DISCUSSION.

Present Status of the BSBI records.

There are numerous ways the data can be compared (described below) and these are as follows but to help understand the reasoning a clear distinction has been made between a SITE and a RECORD. This distinction was made in Box 1 (Page 3). **In summary a site is one 6 figure grid reference and a record is another record within the same 6 figure grid reference:**

1. There were 100 BSBI sites and records having a 6 figure grid reference, of which 12 were duplicates having the same grid reference but found in different years and 9 were duplicates of records for the same year (Table 2). Thus in this example only 79 sites were in reality recorded. In the present survey only 18 (23%) of these sites were found to contain *Potamogeton acutifolius.* This suggests a marked decline in the status of *Potamogeton acutifolius,* with a loss of 77% of the former sites. However this straightforward comparison gives a false impression of the present day status of *Potamogeton acutifolius.*
2. The second example uses an alternative form of reasoning. In total there were nine duplicated records having the same year and the same 6 figure grid reference, for example the Norton Marshes had three records for 1972 and two records for 1989. In this example it has been assumed that the duplicate records in one particular year were all observed by one recorder on the same visit and they were either along the same ditch or probably in a different nearby ditch but that they were all found within the same 6 figure grid reference i.e. 100m square. In Table 2 there are 12 Duplicate BSBI records, duplicating a site in different years and these could be excluded in any comparison of losses, giving a total of 88 sites and records. In the present survey, 12 additional records were found covered by the 18 sites each representing a BSBI site. Thus it can be argued that the present survey contains 30 sites and records having the same 6 figure grid references as the BSBI records. Thus 30 sites and records out of 88 past sites and records gives a 66% loss of sites and records rather than a 77% loss of sites.
3. However both these comparisons may still under-represent the overall status of *Potamogeton acutifolius* as there were 23 New Sites found whilst searching for the BSBI sites. Of these 23 sites, 3 sites each had an additional record falling within the same 6 figure grid reference (Table 1). All of these 26 sites and records were found close to a BSBI site. Thus a much more realistic picture of the status of *Potamogeton acutifolius* is a comparison between 56 sites and records to the 88 past sites and records. This gives an overall 36% loss of sites and records.
4. These arguments could be extended further such that it is wrong to exclude the 12 sites, which were duplicates of the same site but recorded in other years. The reasoning is that these sites found in different years, could be in different ditches but they still come under the same 6 figure grid reference. Thus, and perhaps, the best way of comparing the BSBI records with the present day survey is to compare 100 sites and records against 56 sites and records. This gives an overall loss of 44%.

Whichever argument is preferred all suggest varying degrees of decline from the extreme, one of a 77% decline, to the least extreme one of a 36% decline but the most logical comparison gives a loss of 44% of the BSBI sites and records. Whichever is the correct interpretation all declines give cause for concern. It should be noted that the six records found to represent three 1km Squares (Table 2) are not included in the comparison as there is uncertainty over how many BSBI records should be included to represent these and all the other squares.

The losses overall whilst of great concern fail to take into account some easily reversible factors which would bring back many of the "lost" records for a selected number of sites. It is unlikely that plants will be found again at Shortwood Common, Staines, Lancing, Berwick, the Rother Levels and the River Rother unless there are some remarkable changes in **water quality, water levels and management.** For all the other sites only one of these factors might need to be altered to see the return of *Potamogeton acutifolius* since the present survey potentially has resulted in a better understanding of its ecology. The data collected on such issues as management factors, water quality and water quantity (Appendices 2 to 7) will need to be statistically analysed to give credence to the subjective appraisal discussed in the section on the Ecology of *Potamogeton acutifolius*. It should also be noted that *Potamogeton acutifolius* has robust and very dominant populations at Cantley, Norfolk, the Pevensey Levels, the Amberley Wild Brooks and the Pulborough Brooks.

The Squares.

A number of records were only represented by either a two or four figure grid reference (Appendix 1). These 1km and 10km squares were either visited on a random basis if the number of ditches found in any one square was large or if only containing one ditch then that ditch was surveyed. The details of these searches for *Potamogeton acutifolius* are given in the "Site Descriptions" and the results are summarised in Table 1. Only two of the five 1 km squares at Amberley Wild Brooks, West Sussex, were found to contain records of *Potamogeton acutifolius.* It was recorded in the square for the Pulborough Brooks, West Sussex but only in two of the eight 1km squares representing the Pevensey Levels, East Sussex. It was not recorded at all in the two 1 km squares at Limpenhoe in Norfolk. These results are disappointing but Amberley Wild Brooks and the Pevensey Levels are large areas and a thorough ditch by ditch survey of these areas is recommended. There is little doubt that *Potamogeton acutifolius* does occur in squares F, G and H at the Amberley Wild Brooks. It was recorded, albeit not extensively, in these squares in a previous survey by Abraham (1998). *Potamogeton acutifolius* was found on the Pevensey Levels in squares B and E in the present survey and in the squares B, C, D, E and G in 1989 so it was unlikely that it would have been found in the present survey in squares A, F and H. However the number of records found in the squares C, D and G in 1989 were 4, 12 and 3 respectively. Concern was expressed over the present day condition of the ditches in the sector lying north of the road leading into Eastbourne (Hewitt pers. comm. 2003) so it is perhaps not surprising that at least for squares C and G *Potamogeton acutifolius* was not found in the present survey. Certainly in this sector of the Pevensey Levels, the ditches had more than one of the following three factors operating against finding *Potamogeton acutifolius,* namely: water levels, water quality and overgrown ditches

Number of 10km squares in which *Potamogeton acutifolius* was found in the Survey Results for 2003.

The map in the BSBI Atlas (Preston et. al., 2002) indicates that *Potamogeton acutifolius* occurs in 13, 10km squares. In the present survey it was only found in 7 squares. It was not found in the following squares:

1. The Staines site referred to as the Middlesex site by Preston (1995) as Staines is now in Surrey as Middlesex no longer exists.
2. The site at Lancing on the south coast close to Worthing.
3. The two squares close to Romney Marsh, which includes the River Rother site and the Rother Levels.
4. The Dowels, Romney Marsh, Kent.
5. The Marshes at Berwick, East Sussex.

All of these sites were not grazing marsh sites. Even the Rother Levels site was a drain next to a main road. Apart from the latter site the other sites were ecologically "odd sites" where ordinarily *Potamogeton acutifolius* would not be expected to be found. These must have been more ecologically suitable relict sites of former wetness.

The Ecology of *Potamogeton acutifolius.*

Plant Associates.

Preston (1995) considers that *Potamogeton acutifolius* is most characteristically a species of shallow water, species-rich drainage ditches in grazing marshes where some of its typical associates are *Elodea canadensis, Hottonia palustris, Hydrocharis morsus-ranae, Lemna minor, Lemna trisulca, Myriophyllum verticillatum, Potamogeton natans, Ranunculus circinatus, Sagittaria sagittifolia* and *Spirodela polyrhiza.* Much of the above description of its associates is still extremely relevant but some of the above species when abundant are associated with the decline or absence of *Potamogeton acutifolius. Hydrocharis morsus-ranae* when abundant is often associated with the absence of *Potamogeton acutifolius* and its abundance is often correlated with a ditch beyond the mid point of the management cycle. When *Lemna trisulca* is abundant the ditch has either just been cleansed or the water has a higher pH than the preferred pH of *Potamogeton acutifolius.* Clearly if *Lemna minor* and *Spirodela polyrhiza* are abundant then *Potamogeton acutifolius* may again be absent because of an unsuitable water quality or competitive exclusion. The only species not found to be in association with *Potamogeton acutifolius* were *Hottonia palustris* and *Ranunculus circinatus.* Both of these species were recorded in the present survey. The former was recorded at Limpenhoe, Norfolk and The Dowels, Romney Marsh, Kent and the latter was recorded at Amberley Wild Brooks, West Sussex. None of the sites contained *Potamogeton acutifolius* but with appropriate management it could have been present at Limpenhoe and Amberley. However there was no obvious reason why *Potamogeton acutifolius* was not present at The Dowels. The water quality, management and the rich assemblage of plants were all pointing to suitable conditions for this species. Two associate species are not mentioned by Preston (1995) namely, *Potamogeton lucens* and *Potamogeton trichoides.* The former species grew in association with *Potamogeton acutifolius* on two sites in the Pevensey Levels. The latter species grew in association with *Potamogeton acutifolius* on the

one site where it was found at Limpenhoe, Norfolk, on one site at Amberley Wild Brooks and on three sites at Pulborough Brooks, West Sussex.

It has already been mentioned that *Potamogeton acutifolius* is absent when *Lemna minor, Lemna trisulca* and *Spirodela polyrhiza* are abundant. Conversely it is found when *Ceratophyllum demersum* and *Elodea nuttallii* are abundant or even dominant but it clearly gets "pushed out of the way" by the growth of these species and is likely to recorded only frequently or occasionally. This potential change in status is most probably due to enrichment.

Whilst it is accepted that Preston (1995) is making a generalised statement as to its "typical associates" it is clear that there is regional variation. *Myriophyllum verticillatum* is only strongly associated with *Potamogeton acutifolius* in the grazing marsh ditches of Norfolk and this association was not found at any site in the Pevensey Levels, Amberley Wild Brooks and The Pulborough Brooks. This does not mean that the species is not found in these grazing marsh ditches but it was not associated with *Potamogeton acutifolius* in such ditches during the present survey.

It was also apparent that *Potamogeton acutifolius* was so dominant at many sites, at for example the Cantley Levels, the Pevensey Levels and the Pulborough Brooks, that only, perhaps, one or two other aquatic macrophytes were recorded in association with it and then at very low levels of abundance.

Water Quality.

Mean levels of pH and conductivity were calculated using the data given in Appendices 2 to 7. These are summarised in Table 3.

Table 3 The Mean pH and Conductivity with the Range of Values recorded for all the sites and records found on the Grazing Marshes on which *Potamogeton acutifolius* was recorded.

Grazing Marsh	Total Number of Sites and Records including Squares	Mean pH and Range of Values in brackets.	Mean Conductivity and Range of Values in brackets
Stoborough, Dorset.	9	7.2 (6.8–7.5)	611 (350-800)
Amberley	10	6.6 (6.4-7.1)	239 (200-390)
Pulborough Brooks	11	7.3 (6.8-7.4)	355 (350-375)
Pevensey Levels	12	7.2 (6.9-7.6)	804 (600-925)
Stodmarsh	1	7.5	700
Norfolk	20	7.2 ((7.2-7.6-(8.4))	648 ((400)-600-700-(900)).
Total	63		

pH and conductivity records given in additional brackets apply to 1 "aberrant" reading.

Relationship between pH and Conductivtity.

Ratcliffe 1997 gives alkalinity levels which equate with pH and in turn gives pH bands which correlate with recognised trophic states. A dystrophic water was considered to have a pH of <6, an oligotrophic water pH 6 to 7, a mesotrophic water ca. pH 7 and a eutrophic water of pH>7. Palmer *et. al.* (1992) went on to refine the relationship between pH and alkalinity and equated these variables both with Vollenweiders' trophic states (Vollenweider, 1968) and conductivity. In turn, plant groupings known as "Site Types" were associated with these variables. Thus certain plant species and their associates can be correlated with a particular trophic state which in turn correlates with a certain pH, conductivity or alkalinity.

pH

In general the pH range for *Potamogeton acutifolius* for all the sites, is between 6.6-7.5 and they have a range of values between pH 6.4-7.6. There was one aberrant site where the pH was 8.4. Apart from this site, the pH range "tolerated" by *Potamogeton acutifolius* suggests the species prefers mesotrophic to middle eutrophic water (Palmer *et. al.* 1992). The site with the aberrant pH is at Strumpshaw Fen, RSPB reserve, Norfolk. The Fen was flooded during the winter by eutrophic and brackish River Yare water but the site for *Potamogeton acutifolius* was found at the maximum distance from the river at the extremities of the flood. Other sites at Strumpshaw Fen closer to the River Yare had equally high pH readings but the conductivity readings were marginally higher at 1000 microsiemens (Appendix 7 continued, Sites 40-44). The warden at the RSPB reserve indicated that the salinity on the Fen close to the River Yare was much higher immediately after the flooding and was only just returning to more acceptable levels. Additionally *Potamogeton acutifolius* sites were thought to have been lost because of the flooding (Strudwick T., pers. comm. 2003). It is possible that *Potamogeton acutifolius* survived at the site distanced from the river as salinities should have been lower at the extremities of the flood. The flooding would have increased nutrient levels and raised the pH but presumably not raised the salinity to a level which would have caused its extinction. Thus this site gives a valuable insight into the competition factors facing *Potamogeton acutifolius* when it grows or survives in what appears to be a marginal water quality. At the time of the visit the populations could have been stressed by the high pH. A higher pH suggests two things, more plant nutrients, which induces greater plant growth but more importantly, the ability of species more tolerant of what is effectively hypertrophic water, once kept "at bay" by a lower pH, to grow and out-compete *Potamogeton acutifolius.* This hypothesis was precisely what was happening to *Potamogeton acutifolius.* It seemed to be resisting the competitive effects of these species as it was recorded as frequent to occasional. The site description reads as follows:
"Potamogeton acutifolius was frequent to occasional at this new site for the species. *Ceratophyllum demersum* was abundant but there were frequent growths of the charophyte, *Chara hispida var. hispida* and *Lemna trisulca.* Occasional growths were found of *Hydrocharis morsus-ranae*, the algae *Mougeotia spp, Spirogyra spp.* and *Cladophora glomerata.* The edge was dominated by growths of *Sparganium erectum,* frequent growths of *Berula erecta,* occasional growths of *Phragmites australis, Carex paniculata, Epilobium palustre, Eupatorium cannabium, Juncus acutiflorus, Juncus bulbosus var.fluitans, Lythrum salicaria, Mentha aquatica* and *Alisma plantago-aquatica".*

Conductivity.

The conductivities were very variable but were in two distinct bands, 239 to 355 and 611 to 804 microsiemens. The former band was found at Amberley Wild Brooks and the nearby Pulborough Brooks suggesting the intriguing possibility that these populations were genetically different from the more coastal populations at Norfolk; Pevensey, East Sussex; Stoborough, Dorset and Stodmarsh, Kent.

Summary of pH and Conductivity results.

In summary *Potamogeton acutifolius* appears to be a species preferring a water quality in the range, middle mesotrophy to middle eutrophy with a pH of 6.6-7.5 and has possibly adapted to two levels of conductivity, one of which is mildly brackish.

The Importance of Management.

It was evident during the site visits that *Potamogeton acutifolius* prefers an environment where competition factors are low either induced by a mesotrophic water quality and/or an adaptation to mildly brackish conditions. These factors in themselves can either preclude the overall dominance of any one species in a balanced mesotrophic environment and/or alternatively high conductivities can restrict aquatic floras. However both factors are not sufficient in themselves to prevent other species dominating the niche of *Potamogeton acutifolius* as plant succession proceeds. Thus management is the second critical factor in the continued presence of *Potamogeton acutifolius.*

From the observed condition of the floral assemblages associated with *Potamogeton acutifolius* and its relative abundance it was possible to deduce the point in the management cycle at which it was found, particularly following the valuable management information given by the RSPB wardens at the Pulborough Brooks (Hughes, P., pers. comm., 2003) and Strumpshaw Fen reserves (Strudwick, T., pers comm., 2003). It must be stressed that anyone ditch could not be aged accurately in these reserves as to when it was last cleansed and that the water quality and water levels additionally have to suit the species for the following to be relevant. All the ditches are managed on a need basis and no records were kept of when they were last managed. Subjectively it appears that *Potamogeton acutifolius* prefers a ditch that has been recently managed. In the 1st year after management it might be found rarely or occasionally. In the 2nd year it might often be frequent to abundant. It can be dominant to abundant in the 3rd or perhaps 4th year provided the water quality does not move towards the high eutrophic or hypertrophic state. Thereafter its abundance will decline becoming only found frequently to abundantly by the 5th year then only occasionally by the 6th and rare by the 7th year. By the 8th year it will have temporarily disappeared until the ditch is managed again. However there is a rider to this subjective and generalised assessment as some species if present could out-compete *Potamogeton acutifolius* by the 3rd or 4th year. These species are *Hydrocharis morsus-ranae* and *Stratiotes aloides* (Strudwick, T., pers. comm., 2003). This latter management information certainly applies to the ditch flora at Limpenhoe. Most of the ditches here had excellent water quality and appropriate water levels but the

ditches were under managed being often dominated by *Hydrocharis morsus-ranae* and/or with abundant *Stratiotes aloides.*

The Importance of Traditional Farming Practices

It cannot be stressed enough that the probable losses of *Potamogeton acutifolius* at Limpenhoe are due to the loss of grazing cattle on the marshes following the outbreak of Foot and Mouth Disease in 2001 (George, M. pers. comm., 2003). The marshes were empty of grazing animals except at the one site where *Potamogeton acutifolius* was found, but here the marshes were being grazed by sheep. The loss of stock means that the farmers do not need to manage the ditches so often to keep them maintained as wet fences. Most farmers were mowing the marsh for silage or hay in 2003.

Water Levels.

The third critical factor in the survival and/or presence of *Potamogeton acutifolius* is that of Water Levels. It prefers a brimful ditch or with a freeboard preferably no greater than 30 cms. The preferred depths of water are given below in Table 4 and are taken from the data in Appendices 2 to 7.

Table 4. The Water Depth preferences of *Potamogeton acutifolius* expressed as a Percentage of the Sites and Records.

50cms	60cms	70cms	75cms	80cms	90cms	100cms	110cms	120cms
20%	1%	29%	14%	6%	28%	0%	1%	1%

Clearly *Potamogeton acutifolius* is a shallow water species but there appears to be a trimodal distribution to its depth preference. All the measurements of depth were at the centre of the channel and *Potamogeton acutifolius* grew at these depths up to 80cms. It should be noted that for those records where the preferred depth is given as 90cms the species was not rooted at this depth but was often growing from the edge at around 75cms. Similarly for those records where the preferred depth is given as 110 and 120cms, *Potamogeton acutifolius* was again growing from the edge of the drainage channel at depths of approximately 80 to 90 cms.

Reversing the Losses.

There would appear to be little chance of reversing the losses at the following sites:

1. The Staines site
2. The site at Lancing on the south coast close to Worthing.
3. The Rother Levels.
4. One site on the Stoborough Marshes, Dorset site near the village of Ridge.
5. The Moors site, Dorset.

The first two sites were not grazing marsh sites. They were ecologically "odd sites" and one where ordinarily they must surely have been outliers or relict sites of former wetness.

Potamogeton acutifolius could return to the Rother Levels if the water quality changed from its highly eutrophic state to one of mesotrophy.

Farming practices would have to change on the Stoborough Marsh site at Ridge as the ditches were no longer needed by the farmer as wet fences. They all had low water levels and were overgrown with *Phragmites australis*.

There is a chance that *Potamogeton acutifolius* might re-occur on the River Rother, Kent but this is another ecologically odd site. The water quality is acceptable for the return of the species but the results of the present survey suggest that the river is too deep unless *Potamogeton acutifolius* grows out from the edge.

It is debateable whether or not The Moors site should be managed for the return of *Potamogeton acutifolius* as it an interesting mire site, it is also probably now too acid.

Management Needs. There were several sites where the water quality and water levels indicated that *Potamogeton acutifolius* would have been found at some point in the recent past but that it was now too overgrown to have survived the competitive effects of other species as plant succession proceeded.

The following sites were considered to have temporarily lost *Potamogeton acutifolius* because of the need for management.

1. Newnham Valley and Stodmarsh, Kent.
2. Limpenhoe, Norfolk.
3. Norton Marshes, Norfolk. There were two sites of the correct water quality but water levels needed to be raised as well as the need for management.

Water Quality. The following sites were considered to have lost *Potamogeton acutifolius* because of enrichment problems:

1. One drain and two other sites at Limpenhoe Hill, Norfolk all due to a possible cattle/pig slurry point source pollution.
2. Buckenham Marshes, Norfolk.
3. The Norton Marshes, Norfolk.
4. Strumpshaw Fen, Norfolk.

Buckenham Marshes. The inability to find *Potamogeton acutifolius* at the Buckenham Marshes may be due to diffuse pollution as the pH was often between 7.8 and 8.4 and many ditches had algal problems. The observed enrichment may be difficult to reverse. The marshes are now fortunately owned by the RSPB but the effects of past farming practices seem to take a long time to reverse. For example Site 22 on the Cantley Levels was next to a field on which manure had been applied in 1995 (George 1996) and the effects were still mildly evident in 2003. *Potamogeton acutifolius* was absent in the ditch bordering this field but was present in the ditch on the other side of the drove!

The Norton Marshes. All the BSBI sites on the edge of the grazing marsh were enriched by diffuse pollution, one was suffering from a point source pollution and most also suffered from an absence of management. As such *Potamogeton acutifolius* was not recorded. However *Potamogeton acutifolius* was recorded further into the grazing marsh.

Strumpshaw Fen. The effects of the flood during the winter 2002/2003 should eventually correct itself as water from the spring line around the edge of the Fen will dilute salinities and excess nutrients.

The BSBI records and other Surveys.

There are two surveys, one by George (1996) of the Cantley Levels and the other by Moore and Austin (1997) for the Strumpshaw Marsh, Buckenham Marsh, the Cantley Levels, the Limpenhoe Marsh and the Norton Marsh. The results indicate that *Potamogeton acutifolius* was recorded in 1997, at one site at Strumpshaw Marsh (Fen), one site on the Buckenham Marshes, 33 sites on the Cantley Levels, 7 sites at Limpenhoe Marsh and 7 sites at the Norton Marshes. Whilst these sites and records were generally no greater in number than the BSBI records many were new and would have added to the present survey results if still found. Similarly Abraham et. al. (1997) and Abraham (1998) recorded many new records and sites for *Potamogeton acutifolius* than those represented by the BSBI records at Pulborough Brooks and Amberley Wild Brooks respectively. The Pevensey Levels were surveyed for *Potamogeton acutifolius* for the 1989 re-notification of the SSSI. Again more records and sites were found. Thus the present survey whilst achieving a reasonable comparison against the BSBI records must represent an underestimate of the true abundance of *Potamogeton acutifolius* at these grazing marshes. None of these surveys found any new sites in new 10km squares so the present loss of sites representing 4, 10km squares must stand.

References:

Anon, (1989). Re- notification package for the Pevensey Levels. English Nature, Lewis, West Sussex.

Abraham, F., (1998). Amberley Wild Brooks: A survey of the Ditch Flora 1998. Arun District Council, Bognor Regis, West Sussex.

Abraham, F., Allen, S. D., Hodge, P. J and Willing M. J., (1997). A survey of the Flora and Selected Invertebrate Groups of the Ditches of the Lower Arun Valley. Arun District Council, Bognor Regis, West Sussex.

George, M., (1996). The aquatic flora of the RSPB's Cantley Dyke System. Marsh House Strupshaw, Norwich.

Moore, T and Austin, P., (1997). The Distribution and Abundance of *Potamogeton acutifolius* in Broadland, Norfolk. Contract for English Nature, Norwich.

Palmer, M., Bell, S. L and Butterfield I. (1992) A botanical classification of stanfiong waters in Britain: applications for conservation and monitoring. Aquatic Conservation Volume 2, Issue 2. Wiley, Chichester.

Preston, C. D. (1995). Pondweeds of Great Britain and Ireland. BSBI Handbook No. 8. Botanical Society of the British Isles, London.

Preston, C. D., Pearman, D, J, L and Dines P. (2002). New Atlas of the British and Irish Flora, Botanical Society of the British Isles, London.

Ratcliffe, D. A. (1977) A Nature Conservation Review. Cambridge University Press.