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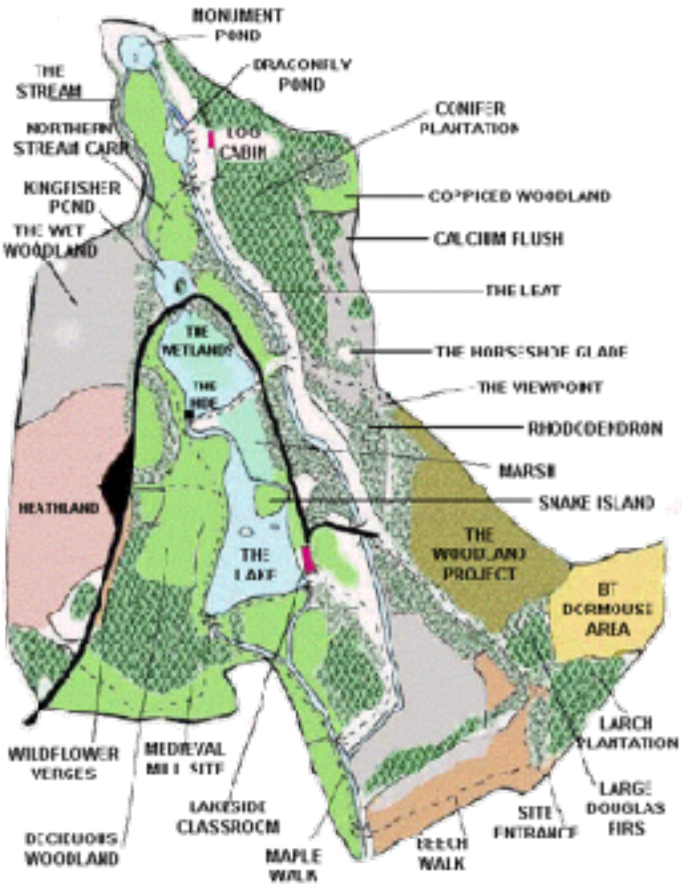
Offwell Woodland and Wildlife Trust – 2017 Sampling Studies

The Offwell nature reserve is a mosaic of habitats spread across a 50 acre site and, as such, lends itself to environmental sampling. This is critical if the diversity of habitats, flora and fauna are to be maintained. The results of these studies will then allow for the revision and implementation of management strategies so that the site is preserved and education can continue well into the future.

1 Water Quality – Abiotic Testing

Offwell consists of a number of water bodies connected by streams and since each water body is connected to another, if there are problems with the quality of one water body it can have a detrimental impact across the site. Therefore, abiotic water testing for pH, dissolved oxygen concentration and dissolved nitrate will highlight any underlying chemical and physical issues at each site. Being situated in the South West of England, Offwell is in the vicinity of farming practices, consisting of crop production and ruminant livestock cultivation, potentially exposing the water systems to harmful external sources of inorganic and organic nutrients. As a result, it is important that the nitrate content of each water body is monitored regularly to avoid high nutrient levels and eutrophic conditions (depletion of oxygen and death of aquatic flora and fauna).



The 4 main water bodies on the site; Monument Pond, Dragonfly Pond, Kingfisher Pond and The Lake will be sampled as well as at the site exit to ensure that the water leaving the site is not contaminated.

Equipment

- Tetra Test kits will be used to measure dissolved oxygen (0_2) and nitrate (NO_3) content. These involve a series of chemical reactions to produce a colour in the water sample and the intensity of the colour corresponds to the concentration present and this is read off a colour chart.
- Electronic pH meter – to obtain the pH of each sample.

- Stopwatch/time keeping device – to accurately monitor the time periods specified in the instructions of the test kits.
- Jam jar – to dispose of the chemical solutions after results are recorded.

Method

1. At the first site, collect a sample of water from the water body which can be used for all tests.
2. Open the nitrate Tetra Test kit and follow the instructions carefully as the number of drops required from each bottle and the volume of water needed in the test vial is very specific.
3. Once all steps have been followed, this test must be left to stand for 10 minutes before it can be compared with a colour chart. During this time, the tests for pH and oxygen concentration can be carried out.
4. Making sure it is calibrated correctly, take the cap off the pH meter and place the probe into the water sample. Gently move the pH meter back and forth and wait until the digital readout settles on a value.
5. Next, open the oxygen test kit and again, follow the instructions precisely.
6. Perform steps 1-5 3 times at each site so that anomalous results can be identified and do not reduce the validity of the conclusions made.

Results August 2017

Site	pH			O_2 (mg/l)			NO_3 (mg/l)		
Monument Pond	7.3	6.9	7.0	11.0	8.0	11.0	17.5	10.0	10.0
Dragonfly Pond	8.9	9.3	9.5	11.0	12.0	>8.0	12.5	15.0	15.0
Kingfisher Pond	7.3	7.3	7.3	>11.0	11.0	11.0	15.0	17.5	15.0
The Lake	7.1	7.1	7.1	<8.0	<8.0	>5.0	12.5	15.0	15.0
Site exit	7.2	7.3	7.3	8.0	11.0	11.0	10.0	10.0	10.0

Mean values and ranges August 2017

Site	pH	O_2 (mg/l)	NO_3 (mg/l)
Monument Pond	7.1	8 - 11	12.5

Dragonfly Pond	9.2	>8 - 12	14.7
Kingfisher Pond	7.3	11 - >11	15.8
The Lake	7.1	>5 - <8	14.7
Site exit	7.3	8 - 11	10

Site	Phosphate (mg/l)		
Monument Pond	0.25	0.25	0.00
Dragonfly Pond	0.25	0.25	0.00
Kingfisher Pond	0.00	0.00	0.00
The Lake	0.25	0.25	0.00
Site exit	0.25	0.00	0.00

Discussion and Conclusion

When considering that 6.5-8.5 is the normal pH range that is expected in freshwater ecosystems, the readings from Monument Pond, Kingfisher Pond, The Lake and the site exit all sit well inside this range, which is encouraging. However, all 3 pH values for Dragonfly Pond of 8.9, 9.3 and 9.5 demonstrate excess alkalinity and thus are alarming. It appears that this is an isolated problem in Dragonfly Pond and it hasn't been caused by an abnormal pH in Monument Pond. It also hasn't impacted the water sources downstream. There were further concerns about Dragonfly Pondeven before any of the practical work had begun. On initial observations, it was concerning that there was an extensive bloom of duckweed which is indicative of eutrophication. If the level of duckweed growth and abiotic conditions are not monitored, mitigation cannot be applied and bacterial action will begin to remove oxygen from the water, suffocating much of the invertebrates and aquatic aerobes within the pond. It is likely that the duckweed bloom is responsible for the high pH due to the fact that it multiplies rapidly and therefore photosynthesis rates are dominating and removing carbon dioxide (which is acidic) from the water. There is also the possibility that below the surface, death and decay is beginning to occur because of lower light penetration, producing ammonium ions (alkaline) and as a result, this has increased the pH. A major problem with the presence of ammonium ions is that under a pH of 9 or above, ammonia gas may be produced and this is toxic. According to further testing, it was found that in areas where there was less duckweed, the pH exceeded 9. This means that the duckweed is probably being killed off by the synthesis of ammonia.

At present, the oxygen concentration at all sites is stable. Dissolved oxygen concentrations below 5mg/l will impact aquatic life and so the results collected are pleasing. Readings at the lake appeared to be a little lower but none the less, were still in a suitable range. It is going to be imperative that the oxygen concentration in Dragonfly Pond is regularly checked and mitigation processes in place for restoring the pond to a healthy state; this is to ensure that eutrophication is not continuing to occur.

The nitrate readings across the site are exceeding natural ranges quite significantly which means that additional sources of nitrate are infiltrating into the water supply upstream of the site. Where this is occurring and the source of nitrates is not fully known. However, Offwell is situated in a large catchment area that is dominated by agricultural practices and so this is the most likely explanation for the readings collected. Most sources state that nitrate levels above 10mg/l will have an effect on freshwater bodies and so looking at these results, there is cause for concern. Only the site exit had consistent readings of 10mg/l and Kingfisher Pond had an average of 15.8mg/l. As a result of these findings, it is probable that the similarly high nitrate concentration in Dragonfly Pond has been one of the factors that has led to the duckweed bloom.

It was then decided that further testing should be carried out for the presence of phosphate in the water bodies across the site and specifically in dragonfly, as it is a key determinant of eutrophic conditions and duckweed blooms (results presented above). Phosphate levels are naturally 0 mg/l but can fluctuate slightly due to the absorption of phosphate into the water from the atmosphere. As seen in the table above, phosphate levels were perfectly normal and only natural fluctuations were observed.

In terms of future sampling it would be advised to carry out these sampling techniques seasonally. But if the problems highlighted in July/August 2017 do not resolve or more are uncovered in future surveys, then the regularity may be forced to increase so that the issues can be closely monitored.

2 Air Quality – Lichen Study

Lichens are an association between a fungus and an alga and so form a mutualistic symbiotic relationship (in which both species co-exist and benefit each other). The algae play an important role in supporting the fungus by producing carbohydrates and proteins through the products of photosynthesis which allow the fungus to grow. The fungus provides a protective layer for the alga. Lichens are known as indicator species as they are sensitive to atmospheric pollution and therefore the presence and frequency of lichens growing on tree trunks and branches provide a useful insight into the quality of the local air. It is expected that due to the rural setting of Offwell, the air quality should be high, but there are no records at Offwell of air quality sampling. The sampling study carried out below will focus on the frequency of a lichen (in this case *Arthonia radiata*) present on 10 different trees of the same species (Beech in this case) around the site to create an Index of Atmospheric Purity (IAP). This is achieved simply by summing the mean frequencies from the 10 trees. It is essential that the same species of tree is used as different species of tree will exhibit different abiotic conditions and this will inevitably have an impact on the growth of lichen. Also, samples must be conducted at the same height above the ground (150cm in this case) and on North, South, East and West sides of the trunk.

Equipment

- A flexible quadrat made of wire and string measuring 30 x 50cm divided into ten 15 x 10cm squares.
- Tape measure/meter ruler to measure height above ground.
- Compass to determine N, S, E and W facing sides of each trunk.
- Lichen identification chart.

Method

1. Use the compass to locate the South facing side of the trunk of the first tree.
2. Measure a height of 150cm from the base of the trunk using the measuring device.
3. Wrap the quadrat around the trunk at this height and count how many squares the desired species of lichen is found in (frequency, maximum number of 10).).
4. Repeat steps 2 and 3 on the North, West and East facing side of the tree.
5. Repeat steps 1-4 on the remaining 9 trees.

Results

Tree	Lichen Frequency				Mean Frequency
	N	S	E	W	
1	1	8	7	6	5.50
2	2	7	6	5	5.00
3	0	6	5	8	4.75
4	2	8	7	8	6.25
5	5	6	4	6	5.25
6	1	6	4	7	4.50
7	3	8	1	3	3.75
8	4	8	4	7	5.75
9	2	6	6	7	5.25
10	1	6	2	5	3.50
					total = 49.50 IAP

Key

IAP	Level of Pollution
Between 0 and 12.5	Very High Pollution
Between 12.5 and 25	High Pollution
Between 25 and 37.5	Moderate Pollution
Between 37.5 and 50	Low Pollution
Greater than 50	Very Low Pollution

Discussion and Conclusion

Arthonia radiata is a crustose lichen that is common across the UK and is overall fairly tolerant to pollution, but does show a particular sensitivity to sulphur dioxide (SO_2). This gas is primarily released through the combustion of fossil fuels. An IAP value of 49.5 would infer that there are low levels of pollution at Offwell. It is possible that the reason for not getting a value above 50 is the impact of anthropogenic activity in the village and the nearby A35 which is likely to be contributing to local nitrous oxide (NOx) and sulphur dioxide emissions. A stand out result was that no *Arthonia radiata* was recorded on the North-facing side of tree 3. This tree was predominantly colonised by moss which perhaps suggests that there is interspecific competition occurring between lichen and moss for resources such as nutrients from the bark of the tree and access to sunlight for photosynthesis. This may be something to investigate in future studies. Because of time constraints, only one species could be sampled and so it is recommended that in future studies, a greater variety of lichen species are identified and sampled to produce more reliable results and valid conclusions. Carrying out this method in different seasons may also be useful to see how the change in anthropogenic activity in each season influences the lichen diversity and IAP values. However, it was observed that there was a rich mosaic of lichens on most tree trunks, also indicating that the air quality at Offwell is high. In addition, the diversity of species observed shows great potential for this study to be extended. Identification of lichen species proved to be challenging, particularly with the crustose lichens studied here due to the similarity in colour and texture. It is encouraged that a magnifying glass is used along with intuitive guides such as those produced by the Field Studies Council (FSC) to aid this process.

3 Water Quality - Biodiversity Indices

Following the concerning results and observations from the abiotic water testing in Dragonfly Pond, a biodiversity index is an applicable study to be conducted in order to determine if the abiotic conditions are having an impact on the ecology within the water body (biotic conditions). A biodiversity index is a quantitative method that is used for obtaining an assessment of the biodiversity of species present. It is also a measure of water quality as a higher biodiversity index equates to a higher quality of water and therefore supports the abiotic results. To provide a comparison, Kingfisher Pond will also be sampled using the same method. This test is time consuming as it involves identifying and counting all individuals present and will require 2 people in order to maintain concentration and the ability to carry it out in an appropriate timescale.

Equipment

- Sampling net – to sample the water body.
- 2 plastic trays, half filled with pond water – one for uncounted invertebrates and one for counted invertebrates.
- Pipettes and scoops to transfer counted invertebrates from the first tray to the second tray.
- Magnifying glasses and identification charts to aid invertebrate identification.

Method

1. At the first pond, dip the net just below the surface and move in a figure of 8 shape three times.
2. Transfer the sample into one of the trays, trying to minimise the quantity of weed and sediment that may distort the water clarity and make counting and identifying the invertebrates difficult.
3. After allowing the water to settle, locate an invertebrate individual and transfer it to the second tray (use the pipette for smaller specimens and the scoops for larger ones).
4. Identify the individual under the microscope and record it. Make sure that the same person does the identification and the other does the transferring.
5. Repeat steps 3 and 4 until all invertebrates in the sample have been identified and tallied. If there are too many of one species to transfer, attempt to count the remaining individuals in the first tray.

Biodiversity Indices

Comparison of Dragonfly Pond and Kingfisher Pond

3 x figure of 8 dip in littoral vegetation, surface and just below surface,
dry, cloudy

	1st Aug 2017		18th Aug 2017	
Species	Dragonfly Pond n	n(n-1)	Kingfisher Pond n	n(n-1)

Cased caddis fly				
Pond snail			2	2
Rams horn snail				
Lesser water boatman				
Greater water boatmen				
Damselfly nymph	17	272	2	2
Dragonfly nymph			1	0
Newt tadpole	1	0		
Mayfly nymph	112	12432	21	420
Flatworm				
Stonefly nymph	2	2		
Water hoglouse	4	12	3	6
Freshwater shrimp	1	0	1	0
Beetle	2	2		
Mite				
Mosquito larva				
Hairworm			2	2
Phantom midge larva				
Leech	1	0		
Pond skater	3	6	1	0
Bloodworm				
Water measurer	2	2		
	N = 145	**Σ = 12728**	**N = 33**	**Σ = 432**
biodiversity index = $\frac{N(N-1)}{\Sigma n(n-1)}$	$\frac{145(144)}{12728}$ = 1.64 **1.64**	/////////////	$\frac{33(32)}{432}$ = 2.44 **2.44**	/////////////

Biodiversity Indices

Comparison of Dragonfly Pond Indices

Comparing 3x figure of 8 with 1x figure of 8 dip

surface and just below surface dry, semi-sunny, warm 19 C

25th August 2017 late morning afternoon

3x pH 7.5 1x pH 6.8

Species	Dragonfly Pond n	n(n-1)	Dragonfly Pond n	n(n-1)
Cased caddis fly	1	0		
Pond snail				
Rams horn snail				
Lesser water boatman				
Greater water boatmen	1	0	1	0
Damselfly nymph	33	1056	16	240
Dragonfly nymph	6	30		
Newt tadpole	2	2	1	0
Mayfly nymph	257	65792	165	27060
Flatworm				
Stonefly nymph				
Water hoglouse	17	272		
Freshwater shrimp	4	12	1	0
Beetle	3	6		
Mite				
Mosquito larva				
Hairworm	1	0		

Phantom midge larva				
Leech	3	6		
Pond skater	2	2		
Bloodworm	1	0		
	N = 331	**Σ = 67178**	**N = 184**	**Σ = 27300**
biodiversity index = **$\frac{N(N-1)}{\Sigma n(n-1)}$**	$\frac{331(330)}{67178}$ =1.63 **1.63**	/////////////	$\frac{184(183)}{27300}$ =1.23 **1.23**	/////////////

Biodiversity Indices

Comparison of Dragonfly Pond and Kingfisher Pond

3 x figure of 8 dip in littoral vegetation, surface and just below surface

dry, 15 C, warmer in the morning

31st August 2017 late morning afternoon

pH 7.3 pH 7.3

Species	Dragonfly Pond n	n(n-1)	Kingfisher Pond n	n(n-1)
Cased caddis fly				
Pond snail			4	12
Rams horn snail				
Lesser water boatman				
Greater water boatmen	1	0		
Damselfly nymph	12	132	4	12
Dragonfly nymph			4	12
Newt tadpole	3	6		

Mayfly nymph	260	67340	27	702
Flatworm				
Stonefly nymph			1	0
Water hoglouse	7	42	7	42
Freshwater shrimp			4	12
Beetle larva			1	0
Mite				
Mosquito larva				
Hairworm	3	6	2	2
Phantom midge larva				
Leech	2	2	1	0
Pond skater	5	20		
Bloodworm	3	6		
	N = 296	**Σ = 67554**	**N = 55**	**Σ = 794**
biodiversity index = $\frac{N(N-1)}{\Sigma n(n-1)}$	$\frac{296(295)}{67554}$ = 1.29 **1.29**	/////////////	$\frac{55(54)}{794}$ = 3.74 **3.74**	/////////////

Summary

As a means of comparison, results take from 2011, where the sampling was carried out using the same method, are also included below.

June 2011

Dragonfly biodiversity index = 4.16

Kingfisher biodiversity index = 5.77

August 2017

Dragonfly biodiversity indices = 1.64, 1.63, 1.29 {1.23 (1x)}

Kingfisher biodiversity indices = 2.44, 3.74

Discussion and Conclusion

The 2017 results show that Kingfisher Pond had a higher biodiversity index than Dragonfly Pond on both occasions that it was performed with three figure of 8 dips. When piecing together these biotic results with the abiotic results, it suggests that the high pH and duckweed bloom in Dragonfly Pond may be impacting the biodiversity. However, what is most alarming is that the species richness in 2011 was considerably higher for both ponds than in 2017. It is possible that the drop in biodiversity in Kingfisher Pond is a result of the excess nitrate noted in the abiotic testing, or perhaps the abiotic abnormalities and duckweed bloom in Dragonfly Pond are producing perturbations on the ecology of Kingfisher Pond. Interestingly, primary sources have stated that when the 2011 results were taken, there were no unusual abiotic conditions and no issues with duckweed. Having tested out the potential of using just one figure of 8 dip to produce a biodiversity index, it was decided that performing three figure of 8 dips increased the number of invertebrates caught, resulting in a more representative indication of biodiversity. Unfortunately, not all of the biodiversity indices could be conducted on the same day, although it was consistently dry on the days that this was carried out.

In terms of the abundance of species, mayfly nymphs were high in number across all of the biodiversity indices. On the other hand, Dragonfly Pond nymph numbers were surprisingly low, especially when compared to the 18 individuals counted in Kingfisher Pond in 2011. The abundance of pond snails also showed a dramatic decline from 2011 and 0 Rams horn snails were identified in 2017. An addition of leeches in 2017 is also noticeable. To conclude, the biodiversity of Dragonfly Pond and Kingfisher Pond has decreased since 2011 and there were also changes in the abundance and even presence of certain species. This sampling study should follow the same schedule as the abiotic testing so that the results can support each other to produce an overall conclusion about the health of the water bodies and systems at Offwell.