Comparative Pond Study:
Analysis of Upper and Lower Man Made Ponds at Cal-Wood

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Photo Credit: Kathy Smith

Background Information for Project

We started with many ideas, which included examining groundwater, discharge and recharge of streams, identify water table and wetlands using specific flora, and impact of invasive species. It was important our study encompass all of our interests and learning needs and apply to the outside world. Another key factor was to maximize expertise of our cooperating scientists.

We finally agreed upon a focus study of how invasive species affect the environment. The specific environment system included the two man made ponds at Cal-Wood. The upper pond has been stocked with trout, and invasive goldfish had also been introduced. The lower pond has not been stocked with fish.

After several attempts, the invasive species (goldfish) were found to be evasive and difficult to catch. Therefore, our study now focuses on water quality of the two ponds and one discharge stream which empties into the second pond.

The water quality focuses specifically on DO (dissolved oxygen) and BOD (Biochemical Oxygen Demand). This study will be compared to a previous study and findings of DO and BOD in the two ponds.

Research Question

How does the water quality of the upper and lower ponds compare in terms of DO and BOD?

Hypothesis

We believe the BOD of the upper pond will higher due to its fish population.
We believe the DO of the upper pond will be lower due to the higher demand for oxygen.

Site Descriptions

Cal-Wood:

Upper Pond, Cal-Wood: N40 08.769 W105 23.398

Open meadowlands in exposed sunlight. Deer often grazing on the meadow slope on the south side of the pond, which continues up in elevation.

Various grasses, and rushes line all sides of the pond.

Upper Pond   Photo Credit: Kathy Smith

Lower Pond, Cal-Wood: N40 09.063 W105 22.897
A trail borders the southern side of the pond. This trail is lined with a clone of *Populus tremuloides* (Quaking Aspen) and patches of *Aquilegia caerulea* (Colorado Columbine). The eastern portion of the pond has willow saplings (*Salix amygdaloides*, or *Salix exigua* ?) populated with hummingbirds.

Lower Pond Photo Credit: Kathy Smith

Discharge Stream, Cal-Wood: N40 09.010 W105 23.219
This stream is an intermittent stream, which flows from Cal-Wood Lodge, partially fed from ground water seepage from the leech field, waste water outflow from the lodge. It feeds into the pond systems in between Upper Pond and Lower Pond.

Upstream from the discharge stream, the stream flow is dependent upon rainfall. After two days of little rain, the flowing stream became a trickle. The herbaceous vegetation consists of grasses and rushes in the streamtable. Other plants found on the moist slope were *Anemone Canadensis* (Northern Anemone), *Cerastium arvense* (Mouse-Ear Chickweed), and *Verbascum thapsus* (Mullein). Further upslope were small stands of aspen (~12 trunks of a single clone) and conifers. Butterflies were abundant on sunny days. Red breasted robins were also common.

Balarat
Balarat is a burn site that borders Cal-Wood on the south side. The river sample sites are approximately 50 meters apart. Samples were taken upstream from the confluence of river one and river two.

River One: N40 08.103 W105 22.467
This river runs down along the bottom a burned hillside. The streamside itself is replete with fresh green vegetation, among these *Aquilegia caerulea* (Colorado Columbine). All plants here are herbaceous.

River Two: N40 08.091 W105 22.436
This river runs down through the burn site, eventually meeting River One. The vegetation found here is the same as in River One.

Sampling Stream 2, Balarat Photo Credit: Kathy Smith

Balarat Pond: N40 08.590 W105 22.605

This large pond has unidentified fish and is situated in a large, sun exposed grassy meadow. Grasses line all sides, with the exception of a small aspen stand on the eastern side.

Balarat Pond   Photo Credit: Kathy Smith

Equipment and materials

Water collection bottles
Probe to measure DO, Salinity, Conductivity, Temp at site
Hip waders
Rain Ponchos
Testing Kits: Hach and Carolina Biological

Quality control

All tests were done at approximately the same time and weather conditions.
The same person collected all water samples, and probe reading.
Nitrate tests were done using multiple sets of equipment to validate accuracy.
BOD samples were all sealed simultaneously.
Samples were taken away from vegetation.
Probe tests were taken at same sites of water colletion.
Probe was calibrated before tests began.
Manual calibration of DO was performed in lab.

Procedure Methods

a) 2 Samples were taken at each of 5 sites.

1) Upper Pond Head
2) Upper Pond Foot
3) Lower Pond Head
4) Lower Pond Foot
5) Discharge stream feeding lower pond

b) 1 water sample sealed for BOD from each site.
c) BOD tests performed after 48 hours
d) Tests done in Lab

1) Nitrates (2 companies: Hach, Carolina Bio)
2) pH
3) Alkalinity
4) Hardness
5) Iron
6) Phosphates
7) Ammonium Nitrate

e) Probe tests at site of collection

1) DO %
2) DO mg/L
3) Conductivity (μS)
4) Conductivity (μS temp adjusted)
5) Salinity ppT
6) Water Temperature ^{o}C

f) Time of collection, outside temperature, and weather conditions were noted
g) GPS coordinates were taken.
f) Stream mapping

Data

Data Collection June 21, 2004
Daily Temp: 41.5 F
Weather: Rainy

Calwood

Test	UP Head	UP Foot	LP Head	LP Foot	Discharge
Nitrates					
Strips,	0	0	0	0	0
Hach, mg/l	0	0	0	0	0
pH, strip	6.00	6.00	6.00	6.00	6.50
Alk, strip					
Alk, ppm	65	60	80	80	100
Iron (+2, +3	0	0	0	0	0
Hardness	25	0	40	25	10
ppm					
PO4	0	0	0	0	
mg/L					
Sal	0	0	0.1	0.1	0.1
ppt					
DO %	56.3	63.1	57.5	70.3	51.9
DO mg/L	5.75	6.63	6.45	7.36	6.35
Conductivit	65.3	62.4	140.3	141.5	163.8
µS (adjust	83.4	80.5	182.2	183.4	231.9
BOD mg/L	0.48	0.74	0.79	1.49	3.11

Data Collection June 22, 2004
Daily Temp:
Weather: Sunny, Clear

Balarat

Test	River1	River2	Balarat Pond
Nitrates			
Strips,	0	0	0
Hach, mg/l	3	2.5	2.5
pH, strip	6.00	6.00	6.00
Alk, strip	30	0	40
Alk, ppm			
Iron (+2, +3	0	0	0
Hardness	0	0	0
ppm			
PO4	0	2.5	0
mg/L			
Sal	0	0	0
ppt			
DO %	77	75.8	89.5
DO mg/L	8.4	8.75	9.25
Conductivit	63	49.5	71.3
μS (adjust	85.7	71.2	90.3
BOD mg/L			

Data Analysis:

One item of note was the difference in salinity between the Upper Pond and the Lower Pond and Discharge Stream. The Upper Pond salinity level was 0.0ppt, while both the discharge stream and lower pond salinity levels were 0.1 ppt. Although this is not a drastic change and poses little environmental threat (Dorrie Panayatou), it is notable. One possible explanation for the increased salinity level is that the discharge stream is partially fed by the waste water seepage from Cal-Wood Lodge. Before the water is discharged from the lodge, is it buffered and filtered by an extensive treatment system. Part of this system contains "two huge blocks of salt" (Shane Milne, Cal-Wood Office Manager). This seems to be a reasonable explanation for the increase in salinity, since the seepage from the waste water pond would seep into the discharge stream.

When comparing our sample sites, we focused on the three areas including, the upper pond (UP), the lower pond (LP), and the Discharge stream, with attention to multiple sample sites in the UP and LP, specifically the head and foot of both.

Our first test, the Salinity test, showed small differences between the three sites. We detected minimal levels (0.1ppt) of salinity in the LP and discharge stream and a reading of 0ppt for the UP. We attribute these differences in salinity levels to the use of salts in the filtration process here at the Cal-Wood lodge. Based on the location of the leach field here at Cal-Wood, we have concluded that salts from the filter system have been introduced to the LP and discharge stream, as they are located below the lodge. We attribute the 0ppt readings of the UP to the fact that it is above the lodge and is not fed from any streams in contact with the leach bed.

Our second test, alkalinity, provided some interesting data. We recorded readings of 65ppm (head of UP), 60ppm (foot of UP), 80ppm for both sites at the LP, and 100ppm for the discharge stream. As alkaline levels are good indicators of a streams ability to buffer acids, we believe that the LP and discharge stream are more stable bodies, the discharge stream being the most able to buffer incoming acids of our three sites.

Our third test, pH, showed very little variation between the three sites. The UP and LP both had readings of 6.0 at both sample sites. The stream had a reading of 6.5, a minimal difference, however still a better reading.

The fourth, test of hardness, shows concentration of dissolved minerals in the sample sites. We found a range of levels, all still indicating soft water levels. The UP read 25ppm (head) and 0ppm (foot). The LP readings were 40ppm (head) and 25ppm (foot). Lastly, the discharge stream read 10ppm. Although different, all three sites still remain between the soft water levels of 0-60ppm.

The next few tests, Iron, Phosphates, Ammonium, and Nitrates, all showed the same 0 readings for all test sites. We predicted an increase in the Ammonium levels of the UP, as the pond is stocked and has quite a different population of aquatic life.

Conductivity, a test for total dissolved solids in a sample, showed a wide range of results for our test sites Because the standard used for calculating conductivity is based on a temperature level of 25* C, we had to increase the values for each reading by 2% for every degree below the 25*C. We found the conductivity levels of the discharge creek the best, with a reading of 231.9 us/cm at 9.8*C. After converting the level based on the 25*C standard, the level for the discharge stream is 302.39 us/cm. Readings between 150-500 us/cm are characteristic of a healthy stream. The LP levels, for both the head and foot, were 182.2 us/cm and 263.26 us/cm after converting. These readings are also characteristic of a healthy stream and we attribute this pond's healthy levels to the contributions made by the discharge stream to the LP. The UP was recorded at 62.4 us/cm and 77.25 us/cm after the conversion. The low levels of the UP indicate deionized water qualities, as indicated by the "Healthy Water, Healthy People Testing Kit Manual."

Dissolved Oxygen (DO) is a great indicator of water quality and sustainability. The higher the DO level the more suitable the water source is for sustaining aquatic life. Dissolved oxygen is recorded in two standards, mg/L and % saturation based on water temperature and elevation. We used the YSI probe to determine our DO levels, as the Hack Water Test Kit had expired, at least for the DO portion. The DO readings for the UP (head) were 56.3% saturation and 5.75 mg/L and 63.17% saturation and 5.75 mg/L. As temperature plays a large role in DO, the UP with a temperature of 13.4*C, could have contained as high a reading as 10.76 mg/L, The levels for the LP were 57.5%, 6.45 mg/L (head) and 70.3%, 7.36 mg/L (foot). Based on the temperature of the LP (12.9*C), the pond can contain levels as high 10.76 mg/L.

Dissolved oxygen levels for the discharge creek were 51.9% and 6.35 mg/L. The temperature of the creek was 9.8*C, which means the creek is capable of containing 11.55 mg/L.

We predicted that the DO would be higher for the discharge creek, as it is experiencing aeration through it's turbulent behavior. We also believed that the UP and LP would have a more abundant population of aquatic life as the UP is stocked and has had a group of goldfish (invasive species) introduced. The discharge creak is also experiencing more direct sunlight throughout the course of the day, which means more photosynthesis is taking place.

Our last test, Biochemical Oxygen Demand (BOD), measures the amount of oxygen consumed by aquatic life over a given period of time. The test is designed to be done over a 5 day period, however with our time restrictions were only able to perform the test for 48 hours. We were unsure how these readings were going to relate, having only the two days to allow for oxygen consumption. As BOD is the difference of DO before and after the timed test, we used the YSI to take our DO readings. The DO for the UP (head) was 5.75 mg/L (before) and 5.27 mg/L (after), giving us a BOD value of 0.48 mg/L. The DO for the UP (foot) was 6.63 mg/L (before) and 5.89 mg/L, giving us a BOD of 0.74 mg/L. The DO for the LP (head) was 6.45 mg/L (before) and 5.66 mg/L, giving us a BOD of 0.79 mg/L. The LP (foot) DO was 7.36 mg/L (before) and 5.87 mg/L (after), giving us a BOD of 1.49 mg/L. The discharge creek had a DO of 6.35 mg/L (before) and 3.24 mg/L (after), giving us a BOD of 3.11 mg/L.

The DO for all the sample sites were above 5 mg/L, which indicates a level of health and potential of a more diverse aquatic population. Looking at the BOD levels, it would be safe to say that the discharge creek has a larger demand and depletion rate of oxygen.

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Based on our data, our sample sites were very similar in water quality. The discharge creek, however, seems to be more suitable for aquatic organisms. The pH (6.5) is the closest to neutral (7) and the alkalinity of 100ppm indicates the stream's strong ability to buffer incoming acids, required to maintain a constant pH level. The discharge creek also had a healthy DO level and high BOD, which indicates a larger population of aquatic organisms and higher demand for oxygen. After only 48 hours the creek BOD had depleted by over 50%, while the other two locations were both less than 10%. These BOD depletion levels support our belief that the discharge creek has a more abundant population of aquatic life.

Conclusions / Intrepretation

Next Questions

Sources

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