed for a minimum of 4 weeks) or	AS ABOVE SPRAY IN LATE SUMMER TREAT PADDOCKS DESTINED FOR SILAGE (as below)
GRASS FOR CUTTING	Silage	SPRAY 7 to 10 DAYS BEFORE CUTTING but only if date of cutting can be predetermined
	or	SPRAY THREE WEEKS AFTER CUTTING
	or	SPRAY IN LATE SUMMER
	Hays	SPRAY THREE WEEKS AFTER MOWING
	or	SPRAY IN LATE SUMMER after the cutting programme has ended

FOLLOWING CROPS

At least 6 weeks should elapse between applying ASULOX and sowing or planting any subsequent crop

TANK MIXING

ASULOX when applied for dock control may be applied as a tank mix with the following for the control of other broad leaved weeds.

AGRITOX 50 + ASULOX MCPA* + ASULOX or TROPOTOX PLUS + ASULOX	To control creeping buttercup, creeping thistle, plantains
COMPITOX EXTRA + ASULOX mecoprop salt* + ASULOX	To control chickweed.

* Approved formulations

Note Only TROPOTOX PLUS + ASULOX is safe for use on grassland with clover.

GUIDE TO DILUTION RATES

FOR DOCKS – 1 PART ASULOX TO 200 PARTS water

KNAPSACK SPRAYER

SPRAYER CAPACITY L	AMOUNT OF ASULOX PER FILLING ml	SPRAYER CAPACITY gal.	AMOUNT OF ASULOX PER FILLING fl oz
5	25	1	¾
7	35	1½	1¼
10	50	2	1½
12	60	2½	2
20	100	4	3¼

STANDARD SPRAYER WITH HAND LANCE

SPRAYER CAPACITY L	AMOUNT OF ASULOX PER FILLING L	SPRAYER CAPACITY gal.	AMOUNT OF ASULOX PER FILLING pt
200	1.0	40	1¾
250	1.25	50	2
300	1.5	60	2½
400	2.0	80	3¼
500	2.5	100	4

CAUTIONS

Where ragwort is present in a treated pasture, this poisonous weed may become more palatable to grazing livestock. They should be denied access to treated areas for at least 4 to 6 weeks or until the ragwort has died and become unpalatable.

Do not treat docks during the winter months, i.e. October to March inclusive, do not treat once the flowering stem starts to emerge or at the flowering stage.

The action of ASULOX against docks is relatively slow. Herbicidal symptoms are yellowing of the leaves and any regrowth is red and distorted. Normally these symptoms do not appear until 3 weeks after treatment, and the full effect may not become apparent until 6 months later.

If over-grazing or poaching takes place after treatment heavy infestations of dock seedlings can occur. They are susceptible to ASULOX.

PRECAUTIONS

WASH HANDS before meals and after work.

KEEP LIVESTOCK OUT of treated areas until foliage of any poisonous weeds, such as ragwort, has died and become unpalatable.*

DO NOT CONTAMINATE PONDS, WATERWAYS OR DITCHES with chemical or used container.**

STORE IN ORIGINAL CONTAINER, tightly closed, in a safe place.

WASH OUT CONTAINER THOROUGHLY and dispose of safely.

When using a hand lance, the following additional precautions should be practised

WASH HANDS AND EXPOSED SKIN before meals and after work.

WEAR PROTECTIVE OVERALLS, BOOTS AND GLOVES during application.

DO NOT BREATHE SPRAY MIST.

WASH ALL PROTECTIVE CLOTHING thoroughly after use, especially the insides of gloves.

* This may take several weeks following spraying, depending upon climatic conditions and growth stage of the weeds.

** The use of ASULOX for the control of bracken and docks near surface waters has been considered under the Pesticides Safety Precautions Scheme. It has been agreed that whilst every care should be taken to avoid [illegible] contamination of running or standing water, adventitious contamination such as may arise during the [illegible] spraying should offer no harm to operators, to users and consumers of the water [illegible] life. Before the spraying of such areas is undertaken the appropriate River Authority [illegible] Authority or Waterworks Undertaking should be notified.

ACKNOWLEDGEMENTS

Throughout this leaflet product names indicated thus ASULOX are the property of May & Baker Ltd [illegible] RM10 7XS

"Agral" is the trade mark of Imperial Chemical Industries plc, England

"Actipron" is the Registered trade mark of the British Petroleum Company plc

Micron "Ulva" manufactured by Micron Sprayers Ltd, Bromyard, Herefordshire

Unilever "Raindrop" nozzles trade mark

For further information about ASULOX please consult your local May & Baker Distributor or May & Baker Representative

fog/mist, has dried and become unpalatable.

DO NOT CONTAMINATE PONDS, WATERWAYS OR DITCHES with chemical or used container.**

STORE IN ORIGINAL CONTAINER, tightly closed, in a safe place.

WASH OUT CONTAINER THOROUGHLY and dispose of safely.

When using a hand lance, the following additional precautions should be practised.

WASH HANDS AND EXPOSED SKIN before meals and after work.

WEAR PROTECTIVE OVERALLS, BOOTS AND GLOVES during application.

DO NOT BREATHE SPRAY MIST.

WASH ALL PROTECTIVE CLOTHING thoroughly after use, especially the insides of gloves.

* This may take several weeks following spraying, depending upon climate conditions and growth stage of the weeds.

** The use of ASULOX for the control of bracken and docks near surface waters has been considered under the Pesticides Safety Precautions Scheme. It has been agreed that, whilst every care should be taken to avoid contamination, the direct contamination of running or standing water, adventitious contamination such as may arise during the normal course of spraying should offer no harm to operators, to users and consumers of the water, to domestic and farm animals and to wild life. Before the spraying of such areas is undertaken, the appropriate River Authority Catchment Board, River Purification Authority or Waterworks Undertaking should be notified.

ACKNOWLEDGEMENTS

ATLAS

2, 4-D

Contains 480g per litre (38% w/w) 2, 4-D as dimethylamine salt

Controls weeds in grassland, cereals and in water.

FOR USE ONLY AS AN AGRICULTURAL HERBICIDE

10 litres

PROTECT FROM FROST

UN No. 3000

Harmful

MF DATE

EXP DATE .. MAY 88

05013

ATLAS INTERLATES LTD., [illegible] Road, [illegible], Kent DA8 1PN
Telephone: Erith (

DIRECTIONS FOR USE

Application

Mixing: Add the appropriate amount of Atlas 2,4-D to clean water in a half-filled spray tank, mix thoroughly and add remainder of the water.

Volume of water: Apply by any standard crop sprayer in no less than 100 litres of water per hectare or 10 gal per acre or more if weeds or crop are dense. Use at least 150 litres water per hectare or 15 gal per acre when spraying grassland.

Notes: Apply when weeds are in their most susceptible stage.

DO NOT use on newly sown leys containing seedling clover.

DO NOT direct drill kale, swedes, turnips or grass mixtures containing clover within three weeks of applying Atlas 2,4-D to grassland.

DO NOT apply immediately before or after sowing crops.

DO NOT apply during rain or if rain is imminent.

DO NOT roll or harrow within a few days of after applying Atlas 2,4-D.

Cereals

Recommendations

Rate of use: It is important not to exceed the recommended rate. In cereals Atlas 2,4-D should not be applied to Spring oats.

Winter Wheat and Rye: 1.4 to 2.8 litres per hectare or 1 to 2 pints per acre.

Winter Barley and Oats: 2.1 litres per hectare or 1.5 pints per acre.

Spring Wheat and Barley: 2.1 litres per hectare or 1.5 pints per acre.

Spring Oats: not recommended.

Timing: Winter cereals: Spray in Spring from the leaf sheath erect stage but before the first node is detectable.

Spring cereals: Spray from the five-leaf stage but before the first node is detectable.

Weed control

The table gives the maximum growth stages at which weeds are controlled or stunted so as not to affect crop growth or harvesting and refers to weeds sprayed in ideal conditions as recommended. Should spraying have to be carried out in less suitable conditions, or where the crop is weaker and less competitive, then the weed susceptibility may be reduced.

Seedling*	Seedling to young plant**
Black Bindweed †	Charlock
Black Nightshade †	Creeping Buttercup
Common Orache	Creeping Thistle
Common Poppy	Fat Hen
Corn Buttercup	Field Pennycress
Docks	Plantain
[illegible]	Shepherd's Purse
Pale Persicaria	Small Nettle
Prickly Sowthistle	Treacle Mustard
Redshank	White Mustard
	Wild Radish (Runch)

† Where these weeds are present use 2.8 litres or 2 pint rate on recommended crops.

* Seedling = Cotyledon + 2 true leaves.

** Young plant = Cotyledon + 4 true leaves.

Grassland

Recommendations

Rate of use: Established leys and permanent pasture: [illegible] litres per hectare or [illegible] pints per acre.

Timing

Weed	When to apply
Common Ragweed	Just before flowering
Curled Dock	
Dandelion	
Plantains	
Common Mouse-ear	Seedling to young plant
Common Ragwort*	When majority of plants are in the rosette stage and growing vigorously. Spray for two successive years in May or June. Hay or silage fields should be sprayed in the preceding Autumn.
Creeping and Meadow Buttercup	Before flowering, but can be treated later if growing well.
Creeping Thistle	Early bud stage. Aerial growth may be killed by a single treatment, but further treatment may be necessary to deal with regrowth.
Daisy	Spring or Autumn.
Horsetails	Apply when vegetative shoots are growing well, usually May or June. Aerial growth only controlled.
Soft Rush	Early Summer. For best results, cut either 4 weeks before or after treatment and remove cut stems.
Spear Thistle	Rosette stage.

* Common Ragwort is poisonous even when cut, inspect fields before taking hay or silage.

Water Weeds

Application

FOR THE CONTROL OF SOME FLOATING AND EMERGENT WATER WEEDS AND FOR MANY BROAD-LEAVED WEEDS GROWING ON WATERWAY AND DITCH BANKS AND IN STILL OR SLOWLY MOVING WATER.

The Rivers (Prevention of Pollution) Acts 1951 and 1961, the Rivers (Prevention of Pollution) (Scotland) Acts 1951 and 1965 may apply to the act of applying this herbicide for the control of weeds growing in or by reservoirs and water courses, e.g. rivers, streams, ditches and drains.

Users must therefore consult the appropriate water authority before applying this herbicide for this purpose. Use of aquatic herbicides is subject to the official Guidelines for the Use of Herbicides on Weeds in or near Water Courses and Lakes published by the Ministry of Agriculture, Fisheries and Food.

Recommendations

Volume of water

Atlas 2,4-D should be applied by sprayer, spray lance or knapsack sprayer in at least 100 litres of water per hectare or 10 gallons per acre.

Timing

Apply when weeds are growing well between May and September.

Rate of use

Low volume sprayer: 4.5 or 9 litres Atlas 2,4-D in at least 100 litres water per hectare or 3.2 or 6.4 pints in 10 gallons per acre.

Spot treatment: 250 ml per 20 litres water or 7 fl oz per 4 gallons in a knapsack sprayer.

Weeds controlled

4.5 litres per hectare or 3.2 pints per acre

Branched Bur-reed, Soft Rush and Water Mint.

9 litres per hectare or 6.4 pints per acre

Water-cress and Great Willowherb.

The best control of Soft Rush will be obtained where the rushes are cut and removed in early summer and the Atlas 2,4-D is applied 4 weeks later.

Compatibility

Atlas 2,4-D is compatible with Atlas CMPP and Atlas MCPA and Approved formulations of cypermethrin.

HARMFUL IF SWALLOWED AND IN CONTACT WITH SKIN.

PRECAUTIONS

WHEN USING DO NOT EAT, DRINK OR SMOKE.
WASH CONCENTRATE from skin or eyes immediately.
WASH HANDS AND EXPOSED SKIN before meals and after work.
KEEP AWAY FROM FOOD, DRINK AND ANIMAL FEEDINGSTUFFS.
KEEP OUT OF REACH OF CHILDREN.
KEEP LIVESTOCK out of treated areas until foliage of any poisonous weeds, such as Ragwort has died and become unpalatable.
HARMFUL TO FISH. DO NOT CONTAMINATE PONDS, WATERWAYS OR DITCHES with chemical or used container. Atlas 2, 4-D however MAY BE USED for the control of aquatic weeds in the presence of fish if used in strict accordance with the directions for waterweed control and the precautions particular to aquatic use.
KEEP IN ORIGINAL CONTAINER, tightly closed, in a safe place.
WASH OUT CONTAINER THOROUGHLY and dispose of safely. Do not re-use.
IF YOU FEEL UNWELL, seek medical advice (show the label where possible).

Precautions particular to Aquatic use
Undesirable taints and odours can be caused by the use of Atlas 2, 4-D in water, and care must be taken to avoid contaminating water extracted for domestic use.
The maximum concentration of Atlas 2, 4-D in the water containing or associated with the weeds to be controlled must not exceed 5ppm at any point.
DO NOT DUMP surplus herbicide in water or ditch bottoms.
DO NOT USE TREATED WATER for irrigation purposes within three weeks of treatment.
AVOID DAMAGE BY DRIFT ON TO SUSCEPTIBLE CROPS. Tomato crops at a considerable distance may be affected.
WASH EQUIPMENT THOROUGHLY with water and wetting agent immediately after use and spray out. Spray out again before storing or using for another product.

MAFF 03052

This product has been approved under the Control of Pesticides Regulations 1986.

Casoron G-SR

HOW IT WORKS

Casoron G-SR is a broad spectrum granular herbicide containing 20% dichlobenil. It is approved under the Control of Pesticides Regulations 1986 for use in water. It controls a wide range of broad-leaved emergents and most rooted floating and submerged species of water weeds.

After application to the water surface, Casoron granules sink down into the mud and disintegrate. The active ingredient is released and is absorbed by the mud. Once absorbed it is taken up by the plant roots causing the death of susceptible weeds. The dose of Casoron is thus not related to water volume as is the case with certain other aquatic herbicides. It is this particular mode of action which enables the partial treatment of submerged weeds.

HOW TO APPLY

Apply by hand, air assisted motorised knapsack or other mechanical applicators direct to the water surface or exposed hydrosoil. Care should be taken to ensure the even distribution of granules.

Water depth		Rate	
mm	*feet*	kg/ha	*lb/ac*
300	*1*	–	–
600	*2*	28*	*25**
900	*3*	40	*37*
900+	*3+*	50	*45*

* It is impracticable to apply this rate to water bodies less than 1.5 metres (*5 feet*) in width or 600mm (*2 feet in depth*). In shallow and narrow waterways use Casoron G.

WHERE TO USE

Casoron G-SR is intended for use either in still waterbodies such as ponds, lakes and reservoirs, or in sluggishly flowing water courses – drains, ditches etc – providing the flow rate does not exceed 90 metres/hour (25cm/10sec). Casoron G-SR is not recommended in faster flowing water unless the flow can be stopped for a minimum of seven days after application.

Use Midstream for the control of submerged aquatic weeds in flowing water.

If fish are known to be present in a waterbody intended for treatment, the following recommendation for partial treatment with Casoron G-SR should be adopted.

Partial Treatment

The uptake of dichlobenil by roots in the mud makes it possible to achieve localised control of submerged and emergent weeds. This is of particular value in amenity and recreational water to provide for example, weed-free bathing areas, or, in a fishery, weed free 'swims'. For the latter a minimum of 20 x 20 metres (20 x 20 *yards*) is suggested.

By ensuring the maintenance of adequate refuge areas needed by fish when lying up or spawning and which form the habitat of many aquatic invertebrates, partial treatment ensures the maintenance of adequate food chains with minimum disruption to the aquatic habitat. It also enables substantial reductions in the costs of treatment.

Partial treatment is most effective on weeds such as *Equisetum* spp, *Hippuris vulgaris*, *Myriophyllum* spp, *Potamogeton* spp, *Ranunculus* spp etc, whose root systems within the mud are extensive. It is NOT effective for the control of detached or free floating species such as *Ceratophyllum demersum* or *Lemna* spp and may result in a lower level of control of *Elodea canadensis* whose root system is rather weak and not very extensive.

Although the recommended timing (see below) is in the early spring, partial treatment can be made somewhat later, once it can be seen where localised control is required. As this may then increase the risk of de-oxygenation caused by weed die-back, it is inadvisable to treat more than 10-20% of the waterbody.

WEEDS CONTROLLED

Susceptible		
Sub.	*Callitriche stagnalis*	Common Water-starwort
Sub.	*Ceratophyllum demersum*	Rigid Hornwort
Alg.	*Chara*	Stonewort
Sub.	*Elodea canadensis*	Canadian Waterweed
Em.	*Equisetum fluviatile*	Water Horsetail
Em.	*Equisetum palustre*	Marsh Horsetail
Sub.	*Fontanalis antipyretica*	Willow Moss
Em.	*Glyceria fluitans*	Floating Sweet-grass
Em.	*Hippuris vulgaris*	Mare's-tail
Fl.	*Hydrocharis morsus-ranae*	Frogbit
Sub.	*Hottonia palustris*	Water-violet
Sub.	*Lemna trisulca*	Ivy-leaved Duckweed
Sub.	*Myriophyllum* spp	Water-milfoils
Sub.	*Potamogeton crispus*	Curled Pondweed
Sub.	*Potamogeton pectinatus*	Fennel Pondweed
Sub.	*Ranunculus spp*	Water-crowfoots
Em.	*Rumex hydrolapathum*	Water Dock
Em.	*Sagittaria sagittifolia*	Arrowhead
Fl.	*Stratiotes aloides**	Water-soldier
Sub.	*Zanichellia palustris*	Horned Pondweed
Moderately Susceptible		
Em.	*Alisma plantago-aquatica*	Water-plantain
Em.	*Berula erecta*	Lesser Water-parsnip
Em.	*Oenanthe* spp	Water Dropworts
Fl.	*Potamogeton natans*	Broad-leaved Pondweed
Em.	*Rorippa nasturtium-aquaticum*	Water-cress
Moderately Resistant		
Fl.	*Nuphar lutea*	Yellow Water-lily
Fl.	*Nymphaea alba*	White Water-lily
Fl.	*Polygonum amphibium*	Amphibious Bistort
Sub.	*Potamogeton lucens*	Shining Pondweed
Em.	*Sparganium erectum*	Branched Bur-reed
Resistant		
Em.	*Butomus umbellatus*	Flowering-rush
Em.	*Caltha palustris*	Marsh-marigold
Em.	*Carex* spp	Sedges
Em.	*Iris pseudacorus*	Yellow Iris
Em.	*Juncus effusus*	Soft Rush
Fl.	*Lemna minor*	Common Duckweed
Em.	*Phalaris arundinacea*	Reed Canary-grass
Em.	*Phragmites australis*	Common Reed
Em.	*Scirpus lacustris*	Common Club-rush
Em.	*Typha latifolia*	Bulrush
Alg.	All filamentous algae (cott)	

KEY Alg. = Algae; Em. = Emergent spp; Fl. = Floating spp; Sub. = Submerged spp

* In certain areas this plant because of its rarity is of botanical interest and importance. Where it is present local naturalists should be consulted before treatment.

WHEN TO USE

Apply early in spring as soon as active weed growth commences usually in March to May. This overcomes the likelihood of subsequent water deoxygenation due to die-back of heavy weed stands.

Residual Activity

One application will provide effective control of susceptible weeds for an entire season.

PACK SIZE

25kg

PRECAUTIONS

WASH HANDS before meals and after work.
DO NOT DUMP surplus herbicide in water or ditch bottoms.
KEEP IN ORIGINAL CONTAINER, tightly closed, in a safe place.
EMPTY CONTAINER COMPLETELY and dispose of safely.
DO NOT USE TREATED WATER for irrigation purposes within TWO weeks of treatment.

OTHER INFORMATION

1. Application of Casoron G-SR to water may lead to illegal pollution. Before using in or near watercourses and lakes therefore, read and follow the requirements set out in the "Guidelines for the Use of Herbicides on Weeds in or near Watercourses and Lakes"* and consult the appropriate Water Authority or River Purification Board.
   *Available from Ministry of Agriculture, Fisheries and Food (Publications), Lion House, Willowburn Estate, Alnwick, Northumberland NE66.
2. Water Authorities in England & Wales and River Purification Boards in Scotland have legal responsibilities under the Control of the Pollution Act 1974. If it is intended to treat in or near a reservoir or water which either enters a river or is part of a river system, the appropriate Water Authority or River Purification Board must be consulted before such treatment is made.
3. Treated water should not be used for irrigation within 14 days of application.
4. Keep granules dry before treatment.

READ THE LABEL BEFORE YOU BUY: USE PESTICIDES SAFELY

ICI Professional Products, Woolmead House East,
Woolmead Walk, Farnham, Surrey. Tel: Farnham (0252) 724525

Product Safety Data Sheet

Product Name: **'CASORON' GSR**

Agrochemicals
Professional Products
Woolmead House East
Woolmead Walk, Farnham
Surrey GU9 7UB

Use: Herbicide (Granules)

Chemical Group: Substituted nitrile

MAFF No: 00451

EMERGENCY TELEPHONE No. (0622) 814777 ANYTIME

ACTIVE INGREDIENT

Common Name: dichlobenil
Chemical Abs Reg No.: 1194-65-6
Chemical Name: 2,6-dichlorobenzonitrile

FORMULATION

A granular product containing 20% w/w dichlobenil.

PHYSICAL AND CHEMICAL PROPERTIES

Greyish white granules.
Flash point: not applicable
Bulk density: 1.1
Water solubility: Insoluble

GENERAL HAZARD STATEMENT

NONE

PRECAUTIONS (from Product Label)

WASH HANDS before meals and after work.
DO NOT DUMP surplus herbicide in water or ditch bottoms.
KEEP IN ORIGINAL CONTAINER, tightly closed, in a safe place.
EMPTY CONTAINER COMPLETELY and dispose of safely.
DO NOT USE TREATED WATER for irrigation purposes within TWO weeks of treatment.
BEFORE USE read the requirements set out in MAFF 'Guidelines for the use of herbicides on weeds in or near water courses and lakes', and CONSULT WATER AUTHORITY.

PROTECTIVE CLOTHING

Refer to:a) Product label precautions for specific clothing requirements.
b) HSE guidelines on handling of pesticides and protective clothing for use with pesticides.

February 1990

FIRST AID

INGESTION
Do not induce vomiting if medical attention can be obtained within a reasonable time (ie one hour); seek such attention immediately. If not, induce vomiting by tickling the back of the throat.

SKIN
Remove contaminated clothing at once. Thoroughly wash areas of contaminated skin with plenty of soap and water. Such immediate action is essential to prevent skin penetration. If feeling unwell, seek medical attention. Contaminated clothing must be re-used only after thorough washing.

EYES
If eyes are contaminated they must be washed out immediately by irrigating the eye for at least 15 minutes. This is done by holding the eye lids open under a steady, gentle stream of water so as to wash off as much of the contaminant as possible. Seek medical attention **after** the above procedure has been carried out.

INHALATION
No adverse effects are likely by this route.

GUIDE TO DOCTOR
If the product is swallowed, symptoms are likely to be non-specific and may include abdominal pain, vomiting and diarrhoea. No specific antidote. General supportive measures only.

STORAGE
Product should be stored in a secure place out of reach of children and pets.

TRANSPORT
Packing Group: Not applicable
IMDG Class/Conveyance Class: Non hazardous for transport
Proper Shipping Name: Not applicable
UN No: Not applicable
PackSize(s):25 kg
No per outer: 1
outers per pallet: 40

EMERGENCY MEASURES

FIRE
If exposed to fire, keep containers cool by spraying with water.Extinguish preferably with dry agent, foam or water spray. Avoid if possible, the use of water jets.

The information in this Data Sheet is correct at the time of printing.
Read the label before you buy: Use pesticides safely

SPILLAGE

If product has entered a water course or sewer or grossly contaminated soil or vegetation in a public place, advise police.

DISPOSAL OF UNWANTED PESTICIDE AND CONTAINERS.

Dispose of product concentrate, diluted product and empty containers according to the 'Code of Practice for the Agricultural and Commercial Horticultural Use of Pesticides' available from MAFF.Contact the Local Council Authority for advice on the disposal of pesticide waste or approved pesticide waste disposal contractor.

TOXICITY

The acute oral LD50 to the rat of dichlobenil is greater than 3160 mg/kg.
The acute dermal LD50 is 1350 mg/kg.

ICI Plant Protection Division

REGLONE

Contains 200 g diquat per litre as dibromide (16.7% w/w)

For desiccation of potato haulm, oilseed rape, laid barley and oats, peas harvested dry, field beans, clover for seed and water weed control

FOR USE ONLY AS AN AGRICULTURAL DESICCANT AND HERBICIDE

1001

HARMFUL IF SWALLOWED
IRRITATING TO EYES AND SKIN
KEEP IN ORIGINAL CONTAINER
KEEP OUT OF REACH OF CHILDREN

PROTECT FROM FROST

Harmful

'Reglone' is a trade mark of the manufacturers Imperial Chemical Industries PLC, Plant Protection Division, Fernhurst, Haslemere, Surrey, Tel: 0428-4061.

This product is approved under the Control of Pesticides Regulations 1986, for use as directed. (MAFF No. 01713).

PRECAUTIONS

General Precautions

WEAR SUITABLE PROTECTIVE GLOVES AND FACE PROTECTION (FACE SHIELD) when handling the concentrate.

TAKE OFF immediately all contaminated clothing and wash underlying skin. Wash clothes before re-use.

WHEN USING DO NOT EAT, DRINK OR SMOKE.

WASH CONCENTRATE from skin or eyes immediately.

DO NOT BREATHE SPRAY MIST.

WASH HANDS AND EXPOSED SKIN before meals and after work.

KEEP AWAY FROM FOOD, DRINK AND ANIMAL FEEDINGSTUFFS.

KEEP OUT OF REACH OF CHILDREN.

KEEP IN ORIGINAL CONTAINER, tightly closed, in a safe place.

WASH OUT CONTAINER THOROUGHLY and dispose of safely.

IF YOU FEEL UNWELL, seek medical advice (show the label where possible).

Precautions Particular to Field Use

HARMFUL TO LIVESTOCK. Keep all livestock out of treated areas for at least 24 hours.

DO NOT FEED treated straw or haulm to livestock within 4 days of spraying.

DO NOT CONTAMINATE PONDS, WATERWAYS AND DITCHES with chemical or used container.

Precautions Particular to Aquatic Use

DO NOT DUMP surplus herbicide in water or ditch bottoms.

DO NOT USE TREATED WATER for human consumption within 24 hours or for overhead irrigation within 10 days of treatment.

WASH OUT CONTAINER THOROUGHLY and dispose of safely

DO NOT RE-USE CONTAINER FOR ANY PURPOSE.

WASH EQUIPMENT THOROUGHLY with water and 'AGRAL' at 50 ml per 100 litres (or 1 fl oz per 10 gallons) immediately after use.

DIRECTIONS FOR USE

'REGLONE' acts rapidly and is active on the green parts of all plants.

Application: Apply through a ground sprayer in good condition. Do not apply through mistblowers.

Volume of Water: Use only clean water. Apply 200–500 litres per hectare (or 20–50 gallons per acre), use higher volumes for dense growth.

Avoid Spray Drift: Do not spray in windy conditions.

Accuracy of Spraying: It is essential to spray accurately and to obtain complete cover of crop and weeds. Make sure jets are in good condition and that sprayer boom is set high enough to ensure complete coverage.

Use of 'Agral': Add 100 ml 'Agral' per 100 litres (4 fl oz per 25 gallons) of diluted spray. Do not use other wetters. DO NOT add 'Agral' for desiccation of potato haulm, peas (harvested dry) or water weed control.

RECOMMENDATIONS

POTATO HAULM DESICCATION

Rate of use: 4 litres per hectare (or 3 pints per acre). Only one application must be made to any one crop.

Volume of Water: 200–500 litres per hectare (or 20–50 gallons per acre). Use 500 litres per hectare (or 50 gallons per acre) where haulm is dense.
DO NOT ADD 'AGRAL' OR ANY OTHER WETTER OR ADJUVANT.

Timing of Application: Apply when tubers are the desired size (In dry conditions see special note below). If tubers are to be stored leave 14 days after spraying to allow skins to set. Regrowth may occur if seed crops are desiccated early.

For Best Results: Spray in bright light and low humidity conditions. The ideal time is mid morning to mid afternoon.

SPECIAL NOTE: Application during or shortly after dry periods. Haulm destroyers may damage tubers if applied during or shortly after dry periods. Dry periods are defined as periods when soil moisture deficits, calculated by the MORECS scale, are in excess of 33–83 mm (1 ½ – 3 ½ in) according to soil and crop type. (See Table below.)
Do not spray when soil is dry. When mist, light rain or heavy dew is present or imminent the risk of damage is increased.
If 13 mm (½ inch) of rain has fallen or the equivalent amount of irrigation has been applied in the previous five days on medium, heavy and organic soils or two days on sands and light soils and the soil is moist around the tubers any crop may be sprayed. Any variety can be sprayed but particular care should be taken to see that the above conditions are observed when spraying drought susceptible varieties, ie Drought Resistence 5 or below on NIAB list or Recommended Potato Varieties scoring over 5 are less liable to suffer damage.
Local soil moisture deficit information is available from your local ICI Plant Protection Representative.

The Maximum Soil Moisture Deficit for Safe Spraying (calculated from MORECS maincrop potato data on soils of medium available water capacity.)

	Crop Type		
Soil Textural Group*	Ware**	Early or Seed	Canning
Sands Very light soils Light soils All stony soils (Including stony medium and heavy soils)	50 mm (2 in)	35 mm (1 ½ in)	DO NOT USE
Medium soils Heavy soils (for stony soils see above)	66 mm (2⅔ in)	50 mm (2 in)	DO NOT USE
Organic soils (over 10% OM) Peaty soils Peats	85 mm (3 ½ in)	66 mm (2⅔ in)	50 mm (2 in)

**As given in MAFF Pamphlet 3001 'Soil Texture (85) System'.*
***If the crop is immature or the haulm is very vigorous at the time of spraying, treat the crop as an early or seed crop.*

'Agral', 'Gramoxone', 'Reglone' and 'Sanspor' are trade marks of the manufacturers Imperial Chemical Industries PLC, Plant Protection Division, Fernhurst, Haslemere, Surrey

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IP 3092

DESICCATION OF CROPS BEFORE HARVEST

Will not hasten crop maturity, if used on unripe crops immature seeds with poor germination and low bushel weight will result.

OILSEED RAPE

Rate of Use: 3 litres per hectare (or 2 pints per acre) in 500 litres of water per hectare (50 gallons per acre).
Add 'Agral' at 100 ml per 100 litres (4 fl oz per 25 gallons) of diluted spray.
Timing of Application: when the seed colour at each of the three sections of the stem is as follows:
Top third: More than half of the seed will be green, firm and pliable with a few early ripening seeds brown or black in colour.
Middle third: 90% of the seed will be reddish brown to dark brown with a few seeds black. The remaining 10% will be green, but must be firm and pliable.
Bottom third: All the seed will be dark brown to black.
This is usually 2–3 days later than windrowing would normally have started.
In crops which are leaning over, the seeds on the upper side of the stem will mature ahead of those shaded from the sunlight. In this situation, spray when all the seed in the exposed pods have turned reddish brown to dark brown. Do not wait for all the seeds in the shaded pods to reach this stage of maturity.
DO NOT apply when the crop is immature or past the recommended stage of maturity. Crops at an advanced stage of maturity will have 90% of the seed black in colour and pod shatter will be evident in early ripening pods at the base and top of main stems.
AVOID desiccation with 'Reglone' on thin, standing rape crops and exposed sites. Losses can occur in windy weather between spraying and combining. Normal or heavy leaning crops do not suffer in this way, such crops are ideal for desiccating with 'Reglone'.
Harvesting: direct combining can normally begin 7 to 10 days after spraying.
Check the moisture content of the seed in the standing crop fom the fifth day after treatment using a moisture meter calibrated for oilseed rape.
Combine harvesting should commence when the seed is mature, black in colour and with a moisture level ideally between 12% and 15%.
To ensure a sound, clean sample of seed, the manufacturers' instructions on setting-up the combine for harvesting oilseed rape should always be followed.

LAID BARLEY AND OATS (for stock feeding only)

Rate of Use: 2–4 litres per hectare (or 1 ½ –3 pints per acre)
Use 2 litres (or 1 ½ pints) for Common Chickweed.
Use 3 litres (or 2 pints) for cereal re-growth and broadleaved weeds.
Use 4 litres (or 3 pints) when Cleaver and Common Couch are dominant.
Add 'Agral' at 100 ml per 100 litres (4 fl oz per 25 gallons) of diluted spray.
Time of Application: Spray when crop is mature for combining.
Harvesting: As soon as desiccation is complete, normally 4–7 days. A delay in harvesting may result in re-growth of grass weeds.
Treated grain and straw may be safely fed to livestock from 4 days after spraying.

PEAS (HARVESTED DRY)

Rate of Use: 2–3 litres per hectare (or 1 ½ –2 pints per acre). Use lower rate on less dense crops.
DO NOT add 'Agral' or other wetter, as the addition of a wetter can cause staining of the peas.
Consult Processors before spraying any peas grown under contract.
Time of Application: Spray when crop is mature, ie when foliage is beginning to yellow and the top pods are fleshy, slightly pitted and green or starting to turn yellow. The seed splits if squeezed. The middle pods are pitted and crinkled, yellow and becoming parchment-like in texture. The seed is rubbery, ie can be squeezed between finger and thumb without splitting and the bottom pods are yellow/brown, parchment-like (paper thin). The seeds are quite hard.
Peas should have moisture content of 45% or less.
Harvesting: Direct combining should be carried out 7–10 days after application as soon as desiccation is complete. Treated haulm may be fed to livestock from 4 days after spraying.

FIELD BEANS (for pigeon and animal feed only)

Rate of Use: 3 litres per hectare (or 2 pints per acre).
Add 'Agral' at 100 ml per 100 litres (4 fl oz per 25 gallons) of diluted spray.
Timing of Application: Spray when crop is mature to desiccate haulm and weeds.
Harvesting: 4–7 days after spraying.

CLOVER FOR SEED

Rate of Use: 2–3 litres per hectare (or 1 ½ –2 pints per acre). Use lower rate on less dense crops.
Add 'Agral' at 100 ml per 100 litres (4 fl oz per 25 gallons) of diluted spray.
Time of Application: Red and White Clover for direct combining: Spray when the crop is mature, 2–3 days before expected date of combining. White Clover combined direct from swath – spray 'Reglone' 1–2 days before cutting.
Harvesting: Direct combining: As soon as desiccation is complete. Delay in combining may result in regrowth. White Clover combined from the swath: Within a few hours of cutting. Clover straw and trash may be fed to livestock from 4 days after spraying.

LINSEED*

Rate of Use: 3 litres in 400 litres of water per hectare (2 pints in 40 gal/acre). Add 'Agral' at 100 ml per 100 litres (4 fl oz/25 gal) of diluted spray.
Timing of Application: When 95% of bolls are brown, ripe and the seeds rattle inside the bolls.
Harvesting: Direct combining can normally begin 7–10 days after spraying.
*Use not approved under the Agricultural Chemicals Approval Scheme.

EVENING PRIMROSE*

Rate of Use: 4 litres in 200–400 litres of water per hectare (3 pints in 20–40 gal/acre). Add 'Agral' at 100 ml per 100 litres (4 fl oz/25 gal) of diluted spray. Generally two sprays are required.
Timing of Application: Spray when the crop is mature to desiccate haulm and weeds. Two sprays may be required 7–14 days apart.
Harvesting: Combining can normally begin 7–14 days after spraying.
*Use not approved under the Agricultural Chemicals Approval Scheme.

WEED CONTROL IN ROW CROPS

'Reglone' may be used in mixtures with 'Gramoxone' 100 to give improved control for certain broadleaved weeds, eg Common Chickweed, Cleavers, Knotgrass and Small Nettle.

Rate of Use: 1.5–2 litres per hectare 'Reglone' (or 1–1 ½ pints per acre) and 2–3 litres per hectare 'Gramoxone' 100 (or 1 ½ –2 pints per acre).

Volume of Water: 200–500 litres per hectare (or 20–50 gallons per acre). Add 50 ml 'Agral' per 100 litres (2 fl oz per 25 gallons) of diluted spray.
Use higher rates if weeds are dense or beyond the seedling stage.

Timing

Overall spraying: Sugar beet, bulbs, vegetable crops before crop emergence or transplanting.
Note: On sandy or peat soils allow 3 days between spraying and expected crop emergence or transplanting.

Potatoes: Early-crop up to 10% emergence, main crop up to 40% emergence provided no plant is more than 15 cm (6 in) high.
Do not apply after emergence to crop growing from diseased seed or very small tubers or under very hot dry conditions.

Inter-row Spraying: Post crop emergence. Use sprayers designed to prevent contamination of the crop foliage by spray.
Most effective control of weeds is obtained when application is made at the seedling stage. Common Fumitory and Knotgrass should be treated at 1st true leaf stage. Cleavers when 2 whorls of leaves are present, Wild oats and volunteer cereals from 2 leaf stage.

WATER WEED CONTROL

'Reglone' may be used for the control of submerged and some floating weeds in still or slow moving water, ie less than 90 metres per hour (300 feet per hour).

Rate of Use
Floating and submerged weeds and some algae: 50 litres per hectare of water surface per metre depth (1 ½ gallons per acre per foot depth). Main species controlled are Blanket Weed *(Cladophera)*, Canadian Waterweed, Rigid Hornwort, Pondweed spp.
25 litres per hectare of water surface per metre depth (¾ gallon per acre per foot depth) for control of Curled Pondweed, Common Watercrowsfoot, Spiked Water-milfoil.

Surface Infestation of Duckweeds *(Lemna* spp): Use 3 litres per hectare (or 2 pints per acre) as a surface spray. Add 'Agral' at 100 ml per 100 litres (4 fl oz per 25 gallons) of diluted spray.

Timing: When weeds are actively growing in late spring and early summer. Blanket weed *(Cladophera)* is best treated before it floats to the surface. Due to the long growing season for many waterweeds and recolonisation from outside, more than one application may be necesary in a season.

Method of Application: 'Reglone' may be applied undiluted or diluted. For small areas or narrow ditches apply at 1 litre (¾ pint) every 10 metre (11 yard) intervals from the bank. For larger areas, injections below the surface by a spray nozzle trailed behind a boat is suitable. Where weed infestation is heavy treat only ¼ of the total area at any one time, this will minimise the adverse effects of rapid weed destruction on fish, due to dissolved oxygen depletion by decaying plants. Successive sections should be treated at 14–21 day intervals.
For similar reasons do not treat shallow fish bearing water, during or shortly after hot weather when dissolved oxygen levels are likely to be lower.

SPECIAL NOTES

1. Application of 'Reglone' to watercourses may lead to illegal pollution. *Before* using in or near watercourses and lakes read and follow the 'Guidelines for the use of Herbicides on Weeds in Watercourses and Lakes' published by the Ministry of Agriculture, Fisheries and Food *and* consult the appropriate Water Authority.
2. *Best results* will be obtained when water is still or moving at not more than 90 m/hour (300 feet per hour).
3. *Muddy Water:* 'Reglone' is inactivated on contact with soil particles, do not treat muddy water and avoid stirring up mud during treatment.

HOP STRIPPING AND WEED CONTROL*

'Reglone' gives a good kill of hop leaves and basal regrowth of hop shoots and also controls broad-leaved weeds when present.

Application: High Volume: Use 2.5 to 3.75 litres per 1000 litres water (2 to 3 pints/100 gal). Apply at least 1120 litres per hectare (100 gal/acre). Use the higher rate where the shoot regrowth and weeds are especially dense. Do not apply above the banding-in string (approx. 3–4 feet).

Timing: Apply in July after the hops have reached the top wire.

Notes: Do not use 'Reglone' for hop stripping in drought conditions. Where grass weeds are also present mixture with 'Gramoxone' 100 will give improved control. Use a tank mix of 1.8 to 2.5 litres of both 'Gramoxone' 100 and 'Reglone' per 1000 litres of water (1.5 t 2.0 pints/100 gal).

* Use not approved under the Agricultural Chemicals Approval Scheme.

COMPATIBILITY

'Reglone' is compatible with 'Du-ter' 50 and 'Sanspor' for use in potatoes.
'Reglone' is compatible with 'Gramoxone' 100 and 'Gramonol' Five for weed control and with 'Gramoxone' 100 for hop stripping.
When applying a tank mixture always consult and comply with the recommendations of the partner product.

'Du ter' is a registered trade mark of Dupher B V Amsterdam, Holland

ICI Professional Products

Midstream

Contains 100 g per litre (7.6% w/w) diquat cation.

HOW IT WORKS

'Midstream', a viscous formulation of diquat, forms gelatinous 'strings' when added to water. These cling to the foliage of submerged weeds to enable the control of weeds growing in fast flowing streams and rivers.

'Midstream' may also be used for the localised control of weed growth in static or sluggishly flowing water bodies – i.e. ponds, canals, drainage channels, etc.

HOW TO APPLY

'Midstream' should be poured undiluted and as supplied into the spray tank.
DO NOT DILUTE with water, either in the spray tank or in the original container to remove residual gel.
DO NOT ADD any wetting agent or other adjuvant.
DO NOT TANK MIX with any other herbicide.

CONVENTIONAL SPRAY EQUIPMENT CANNOT BE USED. Use only a Solo Jetpak 425 sprayer which has been specially modified. These are available from Claxton Engineering, Skillington, Grantham, Lincs. Tel. Grantham (0476) 860870.
NO OTHER EQUIPMENT IS SUITABLE.

WATER LESS THAN 30 cm (*1ft*) IN DEPTH
Apply at the rate of 0.5 litre/100 sq m (*15 fl oz/ 100 sq yds*) of water surface. At this rate, one 5 litre container will treat 1000 sq m (*1200 sq yds*).

WATER MORE THAN 30 cm (*1ft*) IN DEPTH
Apply at the rate of 1 litre/100 sq m (*1.5 pints/ 100 sq yds*) of water surface. At this rate, one 5 litre container will treat 500 sq m (*600 sq yds*).

WHERE TO USE

STILL WATER
As 'Midstream' is formulated to localise the effect of diquat, only those areas in which weed control is required need be treated. Apply evenly to the water surface over the area to be treated. If weed growth has not reached the water surface the gel 'strings' will sink onto the underlying weed. 'Midstream' does not have to be injected.

The localised effect of 'Midstream' may be used to advantage in heavy weed infestations by successively treating areas of weed at 14-21 day intervals. This will minimise the adverse effects on fish of oxygen depletion resulting from plant decay. For similar reasons, do not treat shallow fish-bearing waters during or shortly after hot weather when dissolved oxygen levels are likely to be low.

FLOWING WATER
When applied to the water surface, the gel 'strings' will be carried downstream as they sink. Depending on water velocity, treatment should commence an appropriate distance upstream of the weeds to be treated.

WHEN TO USE

Although 'Midstream' can be applied at any time, best results are obtained in late spring or early summer when weeds are actively growing. 'Midstream' is inactivated by mud and suspended solids and performance is reduced where plants are covered by mud or epiphytic algae. Avoid stirring up mud from the lake or river bed when applying 'Midstream'.

The degree and persistence of control will depend on the degree of initial kill, the growth habit of the weed species present and the rate of re-invasion from untreated areas. Full season control of susceptible species can generally be expected from one correctly timed application.

CONTINUED OVERLEAF

WEEDS CONTROLLED

SUSCEPTIBLE

Callitriche spp	– Water-starworts
Ceratophyllum demersum	– Rigid Hornwort
Elodea canadensis	– Canadian Waterweed
Myriophyllum spicatum	– Spiked Water-milfoil
Potamogeton crispus	– Curled Pondweed
Ranunculus spp	– Water-crowfoots
Zannichellia palustris	– Horned Pondweed

MODERATELY SUSCEPTIBLE

Potamogeton lucens	– Shining Pondweed
Potamogeton natans	– Broad-leaved Pondweed
Potamogeton pectinatus	– Fennel Pondweed
Sparganium emersum	– Unbranched Bur-reed
Cladophora spp, Enteromorpha intestinalis, Spirogyra spp	– 'Cott' or blanket weeds*

RESISTANT

All emergent species.

Hippuris vulgaris	– Mare's-tail
Nuphar lutea	– Yellow Water-lily
Nymphaea alba	– White Water-lily
Polygonum amphibium	– Amphibious Bistort

**A further spray may be required if recolonisation occurs.*

OTHER INFORMATION

It is not necessary to clean the sprayer after each and every use. Prior to storing or when the sprayer will not be re-used for a long period of time, follow the end of season cleaning instructions supplied with the sprayer.

The use of 'Midstream' is subject to the requirements set out in the "Guidelines for the Use of Herbicides on Weeds in or near Watercourses and Lakes". This document is available from the Ministry of Agriculture Publications Branch, Lion House, Willowburn Trading Estate, Alnwick, Northumberland NE66 2PF and should be read in conjunction with the label recommendations for safe use.

If it is intended to treat a reservoir or water which either enters a river or is part of a river system, the appropriate Water Authority or River Purification Board must be consulted before such treatment is made.

Water Authorities in England, Wales and Northern Ireland and River Purification Boards in Scotland have legal responsibilities with regard to the prevention of pollution in rivers and reservoirs under the Control of Pollution Act 1974 and The Food and Environment Protection Act 1985.

Use of 'Midstream' in waters not subject to the above Acts – i.e. ponds and lakes NOT discharging into a water course – is permitted providing the recommended application rates are not exceeded.

HARMFUL
IF SWALLOWED

IRRITATING
TO SKIN

PRECAUTIONS

WEAR PROTECTIVE GLOVES AND FACE SHIELD when handling the product.
TAKE OFF immediately heavily contaminated clothing and wash underlying skin. Wash clothes before re-use.
WHEN USING DO NOT EAT, DRINK OR SMOKE.
WASH SPLASHES from skin or eyes immediately.
WASH HANDS AND EXPOSED SKIN before meals and after work.
KEEP AWAY FROM FOOD, DRINK AND ANIMAL FEEDING STUFFS.
KEEP OUT OF REACH OF CHILDREN.
KEEP IN ORIGINAL CONTAINER, tightly closed, in a safe place.
EMPTY CONTAINER COMPLETELY and dispose of safely.
DO NOT RE-USE this container for any purpose.
DO NOT DUMP surplus herbicide or containers in water or ditch bottoms.
DO NOT USE TREATED WATER for human consumption within 24 hours or for overhead irrigation within 10 days of treatment.
IF YOU FEEL UNWELL, seek medical advice (show label where possible).
FIRST AID: If swallowed, induce vomiting and take patient to hospital immediately.

ICI Professional Products, Woolmead House East, Woolmead Walk, Farnham, Surrey, Tel: Farnham (0252) 724525

0877/P1

IP 6607

Product Safety Data Sheet

Product Name: **'MIDSTREAM'**

Agrochemicals
Professional Products
Woolmead House East
Woolmead Walk, Farnham
Surrey GU9 7UB

Use: Herbicide (Liquid)

Chemical Group: Bipyridyl

MAFF No: 01348

EMERGENCY TELEPHONE No. (0622) 814777 ANYTIME

ACTIVE INGREDIENT

Common name: diquat
Chemical Name :1,1'-ethylene-2,2'-bipyridilium dibromide.
Chem Abs Registry No. : 85-00-7

FORMULATION

A viscous gel formulation containing 100 g/l diquat ion (8.8% w/w).

PHYSICAL AND CHEMICAL PROPERTIES

A black viscous liquid
Specific gravity : 1.13
Water solubility : miscible

GENERAL HAZARD STATEMENT

HARMFUL IF SWALLOWED
IRRITATING TO SKIN

PRECAUTIONS (from Product Label)

WEAR PROTECTIVE GLOVES AND FACE SHIELD when handling the product.
TAKE OFF IMMEDIATELY heavily contaiminated clothing and wash underlying skin
Wash clothes before re-use.
WHEN USING, DO NOT EAT, DRINK OR SMOKE.
WASH SPLASHES from skin or eyes immediately.
WASH HANDS AND EXPOSED SKIN before meals and after work.
KEEP AWAY FROM FOOD, DRINK AND ANIMAL FEEDINGSTUFFS.
KEEP OUT OF REACH OF CHILDREN.
KEEP IN ORIGINAL CONTAINER, tightly closed, in a safe place.
EMPTY CONTAINER COMPLETELY and dispose of safely.
DO NOT RE-USE this container for any purpose.
DO NOT DUMP surplus herbicide or containers in water or ditch bottoms.
DO NOT USE TREATED WATER for human consumption within 24 hours or for overhead irrigation within 10 days of treatment.
IF YOU FEEL UNWELL, seek medical advice (show label where possible).

January 1990

'Midstream' contd.

PROTECTIVE CLOTHING

Refer to:a) Product label precautions for specific clothing requirements.
b) HSE guidelines on handling of pesticides and protective clothing for use with pesticides.

FIRST AID

INGESTION

Induce vomiting by tickling the back of the throat. To help vomiting drink 2 pints of water. Take patient to hospital as soon as possible for a complete stomach wash out to be done. Induce vomiting only if patient is conscious.

SKIN

Remove contaminated clothing at once. Thoroughly wash areas of contaminated skin with plenty of soap and water. Such immediate action is essential to prevent skin penetration. If feeling unwell, seek medical attention. Contaminated clothing must be re-used only after thorough washing.

EYES

Splashes in the eye must be washed out immediately by irrigating the eye for at least 15 minutes. This is done by holding the eye lids open under a steady, gentle stream of water so as to wash off as much of the contaminant as possible. Seek medical attention **after** the above procedure has been carried out.

INHALATION

Not applicable.

GUIDE TO DOCTOR

Nausea, vomiting, abdominal pain and diarrhoea may occur soon after ingestion, followed 24 hours later by burns in the mouth and throat. Kidney damage and shock may occur later, but lung damage does not occur in diquat poisoning. Give stomach washout and test urine and gastric aspirate for suspension of Fuller's Earth and 200 ml of 20% mannitol in for Doctors" (1985). Consult *"The Treatment of Paraquat Poisoning" - a Quick Guide for Doctors*(1985)
(available from ICI Agrochemicals).
Contact nearest Poisons Information Centre for advice on further treatment.

STORAGE

Products must be stored in the original labelled container, tightly closed in a safe place away from children, pets and all food products and protected from extremes of temperature.
Refer to: HSE guidelines on the storage of pesticides.

TRANSPORT

Packing Group: III
IMDG Class/Conveyance Class: 6.1 HARMFUL SUBSTANCE
Proper Shipping Name: Bipyridylium pesticides, liquid, toxic, N.O.S., (contains diquat as dibromide salt)
UN No: 3016
Pack Size(s): 10 litres
No per outer: 2
Outers per pallet: 39

EMERGENCY MEASURES

FIRE

If exposed to fire, keep containers cool by spraying with water. Extinguish preferably with dry agent, foam or water spray. Avoid if possible, the use of water jets.

SPILLAGE

If product has entered a water course or sewer or grossly contaminated soil or vegetation in a public place, advise police.

DISPOSAL OF UNWANTED PESTICIDE AND CONTAINERS.

Dispose of product concentrate, diluted product and empty containers according to the 'Code of Practice for the Agricultural and Commercial Horticultural Use of Pesticides' available from MAFF.
Contact the Local Council Authority for advice on the disposal of pesticide waste or approved pesticide waste disposal contractor.

TOXICITY

The acute oral LD50 for the rat is greater than 2000 mg/kg and the acute dermal toxicity is greater than 4000 mg/kg. It is a moderate irritant to both skin and eyes.

HEALTH CONSIDERATIONS

Contamination when handling the concentrate may result in inflammation and in more severe cases blistering of the skin. Severe irritation and inflammation of the eye may follow accidental contact. Immediate and thorough irrigation is essential. Effects may be delayed by up to 24 hours.

A foliar applied herbicide for the control of annual and perennial grass and broad-leaved weeds before sowing or planting all crops.

For use pre-harvest in cereals and certain other crops, destruction of grassland and in stubbles, orchards, forestry, aquatic and non-crop areas.

Roundup®

Herbicide by Monsanto

IRRITANT

An aqueous concentrate containing 480 g/l (41.1 % w.w.) of the isopropylamine salt of glyphosate - (equivalent to 360 g/l glyphosate) - and ethoxylated tallow - amine surfactant

FOR USE ONLY AS A HERBICIDE

Contents ℮ 5 litres

Monsanto
AGRICULTURAL COMPANY

GENERAL INFORMATION

Mode of Action, Timing of Application and Weed Susceptibility:
Roundup* is a foliar acting herbicide which controls annual and perennial grasses and most broad leaved weeds when used as directed. It is translocated from treated vegetative growth to underground roots, rhizomes or stolons. Leaf symptoms, being a reddening then yellowing of the foliage, are seen first on grass weeds but take longer to appear on broad leaved weeds.

PERENNIAL GRASS WEEDS MUST HAVE A FULL EMERGENCE OF HEALTHY, GREEN LEAF WHICH IS GROWING ACTIVELY AT THE TIME OF APPLICATION. COMMON COUCH REACHES THE SUSCEPTIBLE STAGE OF GROWTH WHEN TILLERING AND NEW RHIZOME GROWTH COMMENCE WHICH USUALLY OCCURS WHEN PLANTS HAVE 4-5 LEAVES EACH WITH 10-15 CM OF NEW GROWTH.

THE MAJORITY OF PERENNIAL BROAD-LEAVED WEEDS ARE MOST SUSCEPTIBLE IF TREATED WHEN THEY ARE GROWING ACTIVELY AND AT, OR NEAR, FLOWERING STAGE.

ANNUAL WEEDS SHOULD BE GROWING ACTIVELY, WITH GRASSES HAVING AT LEAST 5 CM OF LEAF AND BROAD LEAVED WEEDS AT LEAST 2 EXPANDED TRUE LEAVES WHEN SPRAYED.

Weeds become less susceptible to Roundup when their growth is restricted by natural senescence or by drought, frost, high temperature or flooding. A reduced control will result if such conditions occur at, or immediately after, spraying.

Breakdown and Following Crops:
Roundup is rapidly inactivated and degraded by micro-organisms in the soil, water and bottom sediment of aquatic areas. The product is of low toxicity, presenting little risk to operatives, wild-life or the environment when used as directed. All edible or non-edible crops may be sown or planted at specified intervals following the use of this product.
Occasionally, a slight check to crop growth may occur, particularly after direct drilling when crop seeds germinate amongst a mass of decaying foliage, stolons, rhizomes or roots. Thorough cultivations are necessary to disperse or bury the decaying organic matter. Consolidate loose soils and ensure crops are adequately fertilized and appropriate measures are taken to prevent insect and fungus damage to the following crop, especially where following grassland.

Associated Farming Practices:
As Roundup takes a few days to fully translocate throughout a weed, applications of lime, fertilizer, farm-yard manure and pesticides should be made 5 days or more AFTER application of this product.

Weather Conditions:
A period of at least 6 hours and preferably 24 hours rainfree must follow spraying. Do not spray onto weeds suffering from drought stress as reduced control may occur. Do not spray in windy conditions as drift onto other crops or vegetation can cause severe injury or destruction. Do not spray during frosty weather which prevents active growth and can induce weed senescence.

Tank Mixtures:
Roundup may be tank-mixed with either Team* or Frigate surfactant or Mixture B only for specific areas of use as directed by Monsanto.
Do not tank-mix this product with fertilizers or residual herbicides, EXCEPT when directed by Monsanto, as reduced level of weed control may result.

THIS PRODUCT MUST BE USED ONLY IN THE AREAS OF USE RECOMMENDED ON THIS LABEL AND APPLIED ACCORDING TO 'DIRECTIONS FOR USE'. ALL OTHER USES AND METHODS OF APPLICATION ARE EXCLUDED.

DIRECTIONS FOR USE

When used as directed Roundup may be applied to all crops to be used for feed, to wheat and oat crops intended for milling and to barley intended for malt for brewing. Consult your grain merchant before treating any crop being grown on contract and barley intended for malt for distilling.

All varieties of wheat, barley and oats may be treated to gain harvesting and grain storage benefits resulting from the reduction of green material in the crop.

Arable Application:
Under certain conditions the performance of Roundup can be improved by the use of additional surfactant. Where Roundup is used at rates of 2.0 l/ha (1.4 pts/ac) or less, Team or Frigate should be added to the spray solution. Where conventional hydraulic sprayers are being used Team or Frigate should be added to the spray tank solution at the rate of 0.5 litres (0.9 pints) for each 100 litres (22 gals) water volume.
Do not add extra surfactant when using a rotary atomiser sprayer.
Refer to the following table for those uses where the addition of either Team or Frigate is recommended.

Forestry Application:
Where conventional hydraulic sprayers are being used Mixture B may be added to the spray tank solution, at a rate of 2 % of the final water volume, for all pre-plant and post-plant directed sprays in forestry only.
Do not add Mixture B when using rotary atomiser sprayers.

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Area of Use	Target Weeds/ Usage	Weed Infestation	Application Rate L/HA	Application Rate PT/AC	Water Volume	Application Guidance
PRE-HARVEST WHEAT BARLEY AND OATS	Couch grasses (Common couch Black Bent Creeping Bent)	0 to 25 shoots/m^2	2.0 (+)	1.4	Hydraulic Sprayers 80-250 l/ha or Rotary Atomisers 40 l/ha*	Apply when the moisture content of the youngest crop grain is below 30 %, not less than 7 days before harvest. Use high clearance tractors with narrow wheels and crop dividers. DO NOT TREAT CROPS GROWN FOR SEED. Straw may be used for all purposes except as an horticultural mulch. After harvest, chop/incorporate, burn or remove straw as required. Normal cultivations may be made after straw removal.
		25 to 75 shoots/m^2	3.0	2.1		
		Over 75 shoots/m^2 In direct drilled crops	4.0	2.8		
	Perennial Broad-leaved weeds Other perennial grasses	All levels of all species	4.0	2.8		
PRE-HARVEST CEREALS - HARVEST AID	Annual grasses Cereal stems Cereal leaves	All levels of all species	1.0 (+)	0.7	Hydraulic Sprayers 80-250 l/ha or Rotary Atomisers 40 l/ha*	Apply, when the moisture content of the youngest crop grains is below 30 %, not less than 7 days and up to 14 days before harvest for volunteer wheat and wheat crops. Use high clearance tractors with narrow wheels and crop dividers. DO NOT TREAT CROPS GROWN FOR SEED. Straw may be used for all purposes except as an horticultural mulch. After harvest, chop/incorporate, burn or remove straw as required. Normal cultivations may be made after straw removal. NB. If dull weather persists after application allow up to 14 days before harvest - particularly on broad-leaved weeds.
	Annual broad-leaved weeds	All levels of all species	1.5 (+)	1.1		
PRE HARVEST OF OILSEED RAPE AND MUSTARDS	Crop desiccation prior to direct combine harvesting	—	3.0	2.1	Hydraulic Sprayers only 200-250 l/ha	Apply when crop seeds have under 30 % moisture content. Apply to standing crops at these intervals before harvest : oilseed rape - 14-21 days mustards - 8-10 days Use high clearance narrow wheeled tractors using wide booms and crop dividers. DO NOT TREAT CROPS GROWN FOR SEED. After harvest, chop/incorporate, burn or remove straw as required. Normal cultivations may follow after straw removal.
	Couch grasses	Up to 75 shoots/m^2	3.0	2.1		
	Annual weeds	All levels of all species				
	Couch grasses	Over 75 shoots/m^2	4.0	2.8		
	Perennial Broad-leaved weeds Other perennial grasses	All levels of all species				

* Where Rotary Atomiser Sprayers are used, their droplet size must be 200-300μ. (+) For optimum results use additional surfactant as described in 'Directions for Use'.

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Area of Use	Target Weeds/ Usage	Weed Infestation	Application Rate L/HA	Application Rate PT/AC	Water Volume	Application Guidance
PRE-HARVEST OF PEAS FOR COMBINE HARVESTING AND FIELD BEANS	Couch grasses	0 to 75 shoots/m^2	3.0	2.1	Hydraulic Sprayers 80-250 l/ha or Rotary Atomisers 40 l/ha*	Apply when crop seeds have under 30 % moisture content. Apply 7 days or more before harvest. This treatment cannot be used as a crop desiccant. Use high clearance tractors with narrow wheels and crop dividers. DO NOT TREAT CROPS GROWN FOR SEED.
	Couch grasses	Over 75 shoots/m^2	4.0	2.8		
	Perennial Broad-leaved weeds Other perennial grasses	All levels of all species				
IN FLAX CROPS FOR WEED CONTROL AND RETTING AID	Retting aid	—	4.0	2.8	Hydraulic Sprayers 200-250 l/ha only	Apply 10-15 days after mid-point of flowering : the earlier timing should be used in dry seasons. Flax crops may be pulled as normal but supplementary retting should be unnecessary.
	Couch grasses Perennial Broad-leaved weeds Other perennial grasses	All levels of all species	4.0	2.8		
STUBBLES OF ALL CROPS AUTUMN/SPRING APPLICATIONS	Couch grasses	Up to 75 shoots/m^2	3.0	2.1	Hydraulic Sprayers 80-250 l/ha or Rotary Atomisers 40 l/ha*	Do not cultivate BEFORE spraying. Allow a minimum of 5 days to elapse between spraying and cultivations or drilling. Allow volunteer potatoes to make ample top growth before spraying. A minimum period of 21 days weed growth in the spring should occur before spraying.
	Couch grasses	Over 75 shoots/m^2	4.0	2.8		
	Other perennial grasses Volunteer Potatoes (Autumn only)	All levels of all species				
STUBBLES OR PRE-CULTIVATED LAND AUTUMN OR SPRING	Volunteer Cereals Other Annual grasses Annual Broad-leaved weeds	All levels of all species	1.5 (+)	1.1	Hydraulic Sprayers 80-250 l/ha or Rotary Atomisers 40 l/ha*	Cultivations may be made 24 hours after spraying. Direct drilling may take place 2 days after spraying.

*Where Rotary Atomiser Sprayers are used, their droplet size must be 200-300μ. (+) For optimum results use additional surfactant as described in 'Directions for Use'.

Area of Use	Target Weeds / Usage	Weed Infestation	Application Rate L/HA	Application Rate PT/AC	Water Volume	Application Guidance
TOP FRUIT ORCHARDS - PRE-PLANTING	Perennial grasses and Broad-leaved weeds - In Arable Stubbles - In Pastures	 All levels of species	 4.0 5.0	 2.8 3.5	Hydraulic Sprayers 200-250 l/ha or Rotary Atomisers 40 l/ha*	Refer to " Timing of Application ". All Top Fruit crops may be planted from 7 days after spraying.
- WITHIN ORCHARDS OF APPLE, PEAR, PLUM CHERRY OR DAMSON	Perennial grasses and Broad-leaved weeds	All levels of most species	5.0	3.5	Hydraulic Sprayers 200-400 l/ha optimum 250 l/ha	Trees must have been established for 2 years before spraying. Spray after fruit trees have lost all their leaves in autumn. Or before green clusters stage of apple and pear or white bud stage of stone fruit in spring. Avoid contact with tree branches and trunks above 30 cm from the ground.
	Root suckers (late spring treatment only)	All species	5.0	3.5		
AQUATIC AREAS - EMERGENT WEEDS	Common Reed, Soft Rush, Reed Canary Grass, Bulrush, Reed Sweet-grass, Sedges, Water Cress, Whorl-grass, Creeping Bent	All levels of all species	5.0	3.5	Hydraulic Sprayers 200-400 l/ha optimum 250 l/ha	Apply by tractor or boat-mounted sprayer. Observe special PRECAUTIONS for all aquatic uses. In flowing water apply AGAINST the direction of flow.
- FLOATING WEEDS	White Water-Lily Yellow Water-Lily	All levels of both species	6.0	4.2	100-200 l/ha optimum 100 l/ha	Tractor sprayers : Do not exceed 8 kph. Boat-mounted sprayers : Use as slow a forward speed as is practicable. It may be necessary to re-treat floating lilies that are disturbed by a boat-mounted sprayer.
FORESTRY - PRE-PLANTING	Arable Land Planting Replanting and Grassland Areas	Arable weeds Grassland weeds	4.0 5.0	2.8 3.5	Hydraulic Sprayers 80-250 l/ha or Rotary Atomisers 40 l/ha*	All tree species may be planted 7 days or more after treatment.

*Where Rotary Atomiser Sprayers are used, their droplet size must be 200-300μ.

Area of Use	Target Weeds / Usage	Weed Infestation	Application Rate L/HA	Application Rate PT/AC	Water Volume	Application Guidance
GRASSLAND DESTRUCTION AND CONTROL OF ASSOCIATED WEEDS	Short-Rotation Ryegrass with Annual weeds	See Weed Table Page 7	3.0	2.1	Hydraulic Sprayers 150-250 l/ha	Treatment Timings : Refer to " Timing of Application ". 1. Regrowth after grazing or mowing. 2. Before grazing or cutting. - Apply between June-October - Spray crops that are 30-60 cm tall, are not dense and do not contain mature seeds. Grass Utilization : 1. Grass may be utilized in the normal way from 5 days after treatment. 2. Cattle, Dairy Cows and Sheep may graze or be fed the treated forage. POISONOUS PLANT SPECIES MUST BE REMOVED OR BURIED BEFORE REGRAZING OR MOWING. Normal cultivations for the next crop may be made as usual once fields are cleared of grass crops. Grass and clover may be direct drilled following application of Roundup to a) 1-2 year old leys without mat; all surface trash should be removed before drilling, 5 days after spraying or b) long leys with some mat; Roundup should be applied in the autumn and direct drilling delayed until the following spring.
	Leys 2-4 years old with Perennial Grass weeds		4.0	2.8		
	Long leys - 4-7 years old with Perennial Broad-leaved weeds		5.0	3.5		
	Permanent Pasture		6.0	4.2		
	Select application rate to control the least susceptible target weeds.					
NON-CROP AREAS	Annual weeds Perennial Grasses Perennial Broad-leaved weeds	All species All species All species	1.5 4.0 6.0	1.1 2.8 4.2	Hydraulic Sprayers 80-200 l/ha Rotary Atomisers 40 l/ha*	Use areas include: Clearance of land prior to sowing. Weed control in fence lines, stackyards around buildings and storage areas. Roads, paths and ditch edges. Regrowth in root-crop storage areas. DO NOT USE IN OR ALONGSIDE HEDGEROWS. DO NOT USE UNDER GLASS OR POLYETHYLENE
	Refer to section " Hand-held Applicators " page 9					

*Where Rotary Atomiser Sprayers are used, their droplet size must be 200-300μ.

Area of Use	Target Weeds / Usage	Weed Infestation	Application Rate L/HA	Application Rate PT/AC	Water Volume	Application Guidance
FORESTRY - POST-PLANTING (DIRECTED)	Clean-up Around Trees with Knapsack applications, Conifer release	Grasses : Annual/Perennial grasses, Broad-leaved/ Woody Weeds : Bracken/Beech Brush/Brambles Sycamore/Oak Hazel/Willow/Ash Heather (peat soils) Heather (mineral soils) Rhododendron [+]	4.0 3.0 4.0 6.0 10.0	2.8 2.1 2.8 4.2 7.0	Apply at a concentration of 1 part of Roundup 50 parts water (2 %)	It is ESSENTIAL to use a TREE GUARD for all applications made in the growing season. Treat bracken after frond tips are unfurled but pre-senescence. Treat heather late August to end September. All other woody weeds - treat June-August/before leaf senescence (but after new growth of crop has hardened).
	[+] For improved control of Rhododendron add Mixture B at a concentration of 2 % final water volume to 8.0 l/ha (5.6 pts/ac) of Roundup.					
- POST-PLANTING (OVERALL DORMANT SEASON)	Grass Weeds - Lowland Areas - Upland Areas	See Weed Table Page 7	1.5 2.0	1.1 1.4	Hydraulic Sprayers 200-250 l/ha or Hand-Held Equipment - See Page 9	DO NOT OVERALL SPRAY trees being grown for ORNAMENTAL PURPOSES, including CHRISTMAS TREES. Species safe to spray when fully dormant : Corsican, Lodgepole, and Scots Pines, Norway Spruce, Sitka Spruce, Lawson Cypress, Western Red Cedar, Douglas Fir and Noble Fir may be treated in the autumn from early September onwards but NOT in spring. Treat bracken after frond tips are unfurled but pre-senescence.
	Bracken	All levels of all species	2.0	1.4		
	Beech and Birch Brambles		2.0 3.0	1.4 2.1		
	These recommended application rates refer to Forestry usage only. Inadequate control may result if used in other areas.					
- STUMP APPLICATION FOR CHEMICAL THINNING	Deciduous Trees Coniferous Trees	All species All species	10 % solution of Roundup in water 20% solution of Roundup in water			Apply the solution of Roundup at felling in association with a suitably adapted clearance saw (e.g. the Enso attachment to rotary saws) or to the surface of newly cut trees as soon as possible after felling, in the period November to March/April. Do not apply in the period of active sap flow in the spring/early summer.
- CHEMICAL THINNING BY INJECTION OF TREE STEMS	Coniferous and Deciduous species	—	2 mls neat Roundup per cut per 10 cm diameter (or less) tree			Use a hatchet to cut one notch in trees up to 10 cm diameter and apply 2 mls of the solution to each cut. Use two or three notches in trees over 10 cm diameter. Do not treat in the period of active sap flow in the spring/early summer.

* Where Rotary Atomiser Sprayers are used, their droplet size must be 200-300 μ

RUN FINGER ALONG PERFORATED EDGE AND PULL OUT DIRECTIONS FOR USE

IRRITATING TO EYES AND SKIN

PRECAUTIONS :
WEAR SUITABLE PROTECTIVE GLOVES AND FACE PROTECTION (FACE-SHIELD) when handling the concentrate.
WEAR SUITABLE PROTECTIVE CLOTHING (COVERALLS AND RUBBER BOOTS), RUBBER GLOVES AND FACE PROTECTION (FACE-SHIELD AND DUST MASK) when spraying through the ULVA.
WEAR SUITABLE PROTECTIVE CLOTHING (RUBBER BOOTS, WATERPROOF JACKET AND TROUSERS) AND SUITABLE PROTECTIVE GLOVES (SYNTHETIC RUBBER) when using low volume nozzles in a knapsack sprayer, the Herbi and the Weedwiper Mini.
WASH ALL PROTECTIVE CLOTHING thoroughly after use, especially the insides of gloves.
WHEN USING DO NOT EAT, DRINK, OR SMOKE.
DO NOT BREATHE SPRAY MIST.
WASH HANDS AND EXPOSED SKIN before meals and after work.
KEEP AWAY FROM FOOD, DRINK AND ANIMAL FEEDINGSTUFFS.
KEEP OUT OF REACH OF CHILDREN.
HARMFUL TO FISH. Do not contaminate ponds, waterways and ditches with chemical or used container.
KEEP IN ORIGINAL CONTAINER, tightly closed, in a safe place.
WASH OUT CONTAINER THOROUGHLY, emptying washings into spray tank and dispose of safely.
DO NOT RE-USE THIS CONTAINER FOR ANY PURPOSE.
ROUNDUP, however, MAY BE USED for the control of aquatic weeds in the presence of fish if used in strict accordance with the section " Recommendations for Aquatic Weed Control ".

SPECIAL PRECAUTIONS FOR AQUATIC USE
DO NOT DUMP surplus herbicide in water or ditch bottoms.
Maximum permitted concentration in treated water 0.2 ppm.
LIVESTOCK, however, need NOT BE EXCLUDED from treated water.

● Roundup is a Registered Trade Mark of Monsanto

This product is approved under the Control of Pesticides Regulations (1986).
M.A.F.F. Registration N° 01828.

Monsanto p.l.c., Agricultural Division,
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In case of emergency day or night, telephone Monsanto p.l.c. Ruabon (0978) 812100.
Not for reformulation or repackaging.
No licence is granted under any U.S. Patent.

Read carefully the recommendations for use attached to this container

Detailed advice on the use and handling of this product are contained in the separate leaflet attached to this container. All users must ensure that they have read this leaflet and follow its advice before using the product. In the event of the leaflet being detached from the container prior to ultimate sale the user should contact his distributor for an additional copy.

Protect from frost

Made in the United Kingdom

DO NOT MIX, STORE OR APPLY ROUNDUP IN GALVANISED OR UNLINED MILD STEEL CONTAINERS OR SPRAY TANKS.
DO NOT leave spray mixtures in tank for long periods and make sure tanks are WELL VENTED

A Guide to the Application Rate of Roundup Herbicide for Controlling Weed Species in Various Treatment Areas:

1. Grassland Treatments:

Application Rate - 3.0 l/ha:

Annual Meadow-grass	Dock Seedlings	Meadow Fescue	Speedwell species
Common Chickweed	Italian Ryegrass	Meadow Foxtail	Timothy
Common Mouse-ear	Mayweed species	Rough Meadow-grass	

Application Rate - 4.0 l/ha:

Black Bent	Common Bent	Creeping Soft-grass	Plantains
Broad-leaved Dock	Common Couch	Curled Dock	Soft Brome
Cock's-foot	Creeping Bent	Perennial Rye-grass	Yorkshire Fog

Application Rate - 5.0 l/ha:

Bracken**	Creeping Thistle	Red Clover	Spear Thistle
Common Nettle	Daisy	Sedges	Tufted Hairgrass
Common Sorrel	Dwarf Thistle	Sheep's Sorrel	Yarrow
Creeping Buttercup*	Perennial Sow-thistle	Soft Rush	

Application Rate - 6.0 l/ha:

Common Ragwort	Jointed Rush	Red Fescue	Yellow Rattle
Hard Rush	Molinia (Purple Moor-grass)	Sheep's Fescue	
Heath Rush	Nardus (Mat grass)	White Clover*	

* Correct stage of growth at treatment is important.
** At full frond expansion.

2. Forestry Treatments

These recommended application rates refer to use in Forestry areas only. If used in agricultural or horticultural situations inadequate weed control will result.

- Grass Weeds:

Application rate - Lowland Britain - 1.5 l/ha
Upland Britain - 2.0 l/ha

Black Bent	False Oat-grass	Purple Moor-grass	Wood Small-reed (Bush grass)
Cock's-foot	Fescues	Sweet Vernal	Yorkshire Fog
Common Couch	Meadow-grasses	Tufted Hair-grass	
Creeping Soft-grass	Other Bent Species	Wavy Hair-grass	

SPRAY APPLICATION EQUIPMENT AND TECHNIQUES:

OVERALL APPLICATION

Conventional Hydraulic Sprayers:

1. **Sprayer and Nozzle Selection:**
All machines capable of applying accurately 80 - 250 l/ha within a pressure range of 1.5 - 2.5 bars using 80° or 110° nozzles may be used. For application pre-harvest of crops it is essential to use a sprayer whose boom may be raised to the correct height
2. **Water Volume:**
For general use 200 - 250 l/ha is the preferred volume range. For specific uses, volumes may be reduced to 80 - 120 l/ha by selecting low volume hydraulic nozzles, and adjusting pressure of application and tractor forward speed.
3. **Spray Pressure:**
Pressures must be related to tractor forward speed, desired water volume and nozzle type. A range of 1.5 - 2.5 bars must be used to ensure optimum results with minimum risk of drift.
4. **Tractor Forward Speed:**
Speed of travel must be related to nozzle output characteristics. The typical range is from 4 - 9 kph. The slower speeds should be selected for applications pre-harvest of crops and where soil conditions could cause excessive boom bounce and yaw at the faster speeds.
5. **Recommended Nozzle Type, Pressure, Volumes and Tractor Speeds for the Application of 80 - 120 l/ha:**
80° or 110° nozzles able to apply the required volume at pressures between 1.5 - 2.5 bars at between 4 - 9 kph are recommended. Examples of these nozzles are available in a separate handbook.

HAND-HELD APPLICATORS:

1. **Overall, Non-Selective Applications:**

Ulva and Mistblower:
These applicators are recommended for use in FORESTRY areas ONLY. The principle of application is to drift the herbicide onto target weeds taking care to avoid contact between this product and all desired species.
Apply in a total volume of spray liquid at 10-20 l/ha in the Ulva and 90-175 l/ha in the Mistblower using the correct dose of Roundup herbicide to control the particular target species.

2. **Spot or Directed Application:**

Knapsack Applicator:
These may be used in Forestry, Orchards and Non-crop areas. Normal water volume is 200-300 l/ha but by fitting very low volume nozzles it can be reduced to 100-150 l/ha.

Example of Use:
To apply 4.0 l/ha Roundup in 200 l/ha in a Knapsack of 10 litres total capacity add 200 mls of Roundup to 9.8 litres of water. At a walking speed of 1 m/sec and with a 1 m wide swath, the area covered is 500 m^2. To apply 6.0 l/ha add 300 ml to 9.7 litres water to cover a similar area.

Herbi:
This may be used in areas similar to the Knapsack. Select the blue nozzle normally to apply 10-20 l/ha spray volume. Calibrate before each use at a walking speed of about 1 m/sec.

3. **Hand-held Wipers:**

Herbicide Glove:
All free-standing annual and perennial weeds in top fruit crops, wild oats in cereals and annual beet in sugar beet, can be treated with the Croptex Herbicide Glove. Measure 400 ml of Roundup herbicide and make up to 2 litres with water. Add 20 ml of Agral and scarlet dye to obtain desired colour intensity. The dye may be obtained from Hortichem Ltd., Edison Road, Churchfields Industrial Estate, Salisbury, Wiltshire, SP2 7NU. Tel. Salisbury (0722) 20133.

Weedwiper Mini:
This technique may be used in Forestry, Top Fruit Orchards and in Non-Crop and Aquatic areas only. Use a concentration of 1 part of Roundup herbicide plus 2 parts water and add scarlet dye if required.

4. **Cut Stump Application:**

Enso attachment to rotary saws:
This technique is specific to scrub clearance in Forestry. The water soluble dye Methyl Violet 2B may be added to Roundup at a concentration of 0.01 % to help identify treated stumps. This is equivalent to the addition of 1 ml of dye to 10 litres of spray liquid. The dye may be obtained from: BDH Chemicals Ltd., Freshwater Road, Dagenham, Essex, RM18 1RZ. Tel. Poole (0202) 745520 - BDH Technical Services.

TRACTOR-MOUNTED WIPERS:

Treatment of Sugar Beet Bolters, Weed Beet and Other Weeds:
For use in arable crops, grassland and forestry areas. Ensure there is at least 5 cm between the top of the tallest desired vegetation and the impregnated wiper. Two passes in opposite directions will be needed where weeds are dense and successive applications will be required to control weeds that were below the original wiping level. Treat before weed seeds have matured to reduce to a minimum seed return to the soil. Bolting beet should be treated by a series of three applications during early July to early August with two weeks between treatments.
WEEDS MUST BE GROWING ACTIVELY TO BE SUSCEPTIBLE.
DO NOT USE WIPER TECHNIQUES IN SOFT FRUIT CROPS.

Recommended Machines and Dilution Rates:

Hectaspan Weedwiper	Tecnoma Top Weeder
Keenan Weed Licker	Telford Hornburg Chemical Applicator
Matrot Mobilcord	Vicon Wedge-Wik

The recommended concentration is 1 part of Roundup herbicide to 1 part water.
Under hot, dry conditions a concentration of 1 part of Roundup herbicide to 2 parts water is preferred.

For Best Results with all Wiper Applicators:
— Operate at speeds below 5 kph
— Treat when weeds reach 10 cm above the desired vegetation.
— Keep wiping surfaces wet but prevent dripping.
— Clean ropes several times a day to maintain optimum flow rate.

CAUTION
Keep stock out of treated areas for 7 days to allow herbicide to become fully effective.
TREATED POISONOUS PLANT SPECIES MUST BE REMOVED BEFORE REGRAZING OR CONSERVING.
Monsanto does not warrant that the purchase or use of the equipment mentioned in this document will not infringe any patent or trade mark registration.

6. **Filling the sprayer:**
Half fill the spray tank with water and start agitation. Add recommended quantity of Roundup herbicide, top up tank with water to required level.
7. **Calibration:**
Before using a sprayer and, especially, after nozzles have been changed, it is essential to calibrate the sprayer by checking the output of at least one nozzle for each separate boom section of the sprayer
8. **Operation in the Field:**
Check the following before starting to spray:
- That the nozzles are aligned evenly at the correct angle to the direction of travel
- That the boom is level over its width.
- The boom height permits the correct pattern of spray overlap on the target weeds

Rotary Atomisers:

1. **Sprayer Selection:**
The following rotary atomiser applicators may be used to apply this product:

Horstine Farmery Microdrop	C.D.A. Boom and C.D.A. Lightweight
Lely Hydraspin	Cleanacres Dual-Option Sprayer
Tecnoma Girojet	

2. **Droplet Size and Water Volume:**
Set the droplet size to 200-300 μ for each machine and the volume of application to 40 l/ha
3. **Operation in the Field**
Apply at 4-9 kph having calibrated the sprayer accurately. Ensure that sprayer bouts are matched by using markers

Sprayer Maintenance:
Ensure that the sprayer is in good working order by paying particular attention to the condition of the pump, hoses, nozzles or disc assemblies and pressure gauge. Replace damaged, worn or malfunctioning parts. Wash out sprayer thoroughly before and after spraying this product using an effective detergent cleaner and ensure filters, strainer and nozzle assemblies are free of pesticide residues. If extra filtration or pressure damp valves have been fitted for low volume work at 80-120 l/ha make certain this equipment is clean and functioning correctly. Carry out maintenance according to the instructions of the sprayer manufacturer. This is of utmost importance when using low volume nozzles.

Hygiene when using all sprayers:
It is essential to clean-out thoroughly sprayer tanks, pumps and pipelines and nozzle or disc assemblies between applying this product and other pesticides. For example, after spraying this product pre-harvest in cereals the equipment MUST be cleaned completely before it is used to apply a potato blight fungicide, particularly in seed crops

Applications Adjacent to Reservoirs and Water Courses:
Recommendations apply only to the use of this herbicide for the control of weeds growing in or by water and must be read in conjunction with the Official Code of Practice entitled "Guidelines for the Use of Herbicides on Weeds in or near Watercourses and Lakes" obtainable from the Ministry of Agriculture, Fisheries & Food, The Department of Agriculture and Fisheries for Scotland, Department of Agriculture for Northern Ireland and the Welsh Office Agricultural Department

The Rivers (Prevention of Pollution) Acts 1951 and 1961, The Rivers (Prevention of Pollution) (Scotland) Acts 1951 and 1965 and the Northern Ireland Water Act 1972, may apply to the act of applying Roundup for the control of weeds growing in or by reservoirs and water courses, e.g. rivers, streams, ditches, drains and ponds/lakes discharging into such water courses. Users must therefore consult the appropriate Water Authority or water services before applying Roundup for this purpose

The rate of application should be so adjusted that the maximum concentration of the active ingredient at any point in water containing or associated with weeds to be controlled, does not exceed 0.2 parts per million or such water concentration as the Water Authority may require.

However, when used as recommended, under the terms of the Control of Pesticides Regulations (1986), any water subjected to spray drift with Roundup may be used immediately for irrigation purposes. Roundup is NOT in the Health & Safety (Agriculture) (Poisonous Substances) Regulations.

METRIC CONVERSIONS

PRODUCT DOSE L/HA	PRODUCT DOSE PINTS/AC	APPLICATION VOLUME L/HA	APPLICATION VOLUME GALS AC
1.5	1.1	10	1.0
2.0	1.4	20	1.75
3.0	2.1	40	3.5
4.0	2.8	80	7.0
5.0	3.5	90	8.0
6.0	4.2	100	9.0
10.0	7.0	120	10.5
		150	13.5
		175	15.5
		200	18.0
		225	20.0
		250	22.0
		300	27.0
		400	36.0

TRACTOR SPEED K.P.H.	TRACTOR SPEED M.P.H.	SPRAY PRESSURES BARS	SPRAY PRESSURES P.S.I.
4.0	2.5	1.5	21
5.0	3.0	2.0	28
6.0	3.75	2.5	35
8.0	5.0	3.0	42
9.0	5.5		
10.0	6.25		

CONDITIONS OF SALE The following shall form part of any contract of sale of this product whether sold by the manufacturer or a subsequent owner ("The Seller")

1. The Seller warrants that the product complies with the product specification prevailing at the date of sale which is obtainable from the Seller on request provided that (except to the extent any claim is in respect of personal injury or death) the said Seller's liability, for breach of this warranty is limited to the price of the products involved in the breach
2. Except as aforesaid all conditions and warranties statutory or otherwise and express or implied as to the quality of the product or its fitness for any purpose are expressly excluded.
3. Except as aforesaid neither Monsanto nor (where different) the Seller shall be under any liability other than for personal injury or death whether in contract or in tort for any loss or damage arising out of or resulting from the use of the product
4. Monsanto shall in no event be liable for any loss or damage caused by the failure of any person to use the product in accordance with the instructions for use given by Monsanto.

Internationally patented
Dennis Bros. Bury St. Edmunds, U.K.

Clarosan® 1FG

Controls most algae, submerged and free floating weeds in static and slow-moving water

CIBA–GEIGY

Ciba-Geigy Agrochemicals
Whittlesford
Cambridge CB2 4QT
Tel: Cambridge (0223) 833621

EL945156/0605X

CIBA–GEIGY

Conditions of Supply

Subject to the provisions of this clause CIBA-GEIGY PLC warrant the quality of their goods provided they are sold in original sealed packages. Unless specific recommendations in writing are made by the Company, CIBA-GEIGY PLC makes no representation as to the biological or physical compatibility of the goods when mixed or applied with other goods (whether manufactured by CIBA-GEIGY PLC or a third party) or to their efficacy when mixed with such goods. Accordingly, in the absence of such recommendations, goods are mixed and mixtures applied at the user's risk.

The goods supplied are of the description stated on the label and are believed to be suitable for the purpose for which supplied. Since the goods or their performance may be affected by factors beyond the seller's control (e.g. storage conditions, weather and soil conditions and incorrect applications; susceptible varieties of crops; resistant strains of pest organisms) no responsibility can be accepted for any damage, loss or injury whatsoever to persons or property howsoever arising and all warranties and conditions expressed or implied, by Statute or otherwise, are hereby excluded.

No liability shall attach to CIBA-GEIGY PLC or its employees, agents or distributors by virtue of their having supervised or assisted in the application or use of the goods.

Clarosan®

Clarosan is a granular formulation of terbutryne specially formulated to maintain a satisfactory dosage level in water for control of most algae and submerged and free-floating weeds in static and slow-moving water, such as lakes, canals, ditches, farm ponds etc.

Pack size 10 kg paper sacks.

CAUTION

Reduced weed control may occur when Clarosan is used in water courses with peaty bottoms.

This leaflet incorporates changes to the following sections:

CAUTION
General Information – weed control.

General Information

Weed control Clarosan is a granular formulation of terbutryne developed specifically for the control of water weeds. The formulation permits early application so as to avoid de-oxygenation caused by dying or dead vegetation, while continuing to release active ingredient to prevent later re-infestation.

Growth of the weeds ceases more or less immediately but it may be 2-4 weeks before obvious signs of death occur. The kill is much more rapid if the weather is warm, and the weeds are growing rapidly.

In static water, regrowth should not occur for at least 3-4 months. Where water movements occur particularly during periods of heavy rainfall which cause 'flushing', this period can be much reduced.

Clarosan should not be used if the maximum water flow is more than 1 metre per 3 minutes.

Weeds controlled (susceptible)

Algae

Enteromorpha intestinalis	*(Bladder weed)*
Spirogyra spp.	*(Blanket weed or Cott)*
Cladophora spp.	*(Blanket weed or Cott)*
Rhizoclonium spp.	*(Blanket weed or Cott)*

Vascular Plants

Ranunculus spp.	*(Water-crowfoots)*
Callitriche stagnalis	*(Water-starwort)*
Potamogeton crispus	*(Curled pondweed)*
Potamogeton pectinatus	*(Fennel pondweed)*
Elodea canadensis	*(Canadian waterweed)*
Myriophyllum spp.	*(Water-milfoils)*
Ceratophyllum demersum	*(Rigid hornwort)*
Hottonia palustris	*(Water-violet)*
Lemna spp.	*(Duckweeds)*

Weeds suppressed (moderately resistant)

Vaucheria spp.	*(Cott)*
Potamogeton natans	*(Broad-leaved pondweed)*
Hippuris vulgaris	*(Mare's-tails) (only when fully submerged for at least three weeks after treatment)*
Nuphar spp.	*(Water-lilies)*
Nymphaea alba	*(White water-lily)*

Resistant weeds

Polygonum amphibium	*(Amphibious bistort)*

Emergent weeds such as reeds, sedges and rushes.

Note Under certain conditions Nuphar spp. *(Water-lilies)* and Nymphaea alba *(White water-lily)* may be damaged by Clarosan. Where these are desirable species the lower rate should be used, but this may still cause some damage.

Water for irrigation purposes
Clarosan treated water may be used for irrigation purposes 7 days after treatment.

HOW TO USE

Timing For best results apply Clarosan 1FG when weed growth is active but before heavy infestations have built up. This is usually in April or May but may be as late as August.

Dose

Situation	Quantity of Clarosan 1FG	
	kg per 1000 m^3	lb/acre foot of water depth
Susceptible vascular plants and algae.	5 (5ppm)	14
Moderately resistant vascular plants and algae	10 (10ppm)	28

Application Clarosan 1FG should be applied only to those areas of watercourses or lakes where there is, or is expected to be, an infestation of weeds of which control is both possible and necessary. The granules should be spread evenly, either from the bank using a machine with a long throw or from a spreader mounted on a boat. Any suitable machine such as the 'Fontan' air blast knapsack spreader or the 'Vicon' granule spreader may be used.

Clarosan 1FG is for use in static or sluggishly-moving water. The flow in moving watercourses should be stopped for at least 7 days from the time of treatment, or weed control may be reduced.

If dense weed growth is to be controlled without de-oxygenation treat the area in sections at different times. Sections of approximately 400m (400yd) of watercourses or not more than a quarter of the total area of a lake are suggested, with an interval of at least 14 days between applications. This will allow fish to move into untreated sections should the dissolved oxygen content of treated areas fall to a critical level.

It is important that the entire area of lakes should be treated within a 6-8 week period or weed control may be reduced.

Clarosan 1FG may be used in water used for angling but it should not be used in trout farms or other situations where fish are intensively reared and where dissolved oxygen levels are critical.

This product is cleared under the UK Government's Pesticides Safety Precautions Scheme for use as directed. MAFF00520.

FOR USE ONLY AS AN AQUATIC HERBICIDE MAFF00520

Precautions

WASH HANDS before meals and after work.

DO NOT DUMP surplus herbicide in water or ditch bottoms.

KEEP IN ORIGINAL CONTAINER, tightly closed, in a safe place.

EMPTY CONTAINER COMPLETELY and dispose of safely. Do not re-use for any purpose.

DO NOT USE TREATED WATER for irrigation purposes within 7 days of treatment.

KEEP IN A COOL, DRY PLACE.

The official 'Guidelines for the Use of Herbicides on Weeds in or near Watercourses and Lakes' should be read before Clarosan 1FG is used. Copies are obtainable from:
Ministry of Agriculture, Fisheries and Food, Publications Branch, Lion House, Willowburn Estate, Alnwick, Northumberland NE66 2PF.
or
Department of Agriculture and Fisheries for Scotland, Chesser House, 500 Gorgie Road, Edinburgh, EH11 3AW.

Under the Rivers (Prevention of Pollution) Acts 1951 and 1961 and the Rivers (Prevention of Pollution) (Scotland) Acts 1951 and 1965, River Authorities in England and Wales and Purification Authorities in Scotland are legally charged with the prevention of pollution in rivers. If the water which it is proposed to treat with Clarosan 1FG enters a river, or is part of a river system, consult the appropriate River or Purification Authority before treatment. For Northern Ireland the Ministry of Development, Conservation Division holds similar responsibilities to the River or Purification Authorities of England and Scotland.

Use of Clarosan 1FG in waters not subject to the above Acts (ponds and lakes not discharging to a watercourse) is permitted provided the concentration in the water does not exceed 10 ppm of product.

APPENDIX II

Occurrences of *Crassula helmsii* by vice county with numeric National Grid References.

Occurrences of *Crassula helmsii* by vice county with numeric National Grid References to Nov. 1989 for Britain and Ireland assembled by F.H. Dawson, Institute of Freshwater Ecology, River Laboratory, East Stoke, Wareham, Dorset (further details available, 0929-462314 or Fax -462180) (v = sites visited by FHD; a = sites where control attempts were coordinated but not visited.)

	Vice-County No.	Name	Site Waterbody/Name	UK NGR	Source/Ref/Collector	Year	stat
	S	Jersey	damp ground, Valley S. St Mary's Church	(3./.....)	R.W.S. Knightbridge	1983	t
a v			Supply Reservoir, St Peter's Valley	(3./.....)	F le Sueur/FHD	1985	c dr
		Guernsey	nr		B. Bonnard		
	S	Alderney	Old stone water tank, Essex Hill, E. Ald.	(3./.....)	M. Long	1983	c
			Ch. Etocq, Alderney	(3./.....)	J.C. Fluck	1986	p
			Corblets quarry nr Chateau a L'Etoc	(3./.....)	B. Bonnard	1986	p
	1.	W. Cornwall	Heathland pool, Goonhilly Down (N.R.?)	10/719212	A. Byefield	1983	p?
	1b	Scilly	n.r.		R. Parslow		
	2.	E. Cornwall	Morton Pound Fm, Bude	21/274087	VCR undated	1980?	p
			Demo. ponds, Probus	10/89.47.	P. Henville	1986	
v			seepage pool, gorge, Gunver Head (salt spray?)	10/895770	J.E. Oliver/FHD	1986	p
	3.	S. Devon	ponds, Key Transport, Bovey, (SSSI?)	20/862741	D.E. Bolton	1983	i?
			pond, Newcott Fm, Townsgate	20/75.60.	M. Newton	1985	c
a			ditch, Venn Ottery N.R.	30/061918	(M.R. Hughes) DWT field meeting	1980+	t
a v			Decoy Pond Rec. Newton Abbot	20/866704	(A. North)/FHD A P G Mitchelmore	1980+	i
a			pond, Fardel Manor, Ivybridge	20/609573	D. Sharp	1986	P
			g. pond, Axminster (from nursery, Honiton)	30/30.98.	S.N. Axford	1988	
			g. pond, Caravan park, Clyst St George	20/990910	D.E. Bolton	1984	p
	4.	N. Devon	muddy road-side pond, Instow	21/485295	M. Tulloh	1973	l
	5.	S. Somerset	pond, Clapton Court, W. Crewkerne	31/419068	J. Ounsted	1983	p
			garden pond, Knowle St Giles	31/342113	J.E. Keylock	1985	p

	6.	N. Somerset		fishponds, County Hall, Taunton	ST 31/225243	E. McDonnel	1990	p
	7.	N. Wilts		g. pond, Winsley, Bradford	31/80.61.	J.L. Presland	1978	p i l
a				moat, Liddington, Swindon	41/209819	G. Domanievski	1985	c
				pond, by R. Avon, S.E. Malmesbury	31/948844	M. & S. Storey	1989	p
	8.	S. Wilts		(see Wiltshire Flora Mapping Project)		(A.M. Hutchinson)		
				g. pond, Lockeridge	41/14.67.	J.E. Oliver	1986	p
	9.	Dorset		in cult., Ferndown	41/08.01.	(from M. McC.-W.)	1962?	-
a				Weston M. Lake, Corscombe	31/507059	A.T.C. Beddow	1981	c i
				garden pond, Upwey	30/659854	H.J.M. Bowen	1984	p
a v				pond, common land N.R. Corfe Castle	30/965810	J. Bowyer/FHD	1984	p d
			BM	pond, Ose Frm, Sherborne	31/67.08.	B.M. Sturdy	1984	
a v				Lake, Priors Down, Stalbridge	31/750185	D.F.Westlake/FHD	1985	d
				damp soil, Pamphill	31/997003	H.J.M. Bowen/R.Leney	1988	
				fishpond, near Marshwood	30/365983	P. Temple	1988	c
				garden pond, Netherbury	30/472993	P. Temple	1989	c
				Happy Island pond, Bridport	30/479938	P. Temple	1989	c
				Sharpe's pond, Bridport	30/476937	P. Temple	1989	c
				pond, clay works, Creech, nr Wareham(toads)	30/920830?	C. Reading/FHD	1990	p
				g.pond, Stoborough, Wareham	30/930860?	FHD	1990	p i
				pond, Powerstock Common	30/542973	P. Temple	1990	p
a	10.	IOW	BM	pond, Marsh Farm House, Newtown (near NR)	40/422908	Buckle/Seabrook	1965	p
			BM [	field pond, Newtown (peduncles 8-10 mm)	40/42.90.	Seabrook	1965	p
a v				pond, Sandown Golf Club (F Bowles '89/FHD)	40/588849	A.W. Jones	1976	r/i
				drainage channel, R. East Yar, Sandown	40/58.83.	B. Shephard	1979	p
				drainage ditch, Sandown Level	40/608850	B. Shephard	1979	p
a v				new pond & scrape, MOD range, Newtown (NR)	40/443909	B. Shephard/FHD	1985	p
				water lily farm, Chickerell	30/650797	D. Pearman	1990	c
				Pulham	/71.08.	-	-	
	11.	S. Hants	BM [1]	pond, Glen Eyre Hall, Southampton	41/42.15.	Mrs Welch	1957?	l
a v				Sh. ponds, Buddle Green, N. Gorley	41/161118	R.P. Bowman	1976	c
a v				Sh. pools, Hatchet, East Boldre (N.Forest)	41/369013	S.R. Davey/F. Rose	1978	i cc
				Horseshoe Pond, Bournemouth	40/090916	R.C. Stearn	1980	c
a v				ponds, Mockbeggar, Ringwood	41/161099	R.P. Bowman/FHD	1982	d cc
a v				Hill Top pond, nr Beaulieu (New Forest)	41/401031	R.P. Bowman/FHD	1983	c i
				Nursery Pond, Higherend Farm, Hale	41/179178?	J. Ounstead	1983	p
				sm. pond, Whitley Ridge, Brockenhurst (NF)	41/314025	R.P. Bowman	1986	c i
				sm. pond, Hatches Fm, Wellow	41/298198	R.P. Bowman	1986	c i
				Higherend Fm Pond, Hale	41/179177	FHD	1986	a

			East Beaulieu Heath (New Forest)	41/405049	(S. Everett)	1986	d
			new lake, W. side R. Avon	41/089159	J. Ounsted	1980+	i
a	v		gravel pit, Holmesley NR	40/207988	R. Tyler/FHD	1987	i cc
			fishing ponds, Sway?	40/27.97		1987?	
	v		(pond, senior common room, S'oton Univ.	41/44.11.	FHD	1988	i)
			pond by railway, Latchmoor, Brockenhurst	41/292003	R.B. Bowman	1988	p
			pits, Marlpit Oak, Setley	40/285997	A. Bolton	1987	
	v		gravel pit, Lake, Mockbeggar, Ringwood	41/158088	FHD	1988	i
			g.pond, Linwood	41/18.19.	P. Webster	1989	c
			pool, East End, Lymington (rare species)	41/	R.P. Bowman	1990	i
			small pond, nr Mopley Pond, Fawley		R.P. Bowman	1990	i
	12.	N. Hants BM	pond, Vine Cottage, Ewshot(t)	41/81.49.	M. McCallum Webster	1962	p
a			scrapes, Woolmer Forest NR	41/789327	VCR	1986	p con
a			sand spur, Rushmoor Flash NR, Basing. Can.	41/856522	C.R. Hall	1986	i c
a			canal, Claycart Br. NR, Basingstoke Canal	41/852526	C.R. Hall	1986	p
			gr. pit,Yateley Heath Wood	41/794582	C.R. Hall)	1987	p
			gr. pit pond, North Camp	41/885536	C.R. Hall	1988	p
			Eelmoor Flash, Basingstoke Canal	41/842528	C.R. Hall)	1989	p i
			Pontail Flash, Basingstoke Canal	41/823527	C.R. Hall)	1989	p cc
			Puckridge Flash, Basingstoke Canal	41/846528	C.R. Hall)	1989	p
			grav. pit pond, Yately Common SSSI	41/837594	C.R. Hall	1989	i
			school pond Crookham	41/815519	C.R. Hall	1989	c
	13.	W. Sussex	pond by stream, Balcombes copse, Wisborough	51/030236	A.W. Jones	1980	a
		BM	Sandy lane pool, St. Leonards, Horsham SSSI	51/200307	M. Briggs/Earl, Rich	1981	p *
			re-excavated pond, Sandhill Fm, Workington?	51/122135	R.M. Edgar	1987	d
	14.	E. Sussex BM	pond, Hailsham ***	51/587089	Hillman	1962	p
		BM	pond (dew?) on downs, Newhaven (427011?)	51/428015	W.H. Spreadbury	1965	l?
			pond by road, Manor H., Bishopstone	51/471007	A.W. Jones	1968	r
a			Friston Pond	50/551982	Seaford NHS (/BAK)	1978	i
			pond, Pevensey levels, Norman's Bay 672056?	51/673055	P. Maurice	1982	p
			g. pond, Stonesdown Fm, Brightling	51/691195	A.W. Jones	1982	r
			pond, Milton Mount, Pound Hill, Crawley	51/295383	A.G. Hoare *******	1985	p i
			pond, Piltdown	51/443222	A.W. Jones	1985	i
			Ardingley Reservoir	51/331298	AK/A. Hoare	1986	i
			margins, Darwell Res.	51/705208	A.W. Jones/FHD	1986	r i
			(downstr. of 691195)	51/69.18.	A.W. Jones	1986	p
			Wierwood Reservoir, Nr East Grinstead	51/380345	D. Beran/A. Knapp	1987	a
			Chilley Stream, Manxey level	51/64.06.	(B.R.C.)	1987	
			ditch, Poling	51/052045	N. Stewart	1988	p
			pond, Pevensey Marshes	51/687085	A.W. Jones	1988	p

			reservoir, Bewl Bridge		51/699318	P. Harmes	1988 a
			f. pond, Broadstone Fm, Chailey Common	TQ	51/373206	A.W. Jones	1990 p
	15.	E. Kent	n.r.			E.G. Philp	
	16.	W. Kent	2 pond, Sidcup		51/46.73.	F.H. Jones	1960 p
a			garden pond, Nr Chiddingstone Causeway Tonbridge		51/59.47.?	S.L. Melville/EGP	1977 p
			dyke, Cooling Marshes		51/7..7..	E.G. Philp	1989 p
a	17.	Surrey	Barons Pond, Epsom Common		51/200591	L.M.P. Small	1976 p
			Moat Pond, Thursley Common		41/899415?	S. Wenham	1977 l
			pond, Houndown, Hankley (nr river)		41/893407		1980+
			pond, Cranleigh		51/053393	A. Rich	1981 p i
			pond, Wm Curtis Pk, London (filled)		51/334804	B.R.C.	1981 p ?
			Pond Marlpit Lane, Coulsden		51/309583	J.M. Montgomery	1984 p
			drying pond by B3001		41/922433	J.F. Leslie, JES, AJS	1984 p
			**Lower Penn Pond, Richmond Park		51/201731	JFL & JESmith & AJS	1985 c
a			Basingstoke canal		41/892559	JFL, JES, A.J.Stevens	1985 p
			***pond, Felbridge		51/363413	R.D. Hawkins	1985 c
			Basingstoke canal by Wharfenden Lake		41/894567		(1986)
					-41/910565	JFL & JES	1986 i c
			Basingstoke canal, Frimley		41/892564	JFL & JES	1986 p
			Basingstoke canal, Mytchett Br.		41/893555		(1986)
					-41/895567	C.R. Hall	1986 i cc
			Basingstoke canal		41/922433	C.R. Hall	1986 i
			muddy gully, Basingstoke Can., Brookwood		41/962575	SFC meeting	1986 p i
			Mychett Lake		41/894543	C.R. Hall	1987 p
			Gt Bottom Flash		41/895533	C.R. Hall	1987 i c
			pond edge, Horton Country Park		51/186619	J.F. Leslie & K.Page	1987 p
a			stream bank, Sandhurst		41/865608	J.F.L., K.P., J.E.S.	1987 a
			Upper Lake, Sandhurst		41/868608	J.F.L., K.P., J.E.S.	1987 a/d
			Basingstoke canal, Lowshot, (Pirbright)		41/936568	C.R. Hall	1987 p
			ornamental ponds, Wisley Gardens, Boldermere		51/076585	A. Showler/B.S.Hodge	1987 c
			pond, Hambledon		41/95.38.	D. Herhiky	1987 p
			IOW pond, Gt Bookham Comm.		51/126562	(B. Bankes)	1988 p
a			large stew pond, Epsom common		51/185607	E.J.C. & J.B.S.H.	1988 a
			new lake (1986/7), Nonsuch Pk		51/227636	J.B.S.H.	1988 p i
			Basingstoke canal, Ash		41/893520	C.R. Hall	1988 p
			pond, Coulsden Common		51/322570	(C.R. Hall)	1989 c
			Basingstoke canal		41/940560?		(1989)
					-41/943567	C.R. Hall	1989 i
			pond, Badshot Lea		41/864486	C.R Hall	1989 p

				restored pond ('87), Chaldon Church	51/308556	G. Fookes	1989 d
				pond, roadside, Milford	41/945415	K.Page & J.E. Smith	1990 c
				clay pit margins, Newdigate	51/205427	K.W.P. & J.F.L.	1989 i
				pond, Ashtead Park	51/191585	J. Hodge	1989 p
				pond (restored), Banstead Heath	51/228558	C. Birkinshaw	1989 a
				dug pond,Caterham (with aquatics,dried out)	51/316565	G. Fookes	1989 p
				pond, Cranleigh	51/068408	K.Page & J.F.Leslie	1989 d
				Elmore Pond, Chipstead	51/278568	K.P.,J.F.L. & J.E.S.	1990 i
				Golden Spring, Simpsfield Common (SSSI?)	51/	N.K.B. Robson	1990 i
				lower pond, Univ. Bot. Gdn	41/990706	J.E. Smith	1990 p
	18.	S. Essex		garden pond, Little Baddow ******	52/786072	M. Gregory, Snr	1953/4 p
			BM	pond, nr Greenstead Ch. Chip. Ongar	52/539029	E.B. Bangerter,Hall	1956 d
				garden pond, Little Hallingbury	52/505169	J.L. Fielding	1960 p
				shallows, Goldings Hill Upper Pond Epping F.	51/429980	K.J. Adams	1980
				roadside pond, Oak Hill, Epping Forest	51/395910	K.J. Adams et al	1980 d
				Grav. pits, Nazeing, mead. Lee Val. Res.	51/36.9..	K.J. Adams	1980+ p
				Hill Pond, U. Baldwins, Epping F. ??	51/41.96.	F.J. Rumsey & HJM	1983 p
				pond, Woodford	51/3..8..		1984
				gravel pond, Bachwarden, Danbury Common NR	52/77.03.	J. Skinner	1984 p
				stream and pond margins, north of Childerditch	51/612904	A.J. Wake	1985 p
				small pond, Canewdon	51/90.94.	T. Pyner/J. Adams	1986 d s
				pond,?	52/90.15.	R. Wilson	1987
				pond, Landgar Hills, NR	51/691868		1990 c
a	19.	N. Essex		lake, Fingringhoe Wick N.R., Colchester (spreading)	62/03.20.	K.J. Adams	1976 i cc
a v				pond, Fingringhoe Wick N.R., Colchester	62/046194	KJA,J.L.Fielding/FHD	1976 p c
				pond, Broadley Common, Nazeing	52/418062	KJA	1986 p i?
	20.	Herts		pond, Monken Hadley Church (51/246971?)	51/253973	A. Boucher	1976 c i
				ponds, Batchworth Heath	51/077924	A.C. Jeffkins	1979 p
a				pond, Hadley Green, Barnet Common	51/246971	A. Boucher/D. Beran	1982 p i
				pool, Hoddesdon Power Stn	52/388088	A.B. & T.J. James	1982 p
				pond, Measden Village Green	52/428324	(Herts Trust)	1980+
				ponds, Theobolds House, Barnet?	51/20.90.		1989
				g. pond, Warners Ave, Broxbourne	52/3..0..	A. Boucher	1990 p

	21.	Middlesex		in cultiv., Perry/Jacamor, Enfield	52/3..0..	Laundon, 1961	1960 p
				pond, Stanmore	51/164931	BRC	1981
			BM	garden pool, Ruislip	51/09.87.	Mathews	1981 p
				pond, Fryent Country Park, Brent	51/20.90.?	(L. Williams?)	1987
				pond, Dollis Mill Ind. Est. (margins)	51/223863	L. Williams	1987 p
a				pond, Gillespie Nature Park, Islington	51/314861	(U. Maginn)/B Worzel	1988 p i
				Shortwood Pond, Staines	51/048719	K.P.,J.F.L. & J.E.S.	1989 p
				ponds, Capel Manor, Enfield	51/30.90.		1989
				pond, Halebury College, Hertford Heath	52/3..1..	A. Boucher	1990 p
	?	Gt London		Pond, Hare & Billet	51/392762		1989 d
				Pond, Whitefields Mount	51/390764		1989
				pond, Folley Road	51/391767		1989
				Kenwood Pond, Hampstead Heath		R. Carter	1990
a	22.	Berks		pond, Silwood Park	41/94.68.	H.J.M. Bowen	1980 p
				Garden pond U. Bucklebury	41/53.69.	D.J.N. Hind	1983 p
a				pond, Mortimer Common (+ Crested Newts)	41/656646	H.J.M. Bowen	1985 p
				Kennet & Avon Canal	41/6..7..	(P.Marren)	1986? p
				Little Witton Wood	41/571928	(BRC)	1986 p
				pond outlet,Finchhampstead by R.Blackwater	41/775625	(C.R. Hall)	1989 p
				pond, St Mary's School, Hendon		A.M. Andrews	1987 p
a	23.	Oxon		lakes, Sutton Courtney	41/51.93.	J.Killick	1980+ p
				pond, Field End, (Oxon CC, educational)			1986 p
				pond, Hill End Camp (Oxford - Farmoor Rd)	41/.....		c 1985 i
	24.	Bucks	BM	pond, Cholesbury Com.	42/932072	A. Vaughan	1975 p i
				ponds, Gerrards Cross Common	51/0..8..	A. Byfield (1984)	1980+ d
				ponds, Gerrards Cross Common	41/997886	A. Showler	1986 c
				pond, North End	41/735926	H.J.M. Bowen	1980+ p
				pond, Bletchley	42/875339	R. Maycock	1986 p i
				ornamental pond, Cadmore End	41/781939	-	1980+
				ornamental pond, Amersham crematorium	41/948967	A. Showler	1989
				The Dyke, Rye, High Wycombe	41/872924	A. Showler	1989
	25.	E. Suffolk		pool, Felixstow Spa Gdns	62/304344	E.M. & M.A. Hyde	1979 l
				gravel pit, Alderson Lake, Needham Market	62/097545	F.W. Simpson	1984 p
a				flooded pits, Barham	62/120514	VCR	1980 d
	26.	W. Suffolk		n.r.		E. Hyde/F. Simpson	
	27.	E. Norfolk		marsh, Thorpe St Andrew, Norwich	63/267083	ETD/(A Spink'90)	1980+ p
				ditch, Whittingham	63/26.08.	E.T. Daniels	1988 p

28.	W. Norfolk	n.r. (Fish Farm, Diss?)		63/13.79.	C.P. Petch	1980+?
29.	Cambs	ponds, Hackers Fruit Fm		52/39.63.	Swale & Belcher '81	1970+
		pond, Highsett, Cambridge		52/45.55.	S.M. Walters	1980 p
		pond near A604		52/396631	Swale & Belcher '81	1980+ c
		in cult. Cambridge U. Bot. Gdn		52/45.55.	Swale & Belcher '81	1980+
		N. Moore's pond, Swavesey		52/36.78.		1987 p i
		damp, w side of Ouse Washes		52/479870	J. Bratton	1988 i
		g. ponds, Girton, Cambridge		52/424616	H. Belcher	1988 p
30.	Beds	n.r. but expected			C.R. Boon	
31.	Hunts	ornamental pond, Alconbury Weston		52/180772	J.H. Bratton	1985 p
		pond? Colne		52/388765	(BRC)	1985
a 32.	Northants	new pond Seawell Grounds N.R., Litchb.		42/62.52.	VCR	1986? p
		pond, Henington		52/091852	(BRC)	1980+
33.	E. Gloucs	Lake, Arle Court, Cheltenham		32/913215	S.C. Holland/ D.S. Dudley-Smith	1980+ c
av 34.	W. Gloucs	Hoopers Pool, Coverham Enc. Coleford (NR)		32/582123	S.H. Bishop	1983 p i
av		Jugshole Pool, Broadwell, nr Coleford Dean		32/589108	S.C. Holland	1988 r m?
35.	Mons	n.r.			T.G. Evans	
36.	Herefords	g. pond, Bodenham Moor		32/545507	(S.E. Thompson)	1988 p i?
		g. ponds, ?.		32/543505?	"	1988? i?
		field pond, nr Moreton-on-Lugg		32/512463	"	1988? i?
		pond by road, Bolstone		32/551327	"	1988 i?
		pond, Bishopstone		32/426437	"	1988? p
37.	Worcs	4 ponds, Purshall Green	(32/90.71.)	32/7..5..	. Cockerill	1979 c i l?
38.	Warks	****pond, Eastcote, Knowle		42/193783	B. Davies	1986 p
		Olton reservoir, Solihull		42/133815	J.C. Bowra	1986 p i
		gravel pool, Ufton fields, Leamington NR		?42/379615	(P. Copson)/P. Kirby	1987 p i
		pool margin, Maxstoke golf course(379615?)		42/224887	M. Walton	1988 a
		artificial pond, Warwick Univ., Coventry		42/27.67.	FHD	1990 d
39.	Staffs	Garden pond, Tettenhall, Wolverhampton		33/873002	B.R. Fowler	1968 p l?
		quarry pool, Milford, Cannock Chase, SSSI		33/978191	BRF/J. Martin	1979 d?

	40.	Salop	Brown Moss		I.Trueman & G.M.Kay	1990 p cr
a	41.	Glam	Broadpool, Gower NR?	21/51.91.	R.S. Cropper	1984 p l?
			g. pond, Millbrook Rd, Dinas Powys	31/15.71.	J. Kilpatrick	1984 p
	42.	Brecs	g. ponds, Talgarth	32/15.33.	R.G. Woods	1986 p i
	43.	Rads	n.r.			
	44.	Carms	farm pond, Wern Fendigaid ?	41/639453	I.K. Morgan	1987 p
	45.	Pembs	ponds, Scolton C.P.,Spittal, Haverfordwest	SM 12/989220	T. Theobold)	1983?p
av	46.	Cards	pool and ditches, Ynyslas, N.N.R., Borth	22/610939	M. Wainwright/FHD	1986 i con
			pond, Plas Gogerddan	22/63.83.	A. Jones	1989 i
a	47.	Monts	dug pool, Llangadfan	33/02.13.	M. Wainwright	1989 p
	48.	Merioneth	n.r.		P.M. Benoit	
	49.	Caerns	n.r.		M. Morris	
	50.	Denbs	n.r.		J.A. Green	
	51.	Flints	Farm pond, Pydew Farm, Rhyl	33/045816	G. Wynne	1979 p
	52.	Anglesey	n.r.		R.H. Roberts	
	53.	S. Lincs	dis. waterway, Metheringham Delph NR	53/120620	M. Fowler	1981 p
			Denton manor nr. Grantham	43/86.33.	E. Pearce	1981 p
		*****	sand & gravel pit complex, Swanholme	43/945683	T. Smith	1985 p i
			old sand pit, (SSSI)	43/941683	I. Weston, VCR	1980+
			old sand pit, Lincs Trust N.R.	43/914674	I. Weston, VCR	1980+
			field pond, East Rd, Sleaford	53/073459	T. Smith	1990 p
	54.	N. Lincs	S. Engine (Double) Drain, nr Huist Priory	44/777097	H.E. Stace	1986 p
			pond, Crowle (?)			1980+
			fishing lake, Barton/Barrow Clay Pit SSSI	54/038229	H.E. Stace, N.F.S.	1987 p
			fishing pits, Cleatham, nr Kirton Lindsey	44/935005	V. Wilkin J Weston	1990 d
			North Idle Drain, S. of br. N. of Sandtoft	44/74.08.	I.Weston CP,VW & VP	1990 p
			Hatfield Waste Drain,	44/76.10.	I Weston CP,VW & VP	1990 p

	55.	Leics	garden pond, Loughborough		47/53.18.	A.L. Primavesi	1982? p
			pond, Western Park (Leics. Ecology Trust)		43/563043	J.P. Bailey(det.CAS)	1990 p pl.
			Blackbrook Reservoir		43/459176	A.L.P	1984 p
			small pond, Montsorrel		43/573142	A.L.P	1985 c
			pond, Parkfield School, Leicester		43/598079	B.Cockburn/J.Bailey	1990 i
			other ponds		43/5..0..	J. Redmayne	1990's p
	55b	Rutland	n.r.			K.G. Messenger	
	56.	Notts	ditch near County boundary/Leics			A.L. Primavesi	1982? p
	57.	Derbys	pond, Alderley Edge		43/852777	D.J. Tinston	1986 p
			pond, Middlewood Way, Bollington		43/928768	G.M. Kay	1987 p
			? Alsager	(Y)	43/78.56.	G.M. Kay	1989 p
			sh. pond by canal, Hyde		43/942938	G.M. Kay	1990 p
			pond, Tapton (W?) Grove		43/401725	M.C. Hewitt	1984
			Brockwell (disused) res. Chesterfield		43/372718	R.G. Woods)/MCH	1984 p
			Lake, Triangle, Long Eaton	?	43/484319	D.H. Spencer Jones	1990 p
	58.	Cheshire	pond, Willaston		33/33.77.	E.F. Greenwood	1979 p
			marl pit, Littleton, Chester		33/442660	A. Showler	1986 c
			new pond, Bidston		33/238910	I. Wallace	1986 i?
			aq. nursery, Burton		33/333756	I. Wallace	1986? c
			pond marl pit, N of Chester		?33/405698	C. Hayes)/T.Smith/	1988 p
a			pond, nr Alderley Edge		33/8..7..	A. Franks \J.Drage	1988 p
	59.	S. Lancs	garden pond, Formby		34/29.07.	A.S. Gunn (p.c.)	1971? p
a			excav. pond Ainsdale NNR		34/302113	K. Payne	1976 c
			silt in disu. quarry, nr Rochdale		34/948186	D. Smith	1978 p
			Mere Sands Wood, Nr Rufford		?34/46.16.	?	1984?
a			scrape, Formby Pt Car Park		34/2..0..	D. McAleavy	1980+ c
	60.	N. Lancs	pond, Lowther gardens, Lytham		34/359270	J. Steeden	1984
	61.	S.E. Yorks	n.r.			F.E. Crackles	
	62.	N.E. Yorks BM	pond, Sheriff Hutton		44/65.66.	M. Tulloh	1960 p
a			pond on cliff, Cayton Bay, Scarborough		45/05.85.	M. Robinson	1988 p
	63.	S.W. Yorks	n.r.			W.A. Sledge	
			garden pond, York		45/60.50.	S.W. Axford	1988

64.	M.W. Yorks				
65.	N.W. Yorks				
66.	Durham	pond, St Aidans College	45/268412	J. Turner	1972 p
		pond, Witton le Wear N.R.	45/163313	P.R. Appleyard	1982 p
		pond, High Wood, Low Barnston, Sunderland	45/340568	S. Lowe	1990 p
		g. pond, Backworth, Newcastle on Tyne	45/.....	S. Lowe	1990 p
67.	S. Northumb	?pond, Gateshead Festival Gdn(N.Wildlife Tr)	54/238618	M. Jeffries	1990 p pl.
68.	Cheviot	n.r.		G.A. Swan	
69.	Westmorland	pond, Dawes House, Bampton Grange	35/5..1..	D. McClintock	1986 g
70.	Cumb	pond, Silecroft	34/12.80.	R. Jerrans	1988 p
71.	Man				
72.	Dunfr.	[pond nr Moffat, possible site	36/050018	M.Jeffries	1989 p i]
73.	Kircudb	n.r.		O.M. Stewart	
74.	Wigtown	n.r.		A.J. Silverside	
75.	Ayrs	n.r.		B. Simpson	
76.	Renfrews				
77.	Lanarks	n.r.		P. Macpherson	
78.	Peebles	Glenhighton, Glenholm (unconfirmed report)	36/08.31.	(D.J. McCosh)	1970+ p
79.	Selkirks	n.r.		R.W.M. Corner	
80.	Roxburghs	n.r.		R.W.M.C	
81.	Berwicks	n.r.		M. Braithwaite	
82.	E. Lothian	n.r.		E.H. Jackson	

83.	Midloth	ponds, Holyrood Pk, Bawsinch		36/282724	M. Muscott	1981 p
		Scottish Wildlife Trust Res			pl. 1979 ex Norfolk	
a		ornamental pond(s), Edinburgh Univ.		36/268705		1980+
84.	W. Lothian	n.r.			M.M. Scott	
85.	Fife	n.r.			G.H. Ballantyne	
86.	Stirlings					
87.	W. Perth	n.r.			H. Stace/N. Stewart	
88.	M. Perth					
89.	E. Perth	n.r.			R.A.H. Smith	
90.	Angus					
91.	Kincard	n.r.			A.H. Sommerville	
92.	S. Aberd	n.r.			P.R. Marren	
93.	N. Aber	n.r.			D. Welch	
94.	Banffs					
* 95.	Moray BM	5 old gravel pit (Rec. Gdn) Lossiemouth (pedicels 3-5 mm)		38/260690	M.S. Marshall/FHD	1978 c
96.	Easterness					
97.	Westerness	n.r.			A. Slack	
		pool, Pulpit Hill, Oban (with *Nitella & Chara*)		17/851293	M.A.R. & C. Kitchen	1990
* 98.	Argyll	pond, Dunoon(?)		26/143817	Kirby 1964	1964 l
99.	Dunbarton					
100.	Clyde Is	n.r.			A.H. Sommerville	
101.	Kintyre	n.r.			A.G. Kenneth	
102	S. Ebudes	n.r.			E. Bagnall	

103.	M. Ebudes	n.r.			J.W. Clark	
104.	N. Ebudes	n.r.			C.W. Murray	
105.	W. Ross					
106.	E. Ross					
107.	E. Sutherl.	n.r.			J.K. Butler	
108.	W. Sutherl.	n.r.			J.A. Rogers	
109.	Caithn	n.r.			T.H. Keating	
110.	O. Hebrides					
111.	Orkney	n.r.			E.R. Bulland	
112.	Shetland	n.r.			W. Scott	

Ireland

a H 38	Co. Down	shallow claypit lake, Glastry pond pond	J/639630	15/7..2..	R. Weyl	1985 i

Footnotes

* 1 m 2 in 1982
** Short sturdy plants, new strain?
*** adjacent to aquatic nursery
**** pond close to the River Blythe
***** to be declared SSSI (I. Weston, pers. comm.)
****** present from 1950 or before
******* 15 m 2 to 60 m 2 in 2 years to 1987

Sites if doubtful recorded to West and South to include square.

1. Launden 1961 Watsonia 5 59-63.
2. Lousley 1961 Watsonia 5 (introduced with Pontederia from Perry's)
3. Lousley 1956 London Naturalist, 36 , 14-15 (pond dredged but still in abundance)
4. Cockerill, D. 1979 BSBI News 21 , 19
5. Richards, L. 1979 BSBI News 22 , 20-21 (BM note, 3-5 mm pedicels)

Key

t	=	transient	p	=	pond	sm	=	small
p	=	present	d	=	ditch	sh.	=	shallow
g	=	good growth	dr	=	dredged	NR	=	Nature Reserve
i	=	increasing	n.r.	=	not recorded, no records			
a	=	abundant	VCR	=	Vice County Recorder(s)	g.	=	garden
d	=	dominant	SSSI	=	Site of Special Scientific Interest			

l	=	no longer present, lost
c	=	common
r	=	rare
cc	=	causing concern, could be an invited control site
ms	=	regular summer management - drained down
mw	=	" winter " - " "
mh	=	" herbicide " - various
m?	=	management considered
s	=	spreading
con	=	controlled with herbicide, monitoring programme
NGR?=		sites position needs rechecking
pl.	=	planted pond
cr	=	controlled? by removal

APPENDIX III

The Characterisation of the Water Chemistry of Ponds (version to Feb 1990)

On-site characterisation of the water-chemistry of a pond directly enhances an ecological field assessment by providing immediate information to enable the water to be classified or put into context in relation to the

limits for aquatic life,
potential for the growth and abundance of animals and plants
ie the productivity of the water,
requirements of particular groups of animals or plants, and
consequences of excess or imbalance of components through human or other activities eg elevation of plant nutrients from waste waters.

Thus more specifically:

Acidity/Alkalinity - **extremes (<pH4 or >pH10) may limit the presence of aquatic biota;**
whereas
naturally **acid waters** (pH4-7) are characteristic of hard-rock catchments with little aquatic plant growth, low abundances of invertebrate animals and smaller or longer-lived species of fish;
or
alkaline waters (pH 7-10) are characteristic of soft, limestone rock catchments and may have abundant growths of plants, high abundances of invertebrates and fish. pH may increase during the day particularly when aquatic plants (algae or macrophytes) are very abundant, due to the removal of carbon dioxide or bicarbonate from the water during photosynthesis.

Conductivity and carbonate

Carbon is the basic building material of plants and animals. For photosynthesis of plants, the most usable form is inorganic carbon as carbonate and bicarbonate, and these ions, in conjunction with calcium, form the major chemical components of most fresh waters. The likely productivity of a pond can therefore be assessed by measuring its dissolved (ionic) chemical content ie the conductivity of the water.
Thus:
Conductivity - **reflects the productivity of aquatic systems, that is, the abundance and growth of aquatic biota** by indicating, through the total dissolved (ionic) chemical content, the quantity of available inorganic carbon. However,
Care must be taken to separate fresh waters from other high conductivity waters especially salt rich waters eg coastal water bodies etc., by testing directly for sodium, or chloride ions, or by difference through determining either calcium or carbonate, calculating the calcium carbonate content and comparing this with conductivity expressed as a concentration of total salts.

Carbonate is a direct indicator of potential plant production and thus general productivity (see conductivity above).
[Examination of sediments for the smell of hydrogen sulphide ('bad eggs') is also frequently considered a good 'observation' for high plant productivity in some areas, but may be indicator of deterioration or pollution.]

Calcium determinations are used to indicate the form in which carbonate is present (compare the occasional sodium or magnesium dominated waters); this cation is a component of the shells of many molluscs (snails) and crustaceans (freshwater shrimps, etc.).

Plant macronutrients. The presence and correct balance of the three major plant macronutrients, nitrate, phosphate and potassium, is needed for optimum plant growth (in addition to sufficient inorganic carbon as carbonate). Imbalance (nitrogen 10, phosphorus 1, potassium 5-10) and thus limitation of primary production may be deduced from the excess of one and the negligible concentrations of others. Artificial enrichment may be deduced from an excess of all three. A balanced closed system may have a low level of all three but may have abundant plant growth; such low levels also occur in summer when plant growth and the associated nutrient accumulations are at a maximum.

Plant micronutrients. Small quantities of iron and magnesium are amongst other elements needed but which may be limited in availability due to particular conditions. For example, the dissolution of iron, as soluble ferrous salts from the deoxygenated iron-pan soil layer as a result of enhanced or 'lowered' water tables through drainage, may then be precipitated out as insoluble ferric salts in oxygenated waters. Iron may also be lacking in chalk-rich high-pH spring waters through coprecipitation with calcium carbonate, resulting from the loss to the atmosphere of excess carbon dioxide and the inability of the surface water to carry as much carbonate as previously obtained by dissolution of rocks by the elevated pressures of carbon dioxide in the aquifers.

Silicon is required for diatom growth particularly in spring and autumn but although seasonal reductions may occur at these times, redissolution is also an important process.

Toxic metals. Aluminium or zinc are more likely to affect the growth of biota at certain acidities (pH <5) but a full analysis of metals must be considered if unexplained imbalances between potential production and other biota exist.

The analytical precision of these characterisation tests varies from about half a unit interval with test papers ie *c.* 20% on average, down to *c.* 5% for titrations in the field. This assessment procedure is not however a substitute for a representative water sample correctly and fully analysed in a laboratory within a short time of collection.

A progressive series of four stages of water characterisation are proposed which are increasingly detailed and require correspondingly more elaborate test apparatus and take more time but all of which which are compatible with other factors recorded within the National Pond Survey (NPS).

Stage I is the minimum and should always be attempted.

Water samples should represent the whole water body, and ideally, therefore, should be taken from near the centre of the pond in open water away from dense plant stands; additional samples may be required of inflows, seepages or outflows. The time of day when the sample is taken (which should be recorded) is of greater relevance with the increase in Stage of characterisation especially in relation to the dissolved oxygen measurement in Stage III but is pertinent even to the interpretation of pH in Stage I.

Stage I

pH and conductivity

Determination of pH and conductivity of the water sample can provide an estimate of the acidity and total dissolved solutes.

- pH may be measured using an inexpensive **dip-type meter** (available from most laboratory instrument suppliers); calibrate before use and recalibrate daily

or

by **test paper** to within 0.5 units using non-leaching reduced- or narrow-range test papers (eg BDH 4.0-7.0, 6.5-10.0)

-**conductivity** can be measured using an inexpensive dip type meter

or

estimated using test strips for 'total hardness'
(ie alkaline earths but, in practice, calcium plus magnesium)
(eg M 10046, BDH 31540 2L, 3-30 by 5°)

(IF total hardness is greater than 30° suspect the water to be saline; see Stage III).

Water temperature measurement is advisable at the time of collection (to 0.5°C by thermometer, or by electronic meter which is often combined with pH dip-type meters) but temperature is also necessary to correct conductivity determined by meter as these vary by 2-3% for each °C difference in water temperature; the standard temperature is 25°C. Calibration of electronic meters and electrodes should be performed according to manufacturers' recommended procedures (convenient preweighed capsules of pH buffer say pH4, pH7, pH10 ready for dissolution are available). pH and conductivity measurements should be compared to the Table and if their ratio differs from those given, then further Stages of characterisation should be undertaken to define these differences.

pH	<5	5-6.5	6.5-8	8-10	10+
Conductivity μS cm-1 at 25°C					
<50	peat pools	alpine pools		-	-
50-250		lowland clay			
250-400	-	pools		Lowland chalk	Check if afternoon sample from densely
400-1200	-			pools	vegetated pools
1200 +	Check if saline - chloride test Stage II				

Notes

Stage I. The majority of fresh waters in Britain are sufficiently similar to allow conductivity to be a measure of total dissolved inorganic solids. (Total dissolved solids TDS, μS is very approximately equal to 0.65 mg 1-1 but can range 0.55-0.75 for fresh water sulphate or 0.5 for strongly acidic or basic solutions) A multiplier of 0.70 is recommended for the conversion of conductivity (microSiemens cm^{-1} corrected to 25°C) to total dissolved solids (mg l^{-1}). Values between 0.55-0.75 have been suggested (Hem J.D. 1970 see Water Analysis Vol. I Inorganic Species part 1, chapter 4, Ed. Minear R.A. and Keith L.H. 1982, Academic Press, London), but the value towards the upper end of this range was chosen to accommodate the preponderance of carbonate rich waters in the UK (cp sulphate rich waters). This multiplier may be used in Stage III to determine the proportion of the major ions which have been identified.

'Total hardness' test strips have five bands of hardness each of 5° English hardness ie the first is 0-5° and the fifth is 20-25°, but may be estimated to half units of colour change giving 0-3°, 3-5°, 5-8° etc. The multipliers 5.7 and 14.3 can be used to give estimates of calcium plus magnesium, either as calcium to within 3 mg l^{-1} or hardness as calcium carbonate to within 7 mg l^{-1}.

If values are above range of meter or kit, dilutions may be made using deionised water: this can be made conveniently available in the field using water deionising packs (eg Pallintest, Wilkinson & Simpson, Gateshead).

Stage II

If conductivity 1000+

Chloride test (eg simple titration kit Aq 11106, BDH 16535 1H, 2-800 by 2 mg l^{-1} intervals)
if >100 mg l then partly saline and if coastal, consider if pond should be included in survey, or continue Stage II below.

If conductivity 50-1200

Carbonate (hardness) test (eg simple titration kit Aq 8048, BDH 16502 1P, 0.2-80 by 0.2 mmol l^{-1} intervals) (alkalinity = 2 x carbonate hardness).
If >0.5 mmol carbonate then

Calcium test (eg simple titration kit, Aq 11110, BDH 16542 2F, 2-800 by 2 mg l^{-1})
calculate calcium as calcium carbonate (1 mg calcium = 2.5 mg calcium carbonate) and compare to 'total hardness' in Stage I (see notes), if within 20%, accept and assume some magnesium present (or test for magnesium - Stage III).
Nitrate estimate by test strip.

(eg M 10020, BDH 31524 3X, 10-500 mg l^{-1} by 10-250 mg l^{-1} intervals Nitrate,
(multiply by 0.226 to convert to Nitrate Nitrogen).
If <10 mg l^{-1} accept (or test for Nitrate in Stage III).

[If Nitrite test band is positive test for Ammonia - Stage III]
Note: large quantities of plant material may give low plant macro nutrient levels in spring and summer, but these may be elevated in autumn as plant material decomposes. A relatively high level of one of nitrate, phosphate or potassium may typically indicate that one of the other macro nutrients is limiting plant growth.

Dissolved Oxygen - observe pond for fish kills, dense stands of submerged plants at/on surface, dense mats of algae with entrained bubbles or water temperature over 25°C.
If any, assume large daily oxygen changes (or test for dissolved oxygen in Stage III).

If Conductivity <250 or pH <6.5

Observe pond for light brown deposits on substrates or vegetation.
If any, assume iron (or test for Iron in Stage III).

Stage III

Phosphate test (eg two tube colour development slide - comparator method, Aq 14409, BDH special order, 10-160 by 10-30 $\mu g\ l^{-1}$).

Nitrate test (eg two tube colour comparison Aq 8032, BDH special order, 5-140 by 20 $mg\ l^{-1}$)
if >50 $mg\ l^{-1}$ NO_3 or nitrite on test strip positive, test for Ammonia (Aq 14428, BDH 16543 2H, 25-400 $\mu g\ l^{-1}$).

Iron test (eg colour development in test vessel, Aq 11136 or Aq 8013 + 8023, BDH 16504 1T with 16505 1V, 0.1-50 $mg\ l^{-1}$). Total and bivalent ferric iron.
[if iron present and unexplained absence of fauna or poor plant growth - test for Aluminium or Zinc in Stage IV]

Magnesium test (eg two tube colour comparison method, Aq 14419, BDH special order, 4-30 $mg\ l^{-1}$).
if magnesium >10 $mg\ l^{-1}$ and higher than calcium test for Sulphate (eg Aq 14411, BDH special order, 25-300 $mg\ l^{-1}$).

Dissolved Oxygen test by fixation and titration (eg Aq 11107, BDH special order, 0.1-30 by 0.1 $mg\ l^{-1}$).
Water samples should be collected **either** by minimising exchange or entrainment of air by slow and careful filling of sample bottle **or** by flow through a tube to the bottom of the sample bottle inside a larger (x3) chamber with an outlet hole on its top. If access to the water is difficult then a tethered buoyed bottle-sampler may be thrown to a suitable part of the water body; the sampler consists of an outer weighted container with two openings, from one of which a tube passes to the bottom of the sample container and allows changes of water (*c.* 3) from the water body.
Measure water temperature at sampling time.
If <5 $mg\ l^{-1}$ in morning
or >15 $mg\ l^{-1}$ in afternoon, then potential for fish kills.
Consider dawn and mid afternoon samples in summer.

Sodium and Potassium (Group 1 metals)

assume present and sufficient for plant growth if conductivity is high or assume they are present as potassium and sodium chloride and estimate from chloride titration using meter conversion;
(or send sample for analysis).

Stage IV

If low pH (<4.5) consider testing for

Aluminium (eg
Zinc test (eg Aq 14412, BDH 16534 1F, 0.1-5.0 mg l^{-1})
or send water sample (and biota) for full analysis for metals.

If conductivity >50

Silicon test, a requirement for the diatom algae (eg

All conditions

IF fish kills, low invertebrate numbers, absence of plants
consider - intermittent discharges of chlorine containing waters (eg chlorine test)
- pesticides (eg
- variable inflows of water of low oxygen or high oxygen demand
- extremes of pH
- toxic metals

Coliform tests at 37 and 20°C
Biological Oxygen Demands 5 Day BOD (as dissolved oxygen in Stage III).

No endorsement is implied by the inclusion of specific products but merely that satisfactory results and relevant accuracies have been obtained by their use.

(Numbers refer to Merck catalogues Aq = Aquamerk, M = Merckoquant test strips, with BDH catalogue number following as, eg BDH 123.)

Table On-site characterisation of water sampled during the site surveys

River
Site
Distance downsteam, km
Channel width at bank full
Channel depth at bank full
Water depth
Water velocity, m s^{-1}
Substatum size, cm or silt
WATER CHEMISTRY
pH
Temperature ^{o}C
Conductivity $\mu S\ cm^{-2}$
Water colour
anions
Bicarbonate alkalinity meq
Chloride mg l^{-1}
Sulphate mg l^{-1}
Nitrate N mg l^{-1}
Ammonia mg l^{-1}
Phosphate P $\mu g\ l^{-1}$
Silica Si mg l^{-1}
Total anions mg l^{-1}
cations
Calcium mg l^{-1}
Magnesium mg l^{-1}
Sodium (by probe) mg l^{-1}
Potassium mg l^{-1}
Iron total mg l^{-1}
Lead mg l^{-1}
Cadmium mg l^{-1}
Zinc mg l^{-1}
Aluminium mg l^{-1}
Total cations
Comments

APPENDIX IV

'Crassula Watch', Numbers 1, 2 and 3.

No.1 **CRASSULA WATCH** Nov.1987

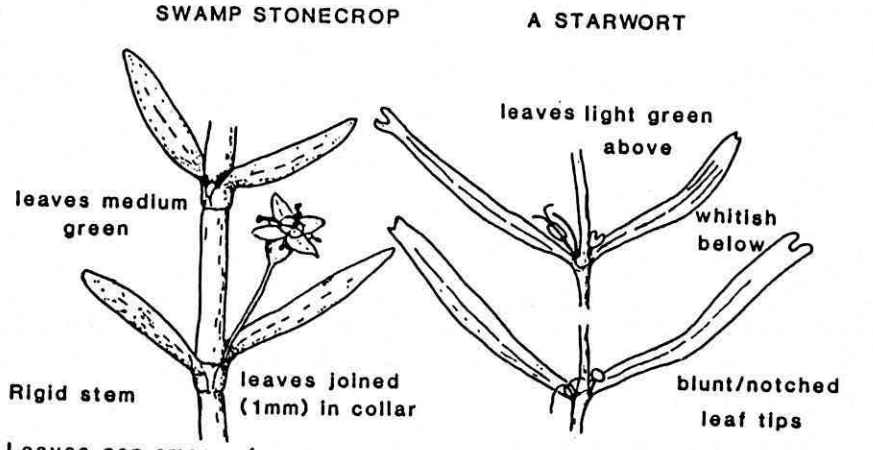
CRASSULA HELMSII HAS INVADED 140 SITES AND NOW DOUBLING EVERY THREE YEARS

THE ALIEN AQUATIC CRASSULA HELMSII

CONTINUES TO EXPAND ITS DISTRIBUTION IN BRITAIN

Further occurrences of C. helmsii (T. Kirk) Cockayne continue to be recorded and the total number has now reached c. 140 sites (late 1987) with fourteen nature reserves or national parks affected to a lesser (0-10 m^2) or greater (12 site occurrences up to 400 m^2 extent). The spread of the plant within sites appears to be greatly variable and has caused widely differing degrees of concern. The previous suggestion that extreme measures of control should be considered, i.e. the use of herbicides in nature reserves, continues to be discussed and selective trials begun; formal recommendations for the best control technique may soon be available following the probability that trials will be financially supported by NCC. Meanwhile the mechanisms of its spread and the effects on the suppression of native flora and fauna, particularly amphibians, continue to be recorded (for BSBI Bulletin 1988).

Fig1.



see also Richards, BSBI News 1979 20-21; Vaughan, BSBI News 1978 19 10-11; Swale & Belcher, Nature in Cambridgeshire, 1982 25 61-62.

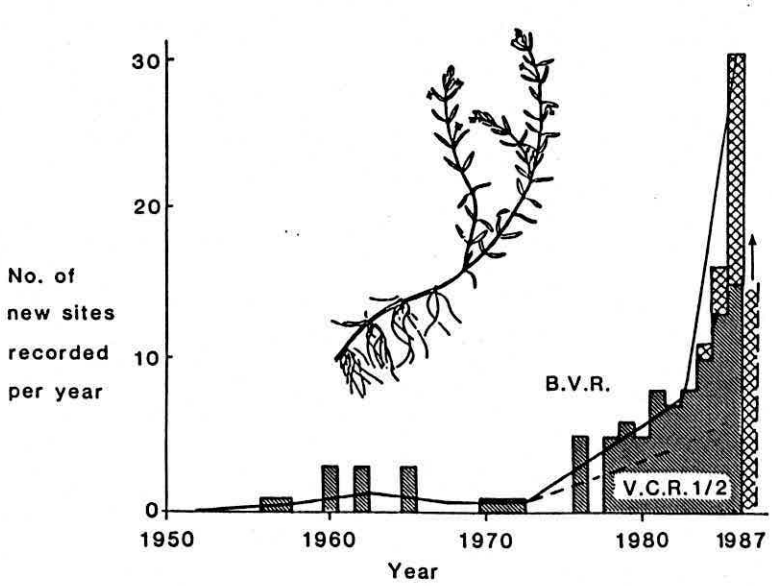
Can you help with

New Records?
Update of distribution at known sites?
Detail of floral or faunal changes (loss)?
Sites for herbicide and other control trials?
Personal experiences of control of the plant?

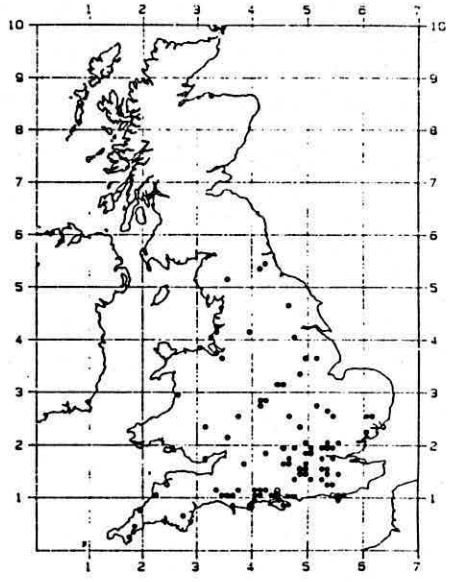
Regular updates will be sent to those participating.

F.H. DAWSON
Freshwater Biological Association, River Laboratory, East Stoke, Wareham, Dorset, BH20 6BB.

0929-462314 (or evenings 09295-3325) (Postage etc refunded if requested.)



An update (cross-hatching) of the annual total of reported occurrences of Crassula helmsii for Britain to Nov. 87 (solid line is 5 year mean, the dashed line is first and second vice county records only).



The distribution of Crassula helmsii in Britain to Nov. 1987 at natural or semi-natural sites.

CRASSULA UPDATES

- 1985 Variously misidentified samples arrive for confirmation; D.F. Westlake suggests Crassula, Max Wade supplies information; undergraduate student sought to assist in field and experimental work appointed for 6 months in 1986.

- 1986 Vice county recorders and others circulated for records; field work commences; growth experiments in tanks and flowing waters. Field survey reveals problems in fishing lakes and nature reserves (P.B.). Poster at BSBI Nov 86 with handout about rapidly increasing distribution.

- 1987 Paper prepared on results.

- FHD interviewed at FBA Open Days. Numerous articles, radio and TV interviews follow:

  Australian invader threatens Britain's waterways - New Scientist
  Waterways may be strangled by rash squeeze - Independent
  Slimy green menace is slowly taking over - Reading Evening Post
  A threat to the pond? - Editorial, Horticulture Week
  Alien from the Swamp - Daily Mail; Weed threat warning - Anglers Mail
  Threat to Forest Ponds - Lymington Times; War of Weeds - Telegraph
  County under threat from the strangler - Gloucester Citizen
  Menace from the swamp - Guardian; The spread of Swamp Stonecrop - NERC News
  Hostile Aussie invader causes concern in Britain - Australian Mercury
  Concern over spread in Britain - will it invade North America?
  - Aquatic Plant News, U.S. Lakeline

- FHD Objectives for future
  1. Confirm the distributional status, extent of invasion and suppression of native flora and fauna
  2. Establish the dispersal mechanisms and vulnerability of sites at the local and regional level
  3. Determine the potential habitat range, genetic variation and seasonal cycle through extending the study of its biology
  4. Develop effective control techniques and programmes compatible with the aims of nature conservation

  (- full details available).

Fig. 2 Expansion of distribution in 5 year intervals
(o = current period; o = previous records)

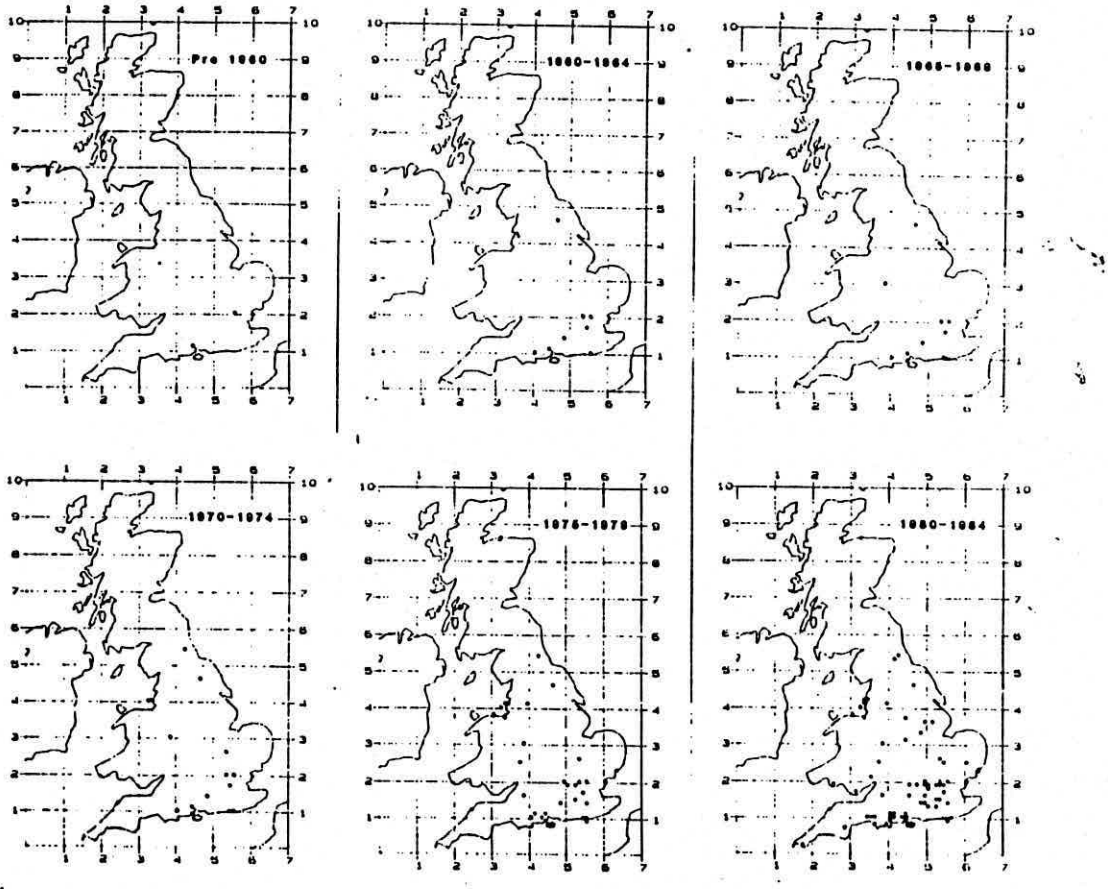


Table 1. The aquatic areas of Hatchet and Little Hatchet New Forest

species potentially at risk (from A.Byfield)

- Ludwigia palustris
- Galium debile
- Illecebrum verticillatum
- Pilularia globulifera
- Cicendia filiformis

and possibly

- Apium inundatum
- Mentha pulegium
- Polygonum minus
- Ranunculus tripartitus
- Eleocharis acicularis
- Elatine hexandra

but also at other sites

- Limosella aquatica
- Pulicaria vulgaris

THE FUTURE

1 Trials begin to select best approved herbicide for control (this is likely to be supported financially by NCC)

2 Organise monitor or coordinate control study sites

3 Monitor changes / loss of flora fauna and habitat

4 Request (1)new records (2) status of existing sites (3) maintain distribution record cards and (4) success of control attempts

5 Establish advice-point,produce recomendations for control

Should sales of C.helmsii (Tillaea recurva) be banned?

Should movement of this plant be restricted?

Join in CRASSULA WATCH and keep in touch

Will it grow in semi-saline conditions?

AN INITIAL STUDY ON THE DISTRIBUTION, BIOLOGY AND CONTROL OF CRASSULA HELMSII (based on a paper by Dawson F.H. & Warman E.A. in Biological Conservation 42, Nov. 1987)

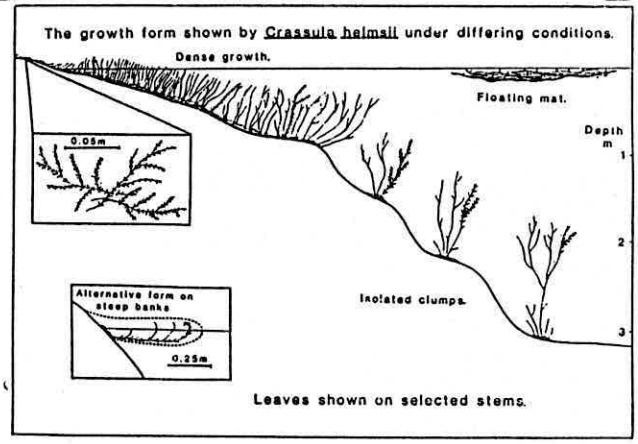


Fig. 4

The growth form of Crassula helmsii in different water depths with internode frequency and leaf size indicated on stems. Scales insets indicate (a) marginal growth and (b) stand form of steeply-inclined banks or bed, shown here at the surface.

Swamp stone crop, Crassula helmsii, a plant alien to Britain and Europe, has rapidly expanded its distribution over the last two decades. Concern has grown because several of these natural sites are in nature reserves where both common and rare native species are rapidly outcompeted by its dense monospecific stands which often continue to dominate throughout the winter months (Table 1). Its occurrence can easily be overlooked (compare e.g. Himalayan and Orange Balsams) as it resembles Sphagnum moss cover in swamps and Starworts (Callitriche spp.) in lakes (Fig. 1). Attempts at control, particularly mechanical, have had only limited success because its potential for vegetative regrowth is very high - each minute node producing at least one and sometimes two new shoots; it has even outcompeted species of Elodea, Nuphar and Phragmites. Concern was greater when it was realised that it is less demanding in its habitat requirements and as such occupies a greater habitat range than previous invasions of alien plants e.g. Elodea spp. It has so far dominated wetland areas of several acres ranging from 0.7 m above water levels, particularly in shallow seasonal ponds of acidic water, to depths of 3 m in lakes of calcareous water (Fig. 4). Plant size varies from compact stands of 0.1 m to large submerged ones of 1.3 m. Biomass is always high, ranging from 0.3 to 1.5 kg dry weight m^{-2}. It is currently confined to static waters but has been shown, experimentally, to grow in moderately fast flowing waters.

The initial occurrences in britain have been sporadic but may be related to its supply for aquaria and garden ponds as an 'oxygenator-plant', because of its vigorous growth and tolerance of varied growth conditions. It is similar in appearance to Crassula (Tillaea) aquatica, a very rare plant remaining in only a single area in Scotland but it can be distinguished because its flower stalks are relatively long (2-8 mm).

Considering the high reproductive potential, rapid spread and the difficulty of control of this variety (?), it is currently recommended that extreme measures are used to prevent its further spread, particularly to further nature reserves, and the invasion of flowing waters.

This initial study suggests that this plant will continue to expand its distribution very rapidly and could become a major problem in aquatic situations including flowing waters and therefore requires further intensive study of its ecology, biology and control rather than its distribution but with particular regard to the development of more aggressive strains for which there is already circumstantial evidence.

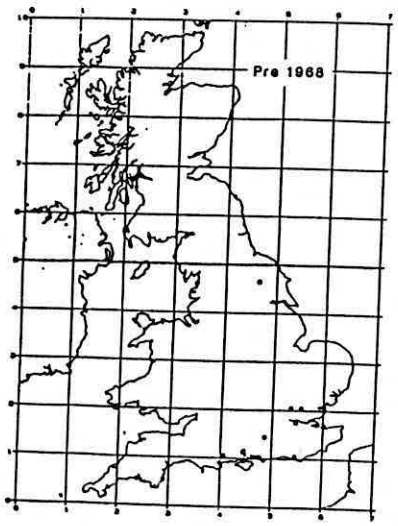
No.2 CRASSULA WATCH Nov.1988

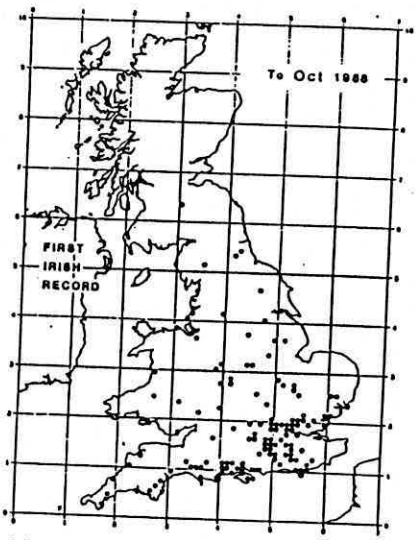
60 MORE SITES THIS YEAR

CRASSULA HELMSII (Tillaea recurva)

has now invaded 200 sites/areas

doubling rate for NEW sites – two years





Increase in last 20 years

The aggressive alien aquatic continues to expand its distribution to sites both in its existing areas and to new sites in Britain. Sites so far investigated (see inside) suggest that this plant's occurrence at sites adjacent to those at which it was initially recorded have been overlooked. A record for one site was subsequently found to have eight different independent stands within a half mile.

THANK YOU TO ALL THOSE WHO HAVE SENT RECORDS

Updates will be sent to all those participating.

F.H. DAWSON
Freshwater Biological Association, River Laboratory, East Stoke,
Wareham, Dorset
Tel. 0929 462314 or Fax 0929 462180 (Postage etc. refunded if requested)

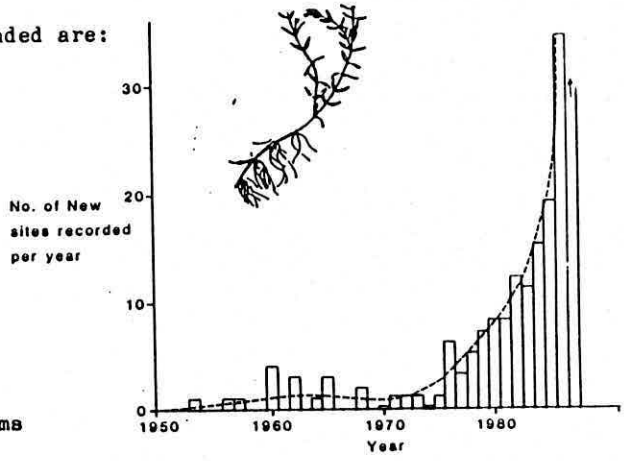
Analysis of the records show the type of sites invaded are:

15% nature reserves or SSSIs (24 site/areas)
27% ponds in farms, parks or private gardens
2% near or in cultivation
3% 'no longer present'

53% other - unspecified natural sites

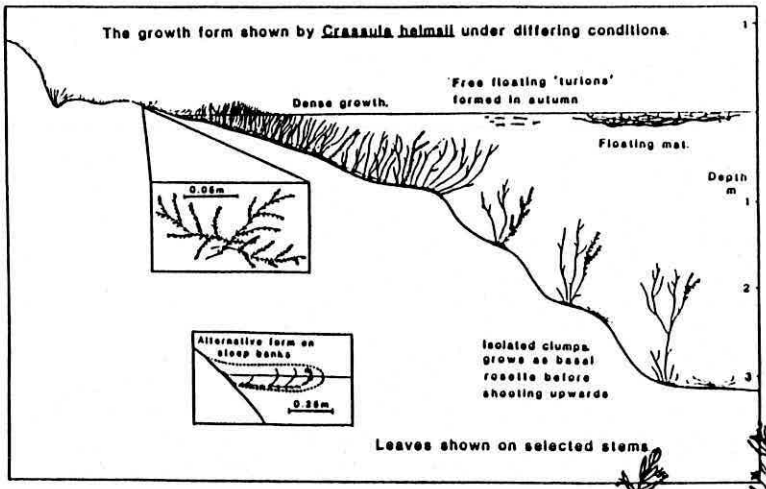
or by the type of water body

72% small ponds - many seasonal
11% large lakes, reservoirs etc.
6% shallow sand or gravel-pit lakes
5% linear shallow ditches or drainage channels
5% in or near flowing channels, canals or streams
1% damp ground



IS THERE ANY EVIDENCE THAT CRASSULA WILL BECOME LESS AGGRESSIVE AND FORM PART OF THE NATIVE FLORA?
The answer so far seems to be generally NO. At sites at which this regression was thought to have occurred Crassula helmsii has again rapidly re-established its dominance.

AN INITIAL STUDY ON THE DISTRIBUTION, BIOLOGY AND CONTROL OF CRASSULA HELMSII (based on a paper by Dawson F.H. & Warman E.A. in Biological Conservation 42, Nov. 1987)

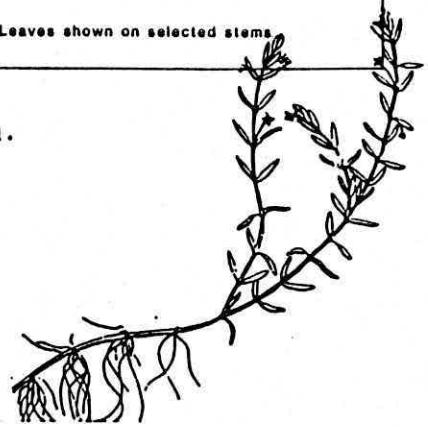


The growth form of Crassula helmsii in different water depths with internode frequency and leaf size indicated on stems. Scales insets indicate (a) marginal growth and (b) stand form of steeply-inclined banks or bed, shown here at the surface.

Sites visited for detailed study

- pool, N. Cornwall, by stream, slightly saline 3-9%.
- pond, Newton Abbot, adjacent to NR, nutrient or depth limited.
- seasonal pond N.T. land, Corfe Common.
- fishing lake to 3 m, comparative herbicide trials.
- ponds in New Forest. Flame throwers - A. Byfield.
- pools, Fingeringhoe Wick NR; good growth even in shade.
- ponds and ditches Ynyslas NR; probably controlled (O)

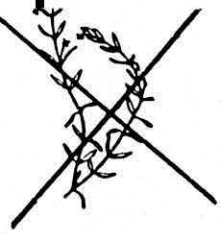
Preliminary isoenzyme study suggests only one 'strain' or little inherent polymorphism.



PREDICTION FOR INVASION

WILL CRASSULA GROW IN SEMI-SALINE CONDITIONS E.G. ESTUARIES?
Preliminary tests indicate that the growth of stems of Crassula decreases with increasing salinity. Growth ceases at salinities of about half seawater but this plant can survive at higher concentrations when supported by its dead stems or on other plants. Crassula may also survive periodic inundation by seawater such as occurs at spring tides.

SOME ATTEMPTS AT THE CONTROL OF THE ALIEN AQUATIC CRASSULA HELMSII



- USE OF FLAME THROWER
  - inefficient, laborious and expensive

- HERBICIDE TRIALS with Approved aquatic herbicides
  - Tank Trials
  - Field Trials

Autumn Trial Results: 0 = control ; u = partial control

Chemical	Terrestrial bracken	Terrestrial dock	Marginal mono-cot	Marginal di-cot	Aquatic free floating	Aquatic sub-merged	Algae
Herbicides							
asulam		x					
2,4-D amine			x	x			
dalapon			x				
dichlobenil						(x)	
diquat					(x)	(x)	(x)
+ alginate						(x)	
glyphosate		x	x	(x)			
terbutryne					x	x	(x)
chemical							
hydrogen peroxide				(x)	(x)	(x)	(x)

Application time - months

J	F	M	A	M	J	J	A	S	O	N	D
			x	x	x						
				x	x	x					
			x	x	x	x	x	x			
			x	x	x	?					
x	x	x	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	x	x	x
						x	x	x			
							x	x			

Methodology

(a) Tank trials of submerged/emergent stands with all Approved herbicides

(b) Field trials of best herbicide over wide geographic and habitat range

(c) coordinate other attempts, synthesise results, produce guidelines

(d) maintain records assess expansion rate, identify potentially new habitats

PRELIMINARY GUIDELINES

Small areas, $< 20m^2$

- use shade material, 6-10 weeks

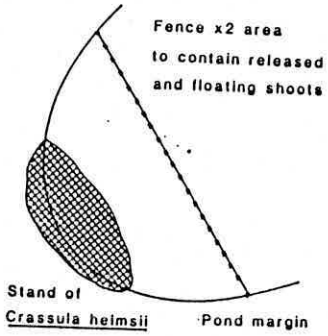
Medium areas, $20-1000m^2$

- fence with fine mesh and treat with approved aquatic herbicide in autumn or spring

OR shade

Large areas, $>1000m^2$ or 25% of water body

- reduce Crassula bulk and compost on-site
- treat emergent and submerged growth with Approved aquatic herbicides
- reintroduce previous flora from less affected part of water body



All areas must be monitored quarterly for up to 5 years.

Control may need to be repeated up to 3 times

Herbicide control aspects are funded by The Nature Conservancy Council

Crassula helmsii is in tissue-culture in Florida - 'to say (this plant) grows like a weed is a gross understatement'

THE FUTURE

1. Guidelines for control ready next summer
2. Study sites continue to be monitored. Native sites to be studied in Australia (FHD, under Winston Churchill Travelling Fellowship 1988/89)
3. New records, status of existing sites, success of control techniques and advice, will continue to be collected or coordinated
   New records and site status always wanted.
   Should sales of C. helmsii (Tillaea recurva) be banned?

THE ALIEN AQUATIC CRASSULA HELMSII CONTINUES TO EXPAND ITS DISTRIBUTION IN BRITAIN

Further occurrences of C. helmsii (T. Kirk) Cockayne continue to be recorded and the total number has now reached c. 140 sites (late 1987) with 14 nature reserves affected to a lesser (0-10 metres square) or greater extent (12 site occurrences up to 400 metres square). The spread of the plant within sites appears to be greatly variable and has caused widely differing degrees of concern. The previous suggestion that extreme measures of control should be considered, i.e. the use of herbicides in nature reserves, continues to be discussed and selective trials have begun; formal recommendations for the best control technique may soon be available following the probability that trials will be financially supported by NCC. Meanwhile the mechanisms of its spread and the effects on the suppression of native flora and fauna, particularly amphibians, continue to be recorded.

Botanical Society of British Isles (BSBI) News
Sept. 1988 No. 49 p. 43

SOME ATTEMPTS AT THE CONTROL OF THE ALIEN AQUATIC CRASSULA HELMSII (T. KIRK) COCKAYNE

Various attempts to control C. helmsii have been studied but as even more occurrences (currently 200, November 1988, with a doubling rate of every two years) have been recorded, a specific study on control by herbicides has been initiated. Initial tank and autumn field trials of all available Approved aquatic herbicides have shown the particular resistance of emergent stands with only glyphosate producing any noticeable degree of control. The growth of submerged stands were however rapidly suppressed using diquat and diquat-alginate although buds on separated shoots started to regrow over subsequent weeks before finally dying, whereas treatment with dichlobenil required 1-2 months to become effective. The commercial chemical hydrogen peroxide was also tested at 20 and 100 g m^{-3} because the absence of toxic or long-term residues made it suitable for nature reserves; growth was unfortunately only suppressed temporarily. Field observations on other techniques such as shading material (successful) and flame throwers (laborious, expensive, and not effective), were studied and some preliminary guidelines for control of sites with differing degrees of dominance by this plant have been produced.

Presented at the Annual Exhibition of BSBI
26th November 1988

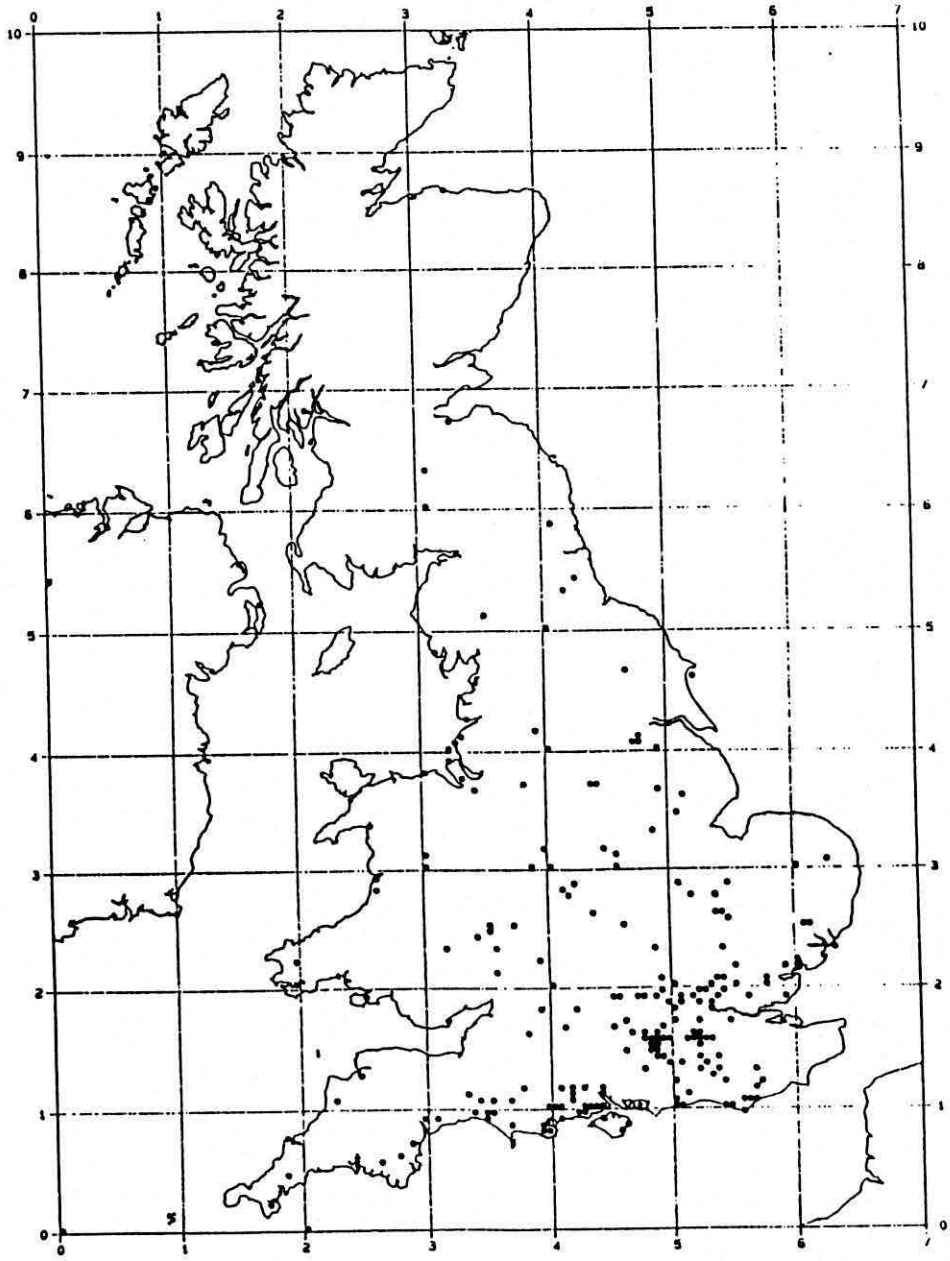
This PLANT'S INITIAL OCCURRENCE CAN EASILY BE OVERLOOKED but it rapidly produces dense monospecific turfs over 10-100's m^2. These suppress existing flora as the plant begins to dominate larger aquatic areas both above and below water. Any further records of suppression of flora or the possible effects on fauna especially frogs, toads or dragonflies or damselflies, would be most welcome.

/

No3 CRASSULA WATCH Nov 1990

270 sites now recorded for Crassula helmsii in Britain

doubling rate for NEW sites 2 – 3 years



Australian Study Shows – Britain is in the Middle of the plant's Environmental Range

THE SPREAD OF *CRASSULA HELMSII* (KIRK) COCKAYNE IN BRITAIN

Dawson F.H. (submitted) The spread of *Crassula helmsii* (Kirk) Cockayne in Britain. (Based on a paper given to Industrial Ecology Group BES on the biology and control of invasive plants, University of Cardiff, 20-21 September 1990)

1. *Crassula helmsii*, an amphibious aquatic plant, has invaded *c*270 natural sites (mid-1990) and invasion of *c* 1000 sites are predicted by 2000 AD.

2. Preliminary morphological and isoenzyme examination indicates that this likely to be only a single strain in Britain.

3. The present distribution based mainly upon information from vice-county recorders indicates that the spread of the plant has been less from natural factors eg animals than from mans activities. There have been deliberate introductions although passive distribution with other water plants, recreational and associated activities particularly fishing and fish transfer and reintroduction of amphibians and reptiles seem to be common, albeit nearly unconfirmable, modes of spread.

4. The predicted rate of invasion is made difficult by several factors including the initial lack of information for identification, confusion with another common water plant, followed by an increase in initial interest for new vice county records followed by a decline and subsequently awareness of the problem stimulated further interest.

5. The growth form and morphology of the plant in its various habitats and its competitive mechanisms together with an analysis of the type of water bodies invaded, are discussed together with a prediction that the majority of temporary and permanent ponds and probably together with drainage channels and some streams in Britain and Northern Europe will be rapidly invaded.

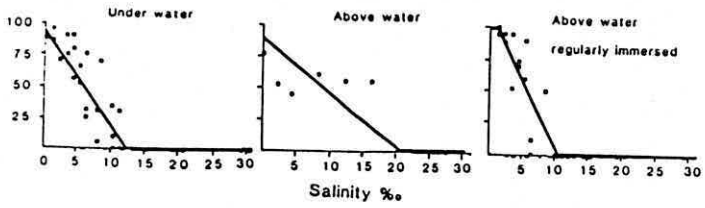
NERC Institute of Freshwater Ecology River Laboratory, East Stoke, Wareham, Dorset, BH20 6BB Tel. 0929-462314, Fax. 0929-462180

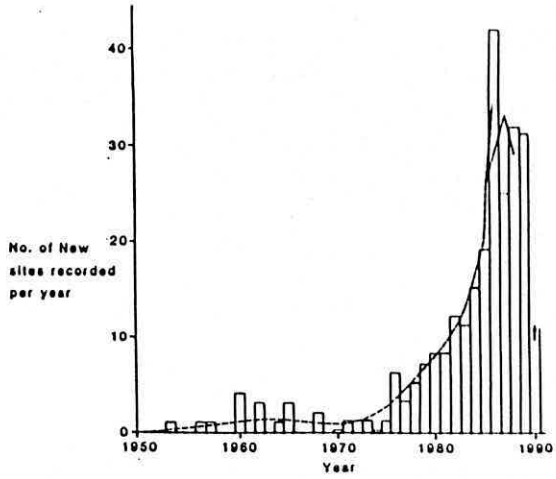
Table 1. Occurrence of *Crassula helmsii* in sites in Britain by (a) type of water body and (b) adjacent land use for sites, in the years to mid 1988 (190 sites) and to mid 1990 (270 sites)

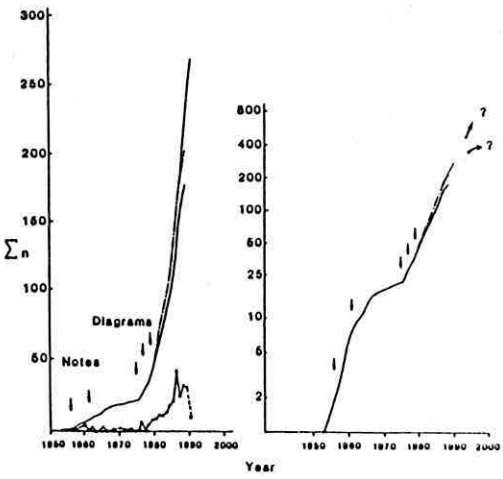
(a) Occurrence by water body	Percentage occurrence mid '88	mid '90	Public Access
small ponds (30% temporary or drying)	70	62 *	variable
tanks		4	restricted
shallow gravel sand or clay lakes	6	7	variable
large lakes or reservoirs	11	9	open/closed
Linear watercourses near static	5	10 *	open
Linear watercourses, flowing (or on banks)	5	4	open
damp ground, marsh	1	2	variable
in cultivation	2	2	closed

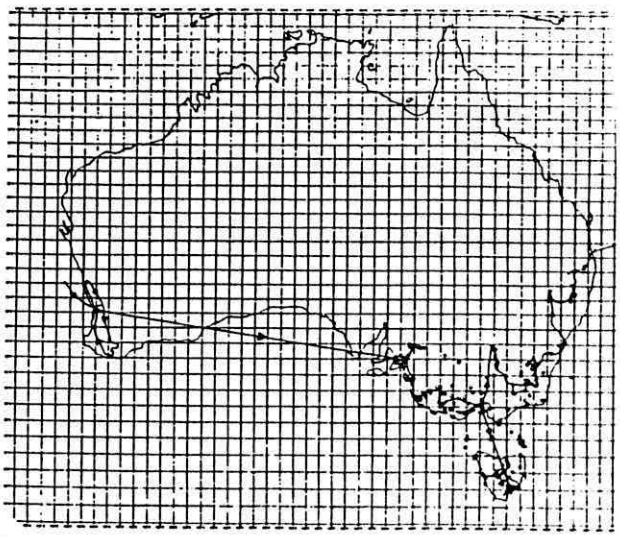
(b) Occurrence by adjacent land use	Percentage occurrence mid '88	mid '90	Public Access
Nature reserves, SSSIs, etc	15	16	restricted
Natural or semi natural areas	55		open
Common land (& woodland)		12	open
Parks, estates, country houses, moats	28	16	restricted
Agricultural land		21	restricted
Private gardens		12	closed
Industrial, extraction of gravel, clay		11	closed
Reservoirs, large tanks		6	closed
Fish & ornamental ponds		4	variable
in cultivation	2	2	closed

Salinity tolerance of shoots, •after 15 days •after 37 days









New records and site status always wanted.

Institute of Freshwater Ecology

Natural Environment Research Council

THANK YOU TO ALL THOSE WHO HAVE SENT RECORDS

Updates will be sent to all those participating.

(Postage etc. refunded if requested)

The distribution and natural habitat of Crassula helmsii in Australia

Summary from Dawson F.H. (1989) Natural habitat and population control mechanism of *Crassula helmsii* (Australian Swamp Stonecrop) in Australia. Report to the Winston Churchill Memorial Trust, 33 pp.

The distribution of this plant in Australia has been confirmed as extending from the east of South Australia to the West coast, from near the south of Tasmania to a little further north in New South Wales than previously considered but not into Queensland. The distribution records for the plant in Western Australia has not been satisfactorily explained although it could have been accidentally introduced from the eastern coast as indicated by its ability to spread by seed or fragment by its distribution around saline estuaries and by experiments on the saline tolerance of its stems.

The plant has a simple basic form but still shows a variety of leaf form which vary in proportion from narrow to broad with blunt to tapering tips, and in flower colour with at least one red flowered form in contrast to the normal white. The plant size and habit varies with its environment but under optimum conditions ariel stems with support of the vegetation may be up to 0.4 m high.

The plant can grow in a variety of habitats from intermittent or drying streams and ditches , to lake margins from underwater to several meters above the water level in particular circumstances. It can tolerate reasonable degrees of interferences such as trampling by cattle, erratic river flows but not saline or hypersaline conditions unless it can become established in freshwater conditions and grow above levels of saline inundation. It is able to colonize areas rapidly e.g. following fire but does not seem to be able to withstand competition from large plants such as reeds (e.g. the situation in Britain). There are distinct associations of plants which are often found at sites where it frequently , occurs. Its habitat requirements overlap with those of Myriophyllum pendunculatum in the cooler south,east and at higher altitudes, with another emergent species of Myriophyllum in the north and probably with its close relative Crassula natans in the west.

Analysis of habitats in which this plant is found suggests initially that it prefers to grow at water level but can tolerate varying water levels of many meters in moist conditions. It cannot tolerate high velocities but will develop in channels subject to such velocities during periods when the flow is slow. It will grow near but not in sea water in estuaries. It will grow at all altitudes up to C. 1500 m in Australia; the influence of frost or snow was not determined although the plant is known to have some resistance to frost. It will tolerate a variety of water qualities from those of low conductivity to those slightly saline with a range of nutrient levels but not if very polluted.

Although many populations of C. helmsii were examined for potential biological control agents i.e. animals or micro-organisms none were actually found and indeed the main limit to growth in Australia seemed to be drying. It was reported verbally that a looper caterpillar was seen sitting upon plants in South Australia and this is being investigated. The tentative conclusion to the wide spread invasion of British wetland sites is that these sites offer near optimum environmental conditions for Crassula helmsii growth on a near continuous basis with little cessation or die back, and continued presence throughout the winter Australian sites reach the optimum condition but some do exist and closely resemble those sites colonized in Britain. Further careful examination of the data from specific areas remains to be undertaken when the area of origin of the British strain of Crassula helmsii has been resolved.

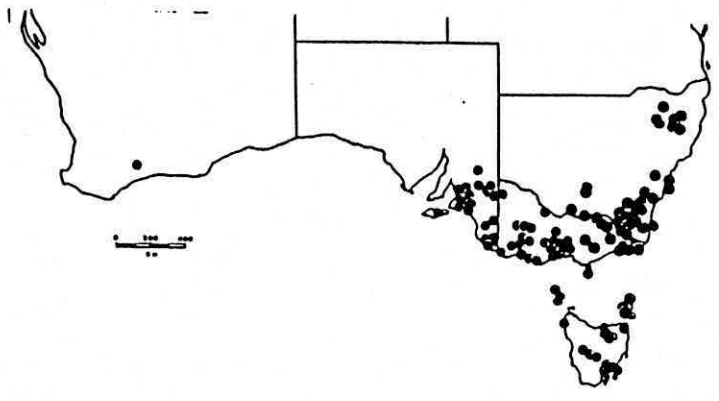


Figure 1. The distribution of Crassula helmsii
(from Toelkan 1981)

APPENDIX V

Proposal to The Essex Naturalists' Trust Limited 28.6.1988

Proposal for testing the efficacy of aquatic herbicides in the control of the alien aquatic *Crassula helmsii* - Australian Swamp Stonecrop in Fingeringhoe Nature Reserve

Following the recent rapid invasion by this alien aquatic of the aquatic areas of several nature reserves, there has been a consequential loss of native flora through overgrowth by its dense swards. The Freshwater Biological Association has been commissioned by the Nature Conservancy Council to investigate its control by approved aquatic herbicides and to produce guidelines for their use. A variety of sites both geographic and morphometric, are required for tests in view of the catholic nature of the growth of this plant (see Dawson & Warman 1987, Biological Conservation 42, 247-272). The trout pond area of the lake represents both the easternmost site in the U.K. and one with a dense but unrooted and floating overgrowth of this plant; there are in addition considerable underwater stands of this plant distributed throughout the lake.

Subsequent to tank trials at the River Laboratory, it is proposed to undertake comparative field trials in the trout pond area of the lake in the reserve. These trials will be conducted in accordance with good practice as set out in the current guidelines (MAFF B2078, copy with the Warden). Thus the aquatic herbicides below would be applied in duplicate during August to strips of 4 m in width and from the margins towards the middle of the pond; strips will be separated by buffer zones.

2,4-D Amine - a selective herbicide for dicotyledonous plants
Diquat - a non-selective contact herbicide
diquat alginate - as above but in a gelatinous formulation allowing attachment underwater
glyphosate - a broad spectrum herbicide

In addition a test with a commercial chemical, hydrogen peroxide, previously shown to be effective in certain conditions, would be undertaken; the particular importance of this chemical is the absence of toxic or accumulating breakdown products.

Assessments will be made 2-3 weeks, 2-3 months and during the spring following herbicide application. Subsequently, next spring it is proposed (funding permitted) to apply in a similar way the following herbicides:
Dichlobenil - a broad spectrum herbicide absorbed mainly through the roots and acting upon growing tips
Terbutryne - a broad spectrum herbicide
The use of a shading material will also be demonstrated to show its role in the control of this plant in small areas of the lake; this will be primarily undertaken in response to local interest.
These field trials are undertaken firstly to determine the effectiveness of approved herbicides in a range of field conditions before, secondly, undertaking joint programmes aimed at eradicating this plant from particular aquatic areas. During this second stage the consequences of removal and the need for replanting or the effects of recolonisation and the role of the seed bank in restoring natural flora will be considered in more detail.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