A COMPARATIVE SURVEY OF ACKLAND'S MOOR POND AND WIDOW'S TENEMENT POND

by

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ABSTRACT

Ackland's Moor and Widow's Tenement ponds have not previously been surveyed in any detail and are typical of the two types of pond on Lundy – flooded quarry and naturally filled weedy. Their historical context is evaluated and suggestions for their longevity proposed. Their biodiversity is summarised and the differences and similarities compared. Biotic and abiotic measurements were made and comparison is made with previous surveys undertaken at various levels of complexity since 1953. The surveys also record the biodiversity before and after the drought of 2011 when both ponds were dry. Data for both ponds in all four seasons of the year during the period 2009 to 2013 are presented and are found to match closely Lundy ponds which have benefited from recent, regular and in depth surveys.

Keywords: *lentic, freshwater, macroinvertebrates, macrophytes, plantkon*

INTRODUCTION

Many of the ponds on Lundy have been surveyed to some degree (George, 1979, 1997, 2007, 2012; George *et al.* 1980, 1981, 1987, 2004). With the exception of Pondsbury and a few recent man-made scrapes, they are predominantly flooded quarry workings. Both ponds accord with the description temperate grassland, intermittent freshwater meso-habitat as described in a suggested classification framework (Williams, 2006). Ackland's Moor and Widow's Tenement Ponds were selected for a number of reasons:

- they are geographically separate – approximately 2.3km apart (frontispiece map)
- each is typical of the two distinct type of ponds on Lundy – a flooded quarry and a natural weedy hollow
- both are virtually un-surveyed
- both are remote from the typical routes taken by visitors and naturalists.

However, the ponds are not totally unknown. Some maps feature them and they have been briefly surveyed by some naturalists, geographers and archaeologists.

METHODS – ABIOTIC

Temperature measurement

At the start of the survey, in 2009, temperature was measured using an analogue minimum/maximum (Six's) thermometer. This was used to record the ambient temperature of air and water in the ponds at the time of the survey. During the survey period progress was made by taking the air temperature before leaving the thermometer for 24 hours to record the diurnal minimum and maximum temperatures.

Later, the opportunity arose to acquire dataloggers with associated deep water containers. This comprised three separate Gemini TK-4014 Tinytag Talk 2 temperature loggers, each enclosed in a Gemini ACS-0001(IP68) stainless steel deep water container for temperature monitoring. One data-logger was placed on the bottom of the pond, a second was placed fully submerged just below the surface and the third placed on dry land on the pond edge. The units were placed at least half an hour prior to the programmed start time for the recording period so that the sensors would have time to match the ambient temperature. By the end of the surveys it was possible to program and deploy the dataloggers to collect data for a month at a time. The resulting data were collected and analysed using the proprietary software kindly supplied by Gemini Tinytag Explorer (V 4.7) (Gemini 2011).

Size

An open reel Stanley 30m fibre glass 'LongTape' measure was used to record the size of the quarry cut into the granite as well as the extent of the water from the summer average to the winter average of both ponds.

Depth

A line weighted with a 140gm lead fishing weight was used to measure the maximum depth of each pond at each visit, and later on a monthly basis. The line is marked at 250mm intervals but is always measured using a tape measure to accurately record the depth. The location of the deepest part was ascertained by repeated soundings early on in the survey, but confirmed in summer 2010 when the ponds dried completely.

Turbidity

A Secchi disk, 20cm in diameter, was lowered into the water until the black and white pattern was out of sight then raised until it became visible again. Turbidity is the average of the two and is always measured in the shade between 9am and 3pm.

Dissolved Oxygen and pH

At the start of the surveys, Johnson Universal pH papers were used to ascertain the pH of the waters, but in March 2012 a digital meter was acquired. This is a Reed YK2001 Intelligent meter with two probes. For pH the probe is a PE-03 general purpose 0.0-14.0 pH and for dissolved oxygen (DO_2) a PDO polarographic (Clark oxygen electrode) dissolved oxygen probe with integrated temperature sensor. After sensor problems a Pen type pH tester was acquired and used.

METHODS – BIOTIC

Macro-Invertebrates

An EFE-GB standard hand net 250mm wide with 1mm mesh was used. The extent of each macro-habitat – open water, open bank side, open water with weed, bank side with weed, shallows and deeps – was estimated and the proportion of the total pond calculated. The in-water survey of a total of three minutes was proportionately distributed between all macro-habitats. An additional minute was allocated to observing the pond before disturbance for surface-dwelling invertebrates and afterwards for the examination of the undersides of rocks or submerged woody material or any areas not practical to sample with a net.

A calculation of relative abundance was made according to the following criteria:

Over 500 individuals	5
200-499 individuals	4
50-199 individuals	3
5-49 individuals	2
Less than 5 individuals	1

Plankton

Plankton was collected with an EFE-GB phytoplankton net 53µm mesh 24cm wide and 0.5m long with 53µm detachable terminal filter. Two trawls were made across the pond with the catch on the filter isolated and preserved in 4% formaldehyde for later identification.

Flora

The type, location and extent of aquatic flora was established and drawn on a sketch map. The relative abundance of each species was calculated using the following criteria:

More than 50%	5
Between 11 and 50%	4
Between 6 and 10%	3
Between 1 and 5%	2
Less than 1%	1

ORIGINS AND CHARACTERISTICS OF THE WATER BODIES

Ackland's (sometimes Acland's) **Moor Pond** (**AMP**) (OS Grid Reference SS 13262 44748)
This is a square cut granite quarry on the third highest point on the island and is cut into a cairn. The National Trust Archaeological Survey (NTAS) 101,095 (Thackray, 1989) conjectures that this cairn may be the upcast from the quarry. The pond has neither inflow nor outflow and relies totally on surface run-off and rainfall for its existence. It has little shelter from the prevailing south-westerly wind and only minimal shelter from the east and south where the quarry has vertical faces. The relict cairn provides some shelter from the north east.

In an unpublished paper on the Lundy quarries, Tony Langham (Langham, 1993) suggests that this quarry may have been a test pit dug by the Lundy Granite Company around 1863 in their search for un-fractured granite. Further, Roger Fursdon, the Island Engineer, suggests that due to the fractured nature of the granite at this site, it was unsuitable for building anything but field walls. A comparison of the eastern wall of the quarry with the nearby airfield north-south wall gives credence to this (Fursdon, pers. comm.) The granite in the field wall and that showing in the eastern wall of the quarry are certainly similar (Plate 1). The 1840 map of the island (Heaven, 1840) does not show this wall, but the map which features in Chanter (Chanter, 1877) does, giving additional support to the quarry dating from after 1863.

Plate 1: Upper: Airfield Wall; Lower: Ackland's Moor Pond eastern wall (Photos © Alan Rowland)

Nonetheless, the first reliable evidence of this quarry as a pond was in 1927:

> '… Major Penn Curzon presented Mr Harman with a Muscovy drake and two ducks, which were liberated on the small pond on the west side of Acland's Moor and never seen again.' (Gade, 1978).

Along with other ponds, Ackland's Moor Pond, was surveyed by Galliford (Galliford, 1954) where he described it as being different from the majority of other ponds on the island and being very alkaline with such a density of microscopic organisms as to render the water opaque.

His entry for this pond, numbered 4 in his list, is reproduced here:

> '4 Pond, Aclands Moor. Pool in old excavation about quarter of a mile north of Old Light. Water very green with algae (mainly *Scenedesmus* and *Pediastrum*), bottom muddy. Evidently much used by cattle, etc. pH 7.5. No. of Cladocera and Rotifera species 10.' (Galliford, 1954)

The next, and final, mention of this pond is in the list of Lundy watercourses compiled by Langham in 1968. Pond number 10 in his listing:

> 'P10 1325 4476 Aclands Moor Pool. This lies on the old Golf Course close to trig. point 466, just south of the pronounced bend in Quarter wall. It is a clean-sided excavation in the granite with shallow muddy water in the bottom. There is no vegetation except in one corner where Peplis and Hypericum are becoming established.' (Langham, 1969)

This man-made granite pond has been in existence for around 100 years and may even date back 150 years to the time of the Granite Quarries.

Widow's Tenement Pond (WTP) (OS Grid Reference SS 1346 4682)

This is a roughly circular, naturally formed pond in the midst of unimproved acid grassland lying within the medieval enclosure of Widow's Tenement. National Trust Historic Buildings, Sites and Monuments Record (HBSMR) records it as a medieval to late nineteenth century dewpond – 'Large cattle pond, c12 yards diameter with muddy bottom, probably a dewpond. Some Potamogeton and Callitriche.' (Thackray, 1989)

In discussion with the National Trust's archaeologist (S. Blaylock, pers. comm.) it was thought to be part of the farm stock watering system. The History of Lundy, (Lloyd, 1925) names Widow's Tenement as North Farm in use in the seventeenth century and Widow's Tenement still contains streams which have the remains of enclosing walls at their origin to prevent stock access and fouling of the water. This pond was open and freely accessible by stock.

The first documentary record of the pond itself is when Galliford surveyed the pond as part of his island wide survey (Galliford, 1954):

> '(12) Widow's Tenement Pond. In boggy area due east of telegraph pole no. 66. pH 5.0. No. of species 6.' (Galliford, 1954)

It is next referred to in the Watercourses of Lundy as:

> 'P2. Widows (sic) Tenement Pond (1350.4680) Large cattle pond about twelve yards in diameter with muddy bottom due east of pole No. 66. Some Potamogeton and Callitriche.' (Langham, 1969)

Ternstrom refers to this pond in her thesis (Ternstrom, 1999), when she states that 'it is not marked on any map.' She does place it within Widow's Tenement enclosure at NGR 1333 4697 with a diameter of 'c. 3.6m (12ft)'. A map record does exist on the 1820 Ordnance Survey map which clearly shows a circular pond in the correct position, although it also shows an outflow as a tributary of St James Stream, the only remains of which is a wet flush to the west of the pond on the cliff top.

It is a naturally formed roughly circular pond used for watering stock within the Widow's Tenement enclosure. The open water sits in a bowl formed by a bed of matted vegetation with no evidence of a muddy bottom. The immediate area around the pond is short *Molinia* grass and remains boggy on the west up to a fringe of *Juncus effusus*, the Soft Rush. The area of open water expands and contracts within this boggy bowl. It may have been in existence for up to 200 years but has most definitely existed in its current form for the last 70 years.

RESULTS

ABIOTICS

Ackland's Moor Pond

This pond is located at the third highest point on Lundy and is exposed to the strong prevailing south west winds coming in from the Atlantic 200 metres away. The pond is formed in a man-made excavation in granite which slopes gradually from its northern end to the vertical southern end where it is deepest. The east and south sides are both vertical walls with a shallow, sloping more open aspect to the west. The depth of the water in the pond varies from empty (Plate 2) to 1.1 metres at its deepest point during the wettest seasons The average summer extent of the water is defined by *Eleocharis palustris,* the Spike Rush*,* which prefers its roots in water and stems in the air (Plate 3)

Plate 2: Ackland's Moor Pond dried out August 2011 (Photo © Simon Dell)

Plate 3: Ackland's Moor Pond summer extent September 2012 (Photo © Alan Rowland)

Plate 4: Ackland's Moor Pond winter extent January 2013 (Photo © Alan Rowland)

whereas the winter extent is defined by *Juncus effusus,* the Soft Rush, which prefers a damp, but not wet, position (Plate 4). At its deepest almost the whole of the excavation is filled and most plants are submerged doubling the normal summer area of water.

When domestic sheep *(Ovis aries)* are allowed on the airfield, they use the pond for drinking as do Sika deer *(Cervus nippon)* and birds; Linnets *(Carduelis cannabina)* and Mallard *(Anas platyrhynchos)* have been seen drinking at the pond. The browsing animals keep the rushes in check by grazing them. Having no inlet or outlet, the dung from these animals provides a deep and smelly sediment in the bottom of the pond.

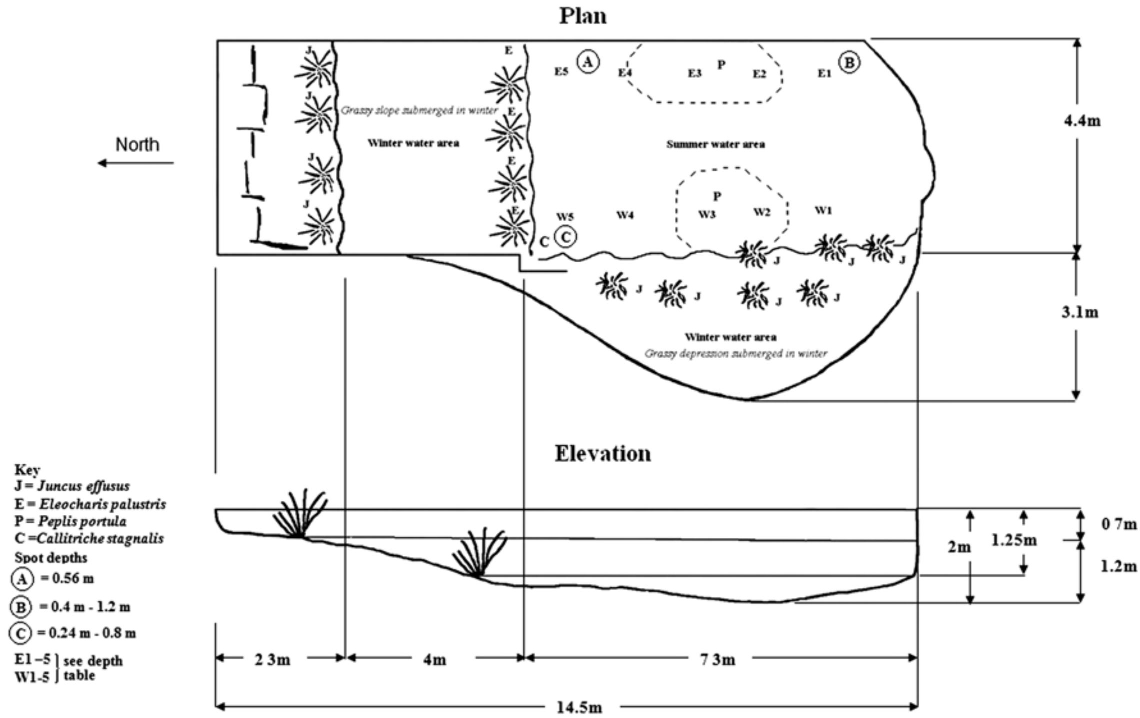

Figure 1: Ackland's Moor Pond sketch map and plan

Water temperature

From November 2011 dataloggers were available and used initially for 24 hours, then in March 2012 for 3 days. By the end of 2012 it was possible to deploy the dataloggers for a month; Figure 2 shows the results. Readings were made every 4 minutes between 5 November and 7 December.

It can be clearly seen that water temperatures closely follow the variations in air temperature, albeit with up a lag of up to one hour. Although water temperatures are very similar varying by only about 0.5°C, it can be seen that bottom temperatures are generally slightly warmer than that at the surface. Despite the wide variation in air temperature, 0.4°C on 30 November and 17.2°C on the 14 November, freshwater fauna have only to cope with water temperature variations of 4°C to 11.2°C with an average of 7.6°C.

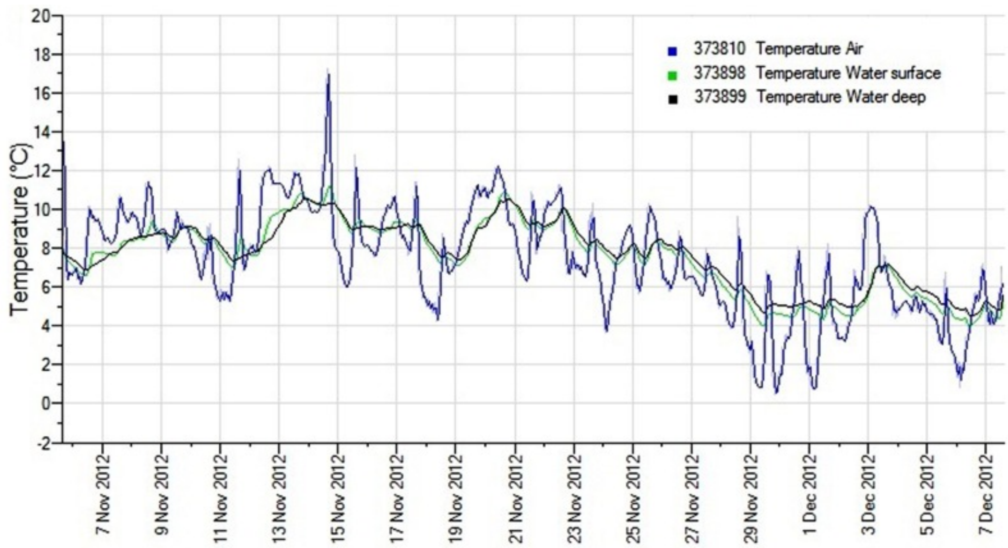

Figure 2: Ackland's Moor Pond graph of Temperature November-December 2012

Depth and Turbidity

This pond has three states – flood, drought and typical. Flood is the winter level and is defined by *Juncus effusus* which grows at the maximum water's edge. Typical is the normal spring, summer, and autumn levels which is defined by *Eleocharis palustris* which likes to be in water at all times. In the late summer of 2011 extreme drought left the pool empty with a dried mud bottom (Plate 1).

A more typical record of depth is shown in Figure 3. The depth of AMP has increased significantly over the 12 month period shown in the graph from a low of 0.5m in April 2012 to over 1m in depth in the winter of that year. Turbidity has been fairly consistent between 0.5m and 0.75m for the most part which meant clear to the bottom in some of the shallower months.

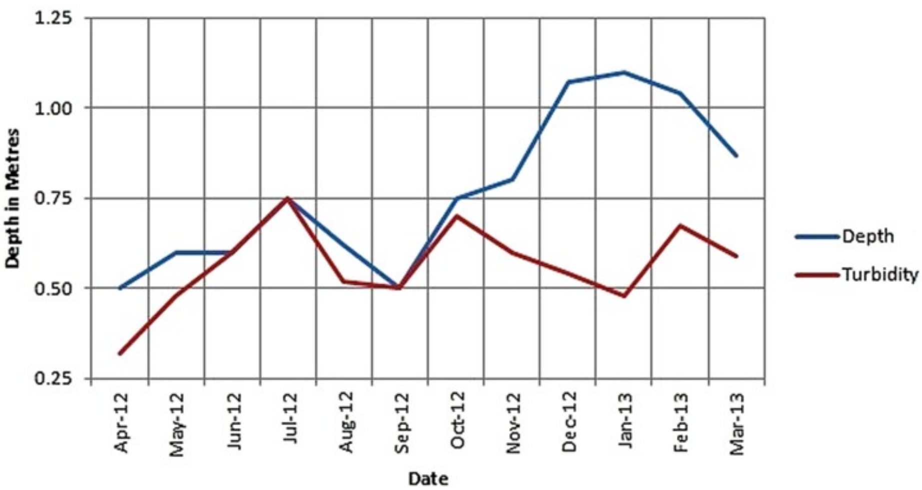

Figure 3: Depth (blue) and Turbidity (red) of AMP over a 12 month period

pH

The acidity or alkalinity of the pond has been measured from 2009 to 2013. Over the period, pH has varied from a high of 6.8 (a false high of 8.5 was recorded due to a faulty electrode which was replaced) to a low of 6.3 but since the monthly monitoring during 2012-3 using a pH meter, it has been consistently recorded at between 6.3 and 6.8 with an average of 6.5 which is only slightly on the acid side of neutral.

Widow's Tenement Pond

This pond is also in a fairly high part of Lundy, north of Threequarter wall and towards the western side of the island. The pond sits in a bowl of earth, the eastern edge of which is distinguished by *Sphagnum* moss and *Juncus articulatus*. The western edge of the bowl is marked by *J. effusus*. The ground between this fringe and open water varies according to the amount of water collected in the bowl. Plate 5 shows the summer area and Plate 6 the winter area. This margin is increasingly wetter when rainfall is greatest and dries out in drier periods when the open water shrinks. The pond is partially boggy and partially open water within the area of this bowl.

Plate 5: Widow's Tenement Pond summer extent August 2012 (Photo © Alan Rowland)

Plate 6: Widow's Tenement Pond winter extent November 2012 (Photo © Alan Rowland)

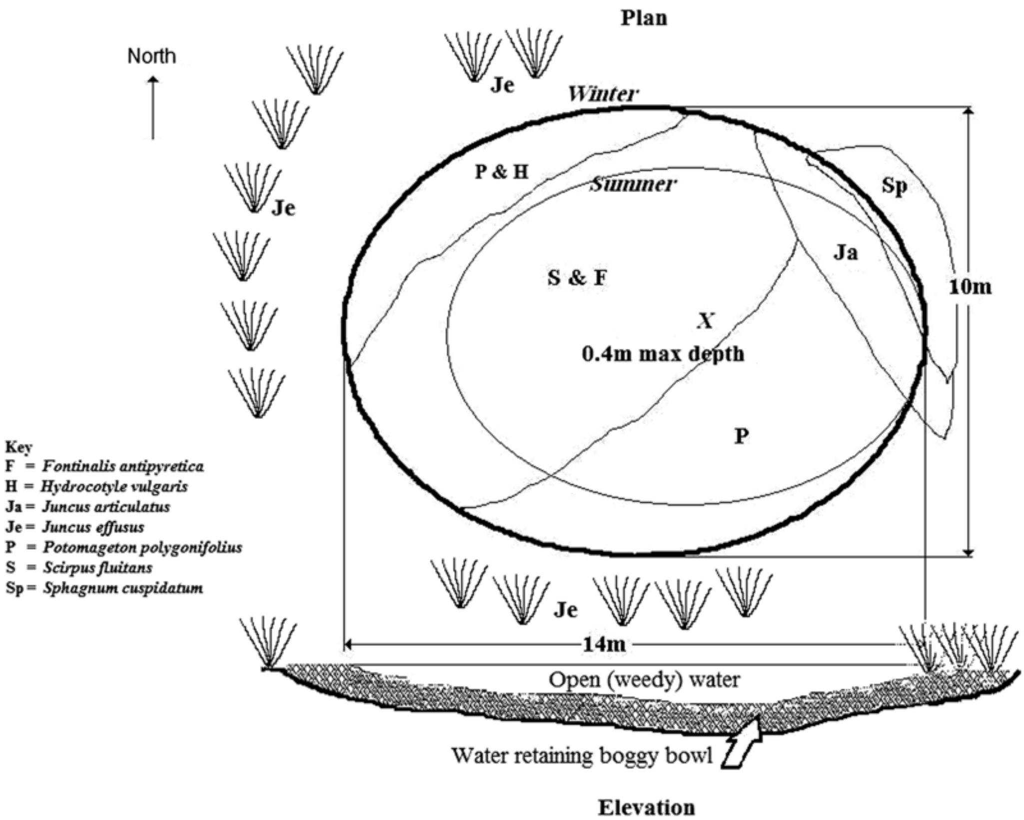

Figure 4: Widow's Tenement Pond sketch map and plan

Water temperature

In such a shallow pond it is to be expected that air, surface water and deeper water temperatures are all quite similar. However, it can be clearly seen that deep water temperatures (black) even out the extremes of air and surface temperatures. These two fluctuate greatly by almost 10 degrees whilst temperatures at the bottom of the pond vary only by up to 4 degrees maintaining a more even temperature even when air temperatures fall below zero and the surface freezes as it did in the winter of 2012-13 (Plate 7). The air temperature in the graph (Figure 5) varied by 13 degrees between -0.5ºC and 12.4ºC which was followed, up to 2 hours later by the surface water temperature between 2.1ºC to 9.8ºC, a variation of over 7 degrees, whereas the deep water temperature varied between 3.4ºC and 9ºC, a range of 5.6ºC with an average of 6.4ºC.

Depth and Turbidity

Depth ranges from empty in October 2011, John Hedger (pers. comm. 24 Oct 11) reported seeing the pond dry: it 'had been dry for ages [with] grass in the bottom, to 0.4m at its deepest.' This 'grass' in the bottom may have been the remnants of *Eleogiton fluitans* or *Molinia* encroachment. The pond is usually very weedy and turbid with much suspended silt.

However, a year-long study with monthly visits built up a more typical picture of the fluctuations in pond depth. It can be seen that this is not a very deep pond; up to 0.4m at maximum depth which fell to 0.15m in May 2012. Neither is it very clear, with turbidity as low as 0.08m and only as high as 0.25m. (Figure 6).

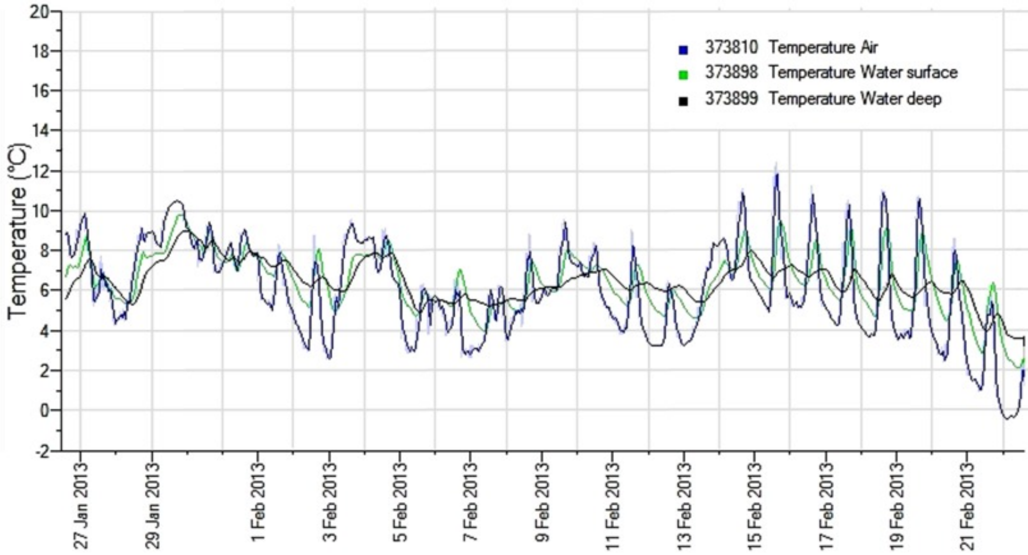

Figure 5: Widow's Tenement Pond graph of Temperature November-December 2012

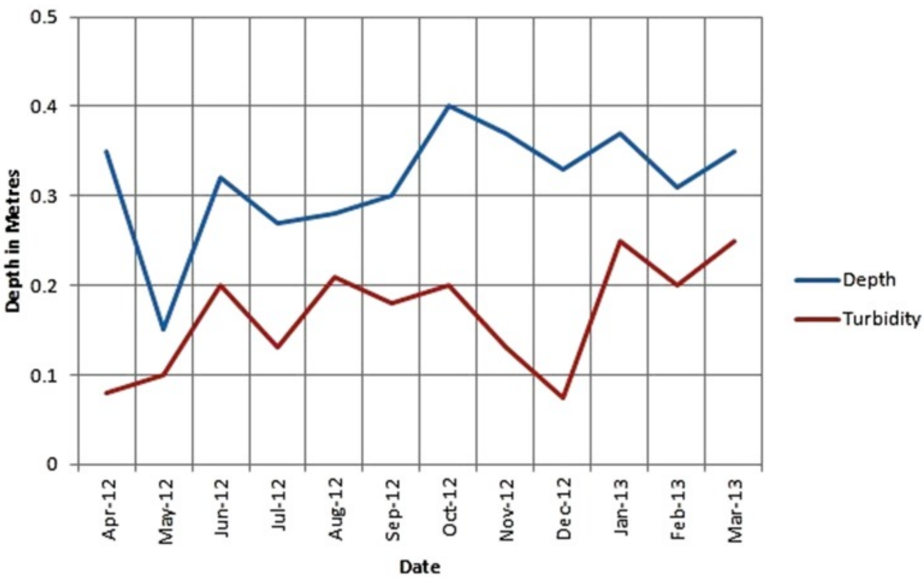

Figure 6: Depth (blue) and Turbidity (red) of WTP over a 12 month period

Plate 7: A frozen over Widow's Tenement Pond February 2013 (Photo © Alan Rowland)

pH

The 12-monthly visits during 2012-2013 confirmed this pond as having a pH of between 4 and 6 and averaging at 4.5 which is typical of acid ponds. Confirmation of its use by mammals as a drinking place was made in November 2010 when a small herd of feral goats *(Capra aegagrus hircus)* were seen drinking from it. In March 2012 three Sika Deer *(Cervus nippon)* were seen moving away from the pond area after having drunk from it. Until the recent dearth of wild rabbits *(Oryctolagus cuniculus)*, each sweep net would recover rabbit droppings from the pond. They were obviously blown in by the prevailing wind and no doubt provided additional nutrients which affected the pH.

FLORA

A combined table for both ponds was considered, but there are so few common species, it would have served little purpose. The keys and abundance data should be read in relation to the plans (AMP Figure 1 and WTP Figure 4) and the Abundance table defined earlier.

Ackland's Moor Pond

From the start of the surveys in November 2009, both Common Spike Rush *(Eleocharis palustris)* and Soft Rush *(Juncus effusus)* have been present. Frequently, Common Duckweed *(Lemna minor)* has been seen blown into stems of the rushes on the northern margin of the pond, and in subsequent seasons, other newly established plants are seen to be uprooted and washed into the northern edge by the prevailing south-westerly winds.

Over the course of the surveys it became apparent that *J. effusus*, which prefers damp grassland, defines the winter water levels, whereas *E. palustris*, which can tolerate submersion up to about 30cm, defines the summer water level.

A further species was noted in February 2010 and two plants survived in May 2010; Water Starwort *(Callitriche stagnalis)* was identified adjacent to W4 and E5 on the diagram. Both were being stranded by the receding water, E5 amongst the waterlogged ground and W4 in a crack between the granite edges. Both began to die back as the water receded and exposed them to desiccation.

In November 2011 after the pond had dried out and begun to refill, mud-loving *C. stagnalis* plants were seen in the shallow edge of the northern slope area and a clump in the deepest part, then 50cm in depth. The drought had resulted in clearer water, allowing light and heat to penetrate throughout the water body.

By 2012 more open water plants were seen; *C. stagnalis* had been joined by Water Purslane *(Lythrum portula)* and now both are established in the clear open water towards the centre of the pool with two emergent plants of Lesser Spearwort *(Ranunuclus flammula)* appearing amongst the submerged *E. palustris*. In January 2013, despite the great depth of water, strong south-westerly winds had uprooted most of these two open water species and blown them amongst the emergent stems of *J. effusus*.

The six flora of AMP are represented by two rushes (Soft and Common Spike), three open water plants (Water Purslane, Water Starwort and Common Duckweed) and a damp-loving perennial herbaceous plant, Lesser Spearwort.

Table 1: Ackland's Moor Pond Macrophyte abundance

Species	Key	Abundance
Juncus effusus L	J	4
Eleocharis palustris (L)	E	4
Lythrum portula (L)	P	4
Callitriche stagnalis Scop	C	4
Lemna minor L		2
Ranunculus flammula L		1

Widow's Tenement Pond

This pond is situated in an exposed upland heath with rushes to the east and Moor Grass *(Molinia coerulea)* up to the pond edge. Feathery Bog Moss *(Sphagnum cuspidatum)* is found both around and in the edge of the eastern end of the pond. The pond is extremely weedy and an attempt has been made to indicate the typical distribution.

Since the start of the survey, with the exception of Round-leaved Crowfoot *(Ranunuclus omiophyllus)*, all species were identified as present and are listed in the following table which shows Greater Water Moss *(Fontinalis antipyretica)*, Feathery Bog Moss *(S. cuspidatum)*, Jointed Rush *(Juncus articulatus),* Marsh Pennywort *(Hydrocotyle vulgaris)* and a further Rush, Floating Club Rush *(Eleogiton fluitans)* and Bog Pondweed *(Potomageton polygonifolius)*.

As in Ackland's Moor Pond, *J. effusu*s defines the wet area and is present at the edges of the wettest, boggy area in which the pond is situated. *J. articulatus* however stands in the water at the eastern edge. Much of the open water is host to the remaining species with an occasional occurrence of the emergent *R. omiophyllus* at the edges. In February 2010 the pond expanded to the defining perimeter of *J. effusus* submerging the ubiquitous *M. coerulea*.

In contrast to Ackland's Moor Pond, Widow's Tenement Pond has a wider floral diversity totalling eight species. This comprises two bryophytes (Feathery Bog Moss and Greater Water Moss); three rushes (Floating Club, Jointed and Soft); two open water plants (Bog Pondweed and Marsh Pennywort); and another damp loving perennial herbaceous plant of the *Ranunculus* species, Round-leaved Water Crowfoot.

Table 2: Widow's Tenement Pond Macrophyte abundance

Species	**Key**	**Abundance**
Eleogiton fluitans (L)	S	5
Potomageton polygonifolius Pourret	P	4
Juncus articulatus L.	Ja	3
Fontinalis antipyretica Hedw.	F	2
Hydrocotyle vulgaris L.	H	2
Sphagnum cuspidatum Ehrb.	Sp	2
*Ranunculus omiophyllus** Ten.		1
Juncus effusus L.	Je	1

*Not shown on the map due to only an occasional appearance

PLANKTON

Plankton hauls have been made at each survey during the 5 years of surveying in accordance with the methods described earlier under Method. A full one-year study (2012-13) which includes these two ponds is in preparation (George and Rowland unpublished), so the results given here refer to main groups of planktonic organisms only. However a fuller analysis was made by Jennifer George of a sample taken at Ackland's Moor Pond in February 2010.

Both ponds share a very similar species list. The Zooplankton is represented by Crustaceans and Rotifers. Various species of plankton are present all year round in varying numbers. The Crustacea comprise Cladocera, Cyclopoidea and Harpacticoidea whereas only *Keratella* species of Rotifers have been identified so far.

<u>Identification by Jennifer George of a sample taken in February 2010 from Ackland's Moor Pond</u>

<u>Phytoplankton</u>

Phylum Chlorophyta (Green algae)

Noted as present: Filamentous green alga

Colonial unicellular green alga - *Desmodesmus (Scenedesmus) magnus Chodat*

<u>Zooplankton</u>

Crustacea:

Class: Branchiopoda Order Cladocera (Water fleas)

Genus Species *Chydorus sphaericus (Muller)* 5

Class: Copepoda Order: Cyclopoidea

Genus Species *Cyclops sp. possibly vernalis (Fischer)* 5

Mostly mature forms, some females with egg sacs. Few juvenile forms.

Class: Copepoda Order: Harpacticoidea

Genus *Canthocamptus sp* 4

Mainly mature forms, males showing modified antennules that are used for grasping the females.

Phylum Rotifera:

Class: Monogononta Order: Ploima

Genus Species *Keratella vulga (Ehrenberg)* 5*

Very, very abundant, over 1000 in sample (hence 5* score)

Genus Species *Keratella serrulata (Ehrenberg)* 4

Numbers 1 to 5 relate to:		
	1	One or two organisms only
	2	3-25
	3	26-100
	4	101-500
	5	Over 500

Trawls have taken place on each survey occasion, and the somewhat limited results are shown below in Table 3.

Table 3: Plankton seasonal occurrence in both ponds

Planktonic Group	AMP	WTP
Cladocera (water fleas)	Sp, S, W	Sp
Copepoda		
Cyclopoidea	Sp, S, A, W	A
Harpacticoidea	Sp, A, W	Sp, A
Ostracoda (ostracods)		Sp
Hydracarina (water mites)	Sp, S	Sp
Rotifera (rotifers)	W	Sp
Chironomidae (midge l.)		A

Key: Sp=Spring (March/April/May); S=Summer (June/July/August); A=Autumn (September/October/November); W= Winter (December/January/February)

MACROINVERTEBRATES

Table 4 lists species for both ponds and are found to be typical of what is expected in small, generally muddy and slightly acid ponds with one exception. *Proasellus meridianus*, the water slater, otherwise ubiquitous on Lundy, is unaccountably absent from both of these ponds. The table gives a combined list of invertebrates from both ponds for ease of comparison. It shows species by season both before and after the drought of 2011. Rare species seen only once are not recorded in the table.

Table 4: Macroinvertebrates before and after the 2011 drought in Ackland's Moor Pond and Widow's Tenement Pond

Phylum and *Name*	**Description**	**Ackland's Moor Pond**		**Widow's Tenement Pond**	
		Pre-2011 drought	**Post drought**	**Pre-2011 drought**	**Post drought**
Coelenterata: hydras and jellyfish					
Chlorohydra viridissima (Pallas)	green hydra	Sp2, S3, A3, W1	Sp1, S1, A2, W,4		
Platyhelminthes:	flat worms				
Polycellis nigra (Müller)		Sp1, S2,A1, W2	Sp1, S2, A2, W2		
Dalyellia viridis (Shaw)		W1	Sp1		
Rhynchomesostoma rostratum (Müller)					Sp1
Nematoda:	roundworms				
Nematodes		Sp1			
Annelida: segmented worms and leeches					
Oligochaeta	segmented worms				
Lumbriculus variegatus (Müller)		Sp1,S2, A1,	Sp1, S2, A1	Sp1, S1	
Naididae					
Nais sp.		A2, W2		S2	Sp1
Dero sp.		S1			
Tubificidae		Sp1, W1			
Hirudinae	leeches				
Helobdella stagnalis (L.)		Sp1, S3, A1, W1	S2, A2, W2	S1	
Protozoa: unicellular animals					
Ciliophora:	ciliates				
Carchesium sp.		S1			
Insecta:					
Ephemeroptera:	may flies				
Cloeon dipterum (L.)		Sp1, A2		S2	
Odonata:	dragon & damselflies				
Enallagma cyathigerum (Charpentier)	common blue damselfly	S1-a		S1-a	
Sympetrum striolatum (Charpentier)	common darter			Sp1-l, S2-al, A2-l	
Ischnura elegans (van der Linden)	blue-tailed damselfly	Sp1-l			
Hemiptera:	water bugs				
Corixidae		Sp4, S3, A3, W2	S3, A2, W1	Sp1, A2, W1	S2, A2, W2
Gerris gibbifer Schummel		S1		S1	
Notonecta marmorea viridis Delcourt		Sp4, S3, A2	Sp1, S2, A1	Sp1, S1, W1	S1, W1
Coleoptera:	beetles				
Acilius sulcatus (L)		Sp2-l, S1, A1, W1-l	S2-l		
Agabus sp adult				Sp1, S1	S2, A2
Dytiscidae		Sp1-l	Sp1-l, W1		Sp1, S1, A2, W2
Enochrus sp				Sp2, S2	S1, A1
Gyrinus substriatus Stephens)				S1	
Hygrobia hermanni (Fabricius)		S1-a, A1-a			
Hydroporus erythrocephalus (L.)				S1-a, S2a-l, A2a-l, W2a-l	Sp1-l, A2 a-l
Trichoptera:	caddis or sedge flies				
Limnephilus vittatus (Fabricius)		S1, W2			
Diptera:	two-winged flies (larvae)				
Chironominae sp.		Sp2, S1, A1, W3	S2, A2, W1	S1, A2, W2	S1, A2, W1
Chaoborus crystallinus (De Geer) *Chironomus*		S1	S1		
plumosus (L)		W1			
Culicidae sp		Sp1, A1	A1		
Tipulidae sp				Sp1	Sp2
Species Totals		24	12	15	10
Overall species total		24		17	

Key: Sp=Spring (March, April, May); S=Summer (June, July, August); A=Autumn (September, October, November); W=Winter (December, January, February)
Numbers 1 to 5 refer to Macro-invertebrate abundance ;
a-adult; l-larvae

Ackland's Moor Pond

This pond is dominated at different times by Green *Hydra*, flatworms, worms, leeches, Corixidae and the larger Water Boatman, *Notonecta*. Chironomidae were present in large numbers both before and after the drought.

Nematodes and Tubificidae, present before the drought, have not yet been recorded nor have mayflies, screech beetles and caddis fly larvae.

During the spring season, surveys produce a superabundance of plankton which gave the catches a pink tinge.

Of the two ponds, Ackland's has the greater number and diversity of species totalling twenty-four, some of which have proved to be unique – *Dalyellia viridis* (green flatworm) has yet to be recorded in any other Lundy pond.

It has proved quick to re-colonise with twelve of the recorded species having reappeared after the drought.

Widow's Tenement Pond

An interesting feature of this pond is the presence of the larvae of two species of Odonata which however, have so far failed to recover after the drought of 2011. This may be due to a poor breeding season in the months following the drought when in contrast, the weather was so wet. However, this does not seem to have affected Coleoptera which continue to be another major feature of this pond.

In both ponds, sediment samples have been taken both intentionally and, when the water level was particularly low, inadvertently. However in all cases no species different from those recovered in open water netting were noted. Similarly when turning over stones in Ackland's Moor Pond, apart from caddis fly cases, no other different species were noted. Widow's Tenement Pond has only two stones, which on examination had no invertebrates associated with them.

In comparison to Ackland's Moor Pond, the species number is lower with seventeen species recorded in total, with fifteen before but only ten after the drought. Flying species of Coleoptera, Hemiptera and Diptera have been quick to colonise. The lack of any muddy bottom to the pond would seem to militate against worms of any family as there are few records of Platyhelminthes, Oligochaeta or Hirudinae. However the weedy nature of this pond appears to favour a wide range of Coleoptera – five species – and Odonata – two species.

DISCUSSION

Drying out

Succession is the gradual colonisation of a water body by gradually less water tolerant flora until it reverts to dry land and is the final stage to which all ponds progress.

Like most of the freshwater habitats on Lundy neither Ackland's Moor Pond nor Widow's Tenement Pond appear to have made any significant progress towards this end, at least not in the last 60 years. *Phragmites australis* is one of the most aggressive colonisers of open water but is absent from Lundy leaving *Juncus* and *Eleocharis* species as the primary freshwater pioneers. Most ponds are fringed with representatives of one or both species. The periodic fluctuations of water level from flood to drought would seem to prevent advances by terrestrial species further into the ponds. This and the depredations of grazing animals would seem to be able to maintain the status quo preventing sufficient accumulation of vegetable mass and subsequent development of soil to the final stage of succession. Nonetheless, both ponds have continued in existence for a provable minimum of 60 years despite their relatively small size. During the last year 2012-13 both ponds were the deepest recorded during the survey period, with ice being present on both ponds in February 2013.

With both ponds being in relatively inaccessible locations there is no record of drying out other than in the late summer of 2011. However there are records of previous droughts which have resulted in dry ponds on Lundy in 1976, 1981, 1995 and 2006 (George, 2007) and there is no reason to suppose these relatively shallow ponds were spared. The survey period bridges the 2011 drought and provides data on the re-colonisation of both macrophytes and invertebrates.

Some species such insect larvae aestivate in the damp mud left in the bottom of ponds and are reactivated once water covers them. Plankton produce resting eggs and some of the worm species encyst themselves whilst others such as Coleoptera and Hemiptera are much more mobile and are able to re-colonise by flying from drying ponds into any newly inundated depression. Table 4 clearly shows the ability of species to re-colonise. However the drought followed by an extremely wet period has so far prevented re-colonisation of Odonata into Widow's Tenement Pond. This is not so with Coleoptera for which this pond is notable; all three genera seen before the drought were present almost immediately afterwards.

It appears that macrophytes also benefit from droughts, with Ackland's Moor Pond being colonised by two open water species in the winter of 2011, Water Purslane *(P. portula)* and Water Starwort *(C. stagnalis).*

That the two ponds are different there is no doubt. Their pH is different, Ackland's Moor Pond being almost neutral and Widow's Tenement Pond more acidic. This is reflected in the species list with Ackland's Moor Pond being host to many soft-bodied members of the worm family. Widow's Tenement Pond does not host many species and is unusual in that only one leech has so far been found and the almost ubiquitous Platyhelminthes are absent. Widow's Tenement Pond being acidic and weedy is a haven for various water beetles and, before the drought, Odonata larvae, although adults are seen at both ponds. Unaccountably, the Water Louse *(Proasellus meridianus)*, found in all other Lundy ponds (George, 2007), which should be in these ponds, is absent from both. Both ponds are important watering holes for birds and mammals and as such will be liable to receive transported eggs, larvae and adult invertebrates as well as benefiting from their waste products.

CONCLUSIONS

Both Ackland's Moor and Widow's Tenement Ponds are broadly comparable with similar ponds on Lundy. Neither has a particularly abundant species diversity and no rare nor indigenous species have been found. Between them most freshwater taxa that are present on the island are represented. Both provide a reservoir of species for the rest of the island during low water periods and being located in relatively dry areas of the island provide vital open water for long periods – important watering holes for domestic and feral stock.

Given their position with neither inflow nor outflow, they could be expected to be anaerobic and species poor. Van der Valk describes how the transport of air into the water column can be slow in still air and rates of oxygen consumption within higher than rates of diffusion into the water column (Van der Valk, 2006). The exposure to prevailing high winds constantly stirs up the water column increasing oxygen diffusion and thus allowing a greater diversity of species than could be expected in such ponds.

At different times of the year Ackland's Moor Pond in particular hosts large numbers of separate species – Corixidae, green *hydra*, leeches and Flatworms. At other times, algae, blanket weed as well as exuvia cover the surface when the Chironomidae hatch. Widow's Tenement Pond is always weedy and silty offering a very sheltered and safe habitat for Coleoptera, notably *Enochrus* sp., where up to 30% of those caught are found to be carrying eggs.

Both ponds are able to recover and regenerate their diversity in less than a year either from adjacent more permanent water bodies or from species with drought resisting strategies after drying out.

Their longevity, aided by human neglect, drought and flood is proven by their permanence of at least 60, and probably more, years.

In comparison with those ponds which have been previously surveyed in some detail, the macroinvertebrate species counts compare very favourably.

The count for Pondsbury has been as high as 40 species (Clabburn 1993) although in more recent times it was 19, closely followed by Quarter Wall Pond with 17 (George, 2007) whereas Ackland's Moor Pond had, up to 2011, 24 species and Widow's Tenement Pond 17. Other surveyed ponds were less rich with Quarry Pond eight and Rocket Pole Pond seven species.

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