Southern Cayuga Lake Watershed

Matthew Gonser

KEYNOTES:

(1) The Lake is an accreting system
  a. In-stream and channel erosion and sedimentation is the result of large-scale geomorphologic processes, a geologic legacy of glaciations
  b. Human land use practices have historically aggravated upland soil erosion contributing to sediments in the hydrologic system, a process known as legacy sediment development

(2) Accretion is a natural process (modified by human activity) and unlikely mitigated

(3) Continuous sedimentation creates a maintenance issue

(4) Sediment in the inlet is a resource: SPOILS➔SOILS

To understand the process of sedimentation in the Cayuga Inlet system it is necessary to step back, look upstream and consider what the contributors to the system are. Through a watershed approach it is possible to qualify what the hydrologic and material inputs are and ask whether it is possible to prevent the sediments from entering the system, thus reducing the need for dredging maintenance. As found through this investigation sedimentation in the inlet is the legacy of geologic and glacial processes, with contributions from human activity in recent history. These effects are observed today and the ability to influence and/or reduce them is unlikely.

South Cayuga Lake Inlet Complex

Watersheds operate at several scales (Figure 2.1.a-c), from large bodies of water and their surrounding environments (1), the waterways that flow through them (2), and the geologic matrix that composes the edges and bottoms of the hydrologic channels (3). A watershed is the upslope area that drains to a specific point, typically the outlet of a stream, river, or lake or the point where a lower order stream meets a higher order stream (Hollingshead, Anderson, and Haith, 2008.). The South Cayuga Lake Inlet Complex is fed by four (4) subwatersheds: Cayuga Inlet, Buttermilk Creek, Six Mile Creek, and Cascadilla Creek (Figure 2.2 – The four subwatersheds that feed the South Cayuga Lake Inlet Complex (hillshade vertical exaggeration 5x)). Cayuga Inlet is the second-largest in area, receives flows from Treman State Park and outlets through the Flood Control Channel. Buttermilk Creek is the smallest in area, flows through Buttermilk Falls State Park, and outlets into the Flood Control Channel. Six Mile Creek is the largest in area, provides the city's drinking water supply, and is channelized through its lower reaches through South Ithaca. Cascadilla Creek is the second smallest in area, runs through Collegetown, Downtown, and outlets into the inlet at the Farmers Market.

Figure 2.1 a

Figure 2.1 b

Figure 2.1 c

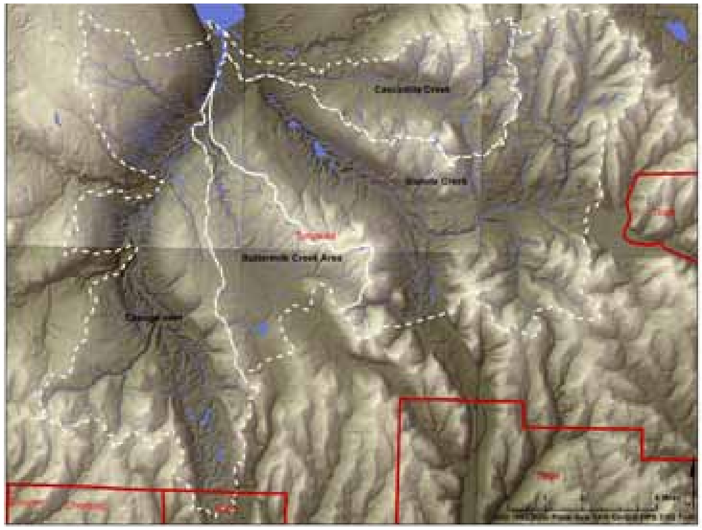

Figure 2.2 - The Four Watersheds that Feed South Cayuga Lake Inlet

Table 2.1 - Sediments' potential impact on water resources (adapted: G/FLRPC and EcoLogic, 2001a, Table 3.1.1, p.3-2)

Pollutant	Impact
Sediment: - From Natural erosion of stream channels, construction, urban runoff, gravel operations, agriculture, logging, hydromodification	*On Fisheries:* - Decreases transmission of light, which affects plant production (food and cover), behavioral activities (nesting, feeding, mating), respiration, digestion, reproduction - Increases surface water temperature, which decreases dissolved oxygen concentration in water - Decreases spawning habitat (fills pools and nest sites) - Transports absorbed contaminants *On Water Supply:* - Damages water treatment pumps, equipment - Increases treatment costs - Reduces reservoir volume - Toxic substances may adhere to sediment - Nutrients increase, which stimulates algae growth - Decreases river bottom infiltration, which reduces well yield *On Wetlands:* - Reduces flood storage - Increases peak discharge - Alters habitat *On Recreation:* - Decreases clarity of water (public health and safety) - Reduces aesthetic and recreational value - Reduces sport fishing populations

Sedimentation – Contributors to the South Cayuga Lake Inlet Complex

The proximate cause of sedimentation in the inlet system is erosion. Erosion is the process by which soils are worn away by wind, water, and other natural agents; human activity can aggravate this process. However, the ultimate cause of sedimentation in the inlet system is the geologic legacy of glaciations and a period of legacy sediment development in the recent history of European settlement in the area (ca. 1790).

The Cayuga Lake Watershed Restoration and Protection Plan (2001) and the Cayuga Inlet Dredging Project Site Reconnaissance Report (2010) identified sediment (erosion of stream beds and banks, and not current land use practices) as the most-signification non-point source (NPS) pollutant affecting Cayuga Lake and its tributary streams. Sediment, as a pollutant, has several impacts on water resources (Table 2.1):

The concept of legacy sediments identifies sediment eroded from upland areas after and during centuries of intensive land uses. Deposited in valley bottoms along stream corridors, legacy sediments bury pre-settlement streams, floodplains, wetlands, and valley bottoms
(Figure 2.3 – Diagram of legacy sediment development (Maryland piedmont floodplain development model. Jacobson, B.D. and Colemen, D.R. 1986. Figure 7: 635)). They alter and continue to impair the hydrologic, biologic, aquatic, riparian, and water quality functions of pre-settlement and modern environments (Hartranft, n.d.).

The period of greatest legacy sediment development in Tompkins County occurred between 1790 (i.e., approximate period of major European settlement) and 1900. From a 1790 baseline figure for forest cover of nearly 100%,

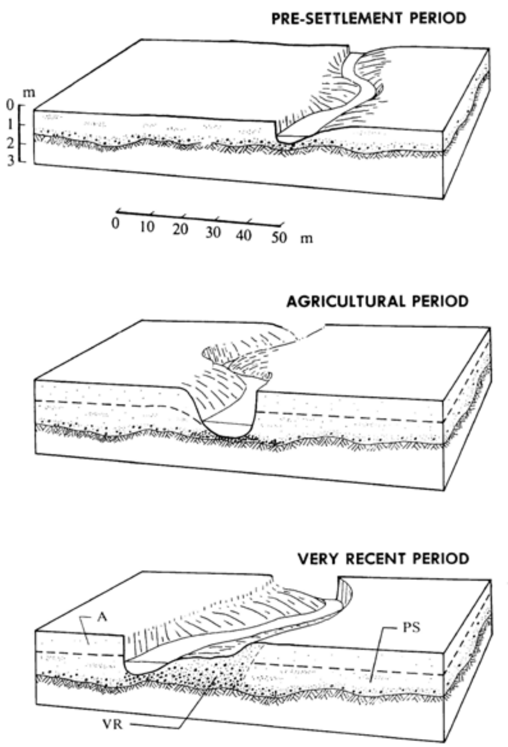

Fig. 7. Flood plain development model. Schematic representation of three-stage development of Maryland Piedmont flood plains. Pre-settlement period (PS): undisturbed stream in natural regime. Agricultural period (A): excessive upland erosion and flood plain sedimentation. Very Recent period (VR): reduced sediment load, reworking of flood plain sediment and redeposition of coarsest sediment as new, lower flood plain level.

Figure 2.3 - Diagram of legacy sediment development

forest cover dropped to 19% by 1900 (Smith, Marks, and Gardescu, 1993). However, this percentage increased to 28% in 1938 and 50% by 1980 (Figure 2.4 – Canopy cover of the South Cayuga Lake area). This fact indicates that the majority of forests in Tompkins County today are post-agricultural, and of these reforested areas

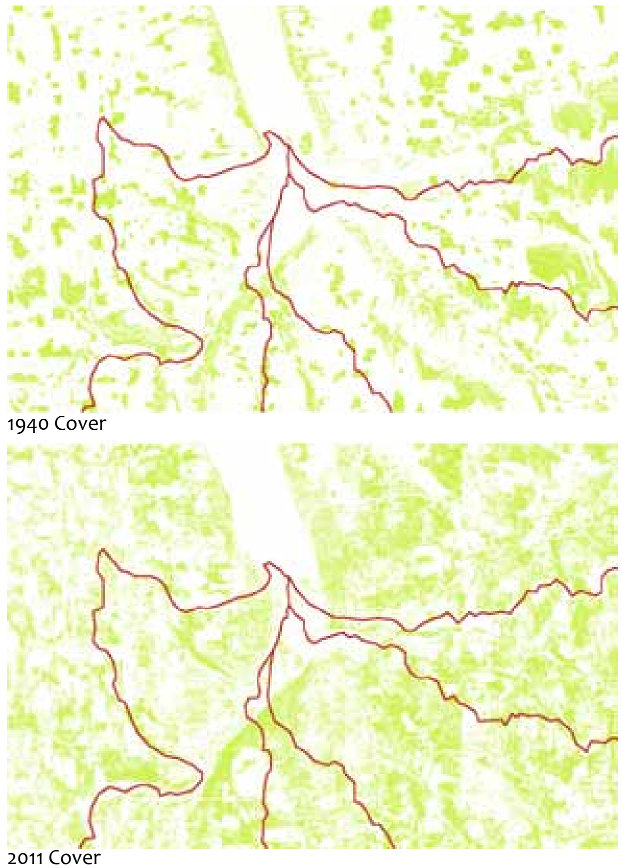

Figure 2.4 - Canopy cover of South Cayuga Lake area

it is predominantly on the steeper lakeside and streamside slopes rather than the flatter uplands (Smith et al., 1993). Yet, the impacts of the historical forest clearance are being felt today, as legacy sediments are transferred downstream including the inlet complex, and are mostly irremediable.

Two other major contributors are roadbanks and streambanks (Figure 2.5.a-b – Streambank and roadbank erosion following Tropical Storm Lee, Banks Rd., Six Mile Creek, Ithaca NY (30 September 2011 – Photo: M. Gonser)) . Roadside ditches are sources of sedimentation and erosion. Generally, the closer they are to the lake the more erosion is occurring mainly due to steep gradients from the upland portions of the watershed down to the lake (G/FLRPC and EcoLogic, 2001a, p.14). With the exception of the Buttermilk and Cascadilla

Figure 2.5 a - Roadbank erosion

Figure 2.5 b - Streambank erosion

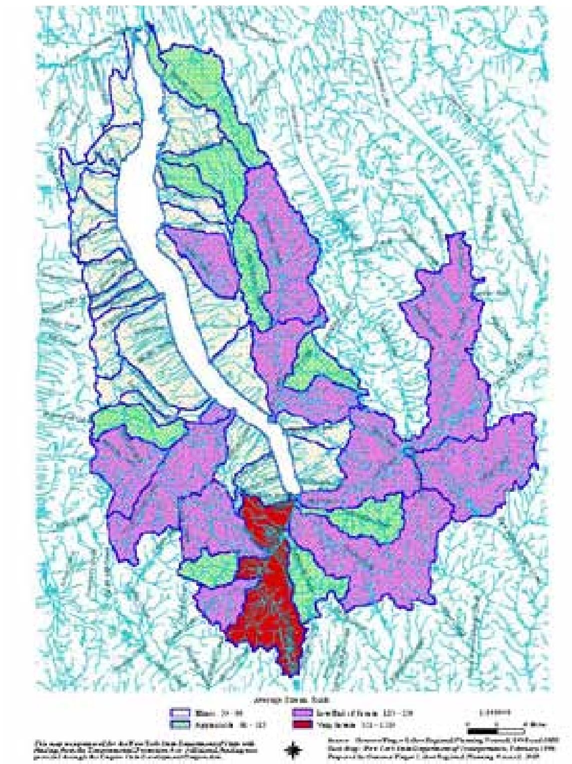

Figure 2.6 - Erosion classification by subwatershed

Creek watersheds, the southern subwatersheds have numerous road ditches classified as “very severe”. Six Mile Creek roadbanks are areas of concern, with numerous sites documented as moderately eroded or severely eroded. Cayuga Inlet appears to have serious roadbank erosion. G/FLRPC and Ecologic (2001a) found a number of road ditches documented as having moderate or severe erosion problems, and a few very severe sites.

In the southern tributaries of Cayuga Lake, the primary source of sediment appears to be streambank erosion, not runoff from construction sites or cultivated fields (G/FLRPC and EcoLogic, LLC. 2001a, p.2). The southern portions of Tompkins County are generally steeper and less amenable to agriculture. The Cayuga Inlet is characterized as very severe and contains some of the highest stream ranks in the watershed (Figure 2.6 – Erosion classification by subwatershed: Streambank Inventory and Average Stream Rank (G/FLRPC and Ecologic, 2001a, Map 3.4.3)). Though qualitatively ranked, is it possible to quantify the material flows through the South Cayuga Lake Inlet Complex?

Soil Mass Loading/Wasting

The Cayuga Lake Generalized Watershed Loading Function Geospatial Database (GWLF) (Haith and Shoemaker, 1987) was designed to quantify factors associated with non-point source (NPS) pollutants in the Cayuga Lake watershed at the landscape scale. The database contains information on land use, land cover, soil characteristics, climate, sewer and septic systems, impervious surfaces, and topography for the entire Cayuga Lake watershed. Focusing the model on the four (4) subwatersheds of the Cayuga Inlet system we can extract the following sediment yield estimates (Table 2.2):

Table 2.2 - Sediment yield estimates per subwatershed generated by the GWLF (Haith and Shoemaker, 1987)

Subwatershed	Sediment Yield Estimates (kg/ha/yr)	Area (ha)	
Buttermilk Creek	49	2942	
Cascadilla Creek	40	3451	
Cayuga Inlet	91	10,336	
Six Mile Creek	54	13,306	
Totals	234	30,035	**7,028,190 kg/yr**

These numbers, though not necessarily equating to sedimentation in the inlet itself, are useful when considering maintenance and management regimes in light of the current issue of deferred maintenance, and this and future dredging projects. That is, this model can be applied to an approximate mass balance of the inlet system, quantifying the inputs and outputs against some time component (i.e., number of years of dredging project or frequency of maintenance dredging).

With known erosion classifications and sedimentation estimates for the four (4) subwatersheds the next question is are certain places more susceptible and is it possible to intervene? One measure of such soil mass wasting events is landslide susceptibility. In general, a landslide is the downward movement of a slope and materials under the force of gravity. As may be expected with the topography of the local gorge channel systems there is potential for stream bank and wall failures resulting in greater-than-normal erosion.

The team conducted a landslide susceptibility analysis adapted from a USGS/NYSGS preliminary landslide analysis algorithm (NYS Division of Homeland Security and Emergency Services, 2007). The two inputs into the model are slope and soil conditions, from which six (6) weighted factors are derived and used to determine a hazard range. The factors are derived from two (2) data sources: digital elevation models (DEMs) – (1) slope; USDA SSURGO Digital Soil Survey – (2) American Association of State Highway and Transportation Officials (AASHTO) soil classification, (3) liquid limit, (4) hydrologic group, (5) physical soil properties (as % silt and clay), and (6) hazard of erosion (see Appendix X for an abridged methodology). The resultant output (Figure 2.7 – Landslide susceptibility for the four (4) South Cayuga Lake subwatersheds (hillshade exaggeration 5x)) illustrates that the area's highest hazard zones are along gorge channels and stream banks. As previously noted, these fragile systems undergo a natural erosion process that is unlikely to be influenced through human intervention.

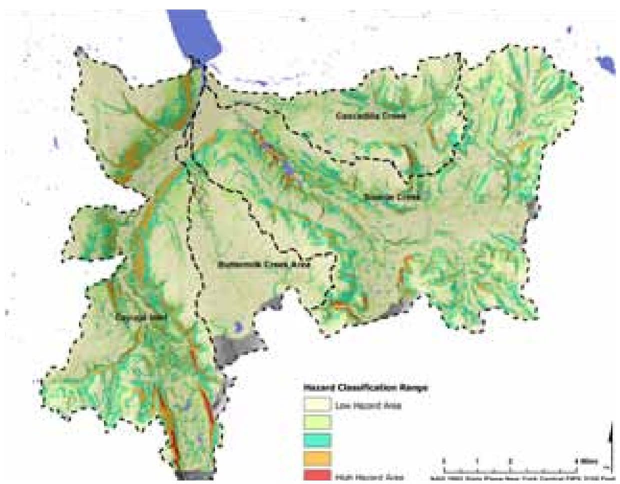

Figure 2.7 - Landslide susceptibility for the four (4) South Cayuga Lake subwatersheds (hillshade exaggeration 5x)

However, this model is merely a depicted of the susceptibility of land to mass wasting and is not a determination of occurrence. Though the landslide susceptibility analysis is useful in identifying areas of concern, field checks are necessary for validation. Current canopy cover (estimated at 55-60%), which suggests slope stability, qualitatively appears to correspond with the areas of higher landslide susceptibility indicating that land cover and use is an important additional factor to consider, and is a condition that is perhaps improving (Figure 2.8 – Current canopy cover within the four (4) South Cayuga Lake subwatersheds with hydrography).

Figure 2.8 - Current canopy cover within the four (4) South Cayuga Lake subwatersheds with hydrography

Mass Balance – Maintenance and Management Regime

The issue surrounding the inlet system is an extended period of deferred maintenance. As a naturally accreting system, the inlet experiences annual sediment inputs that either fall out of solution in the inlet or are transported to the lake (Figure 2.9 – Sediment plume in South Cayuga Lake, 1993 (G/FLRPC and Ecologic, 2001a, Figure 4.2.8)). This sedimentation necessitates dredging of the material to ensure the ecosystem services of navigation and recreation within the inlet. So, what does this all mean? What has been learned from the investigation of sediment inputs and the specifications of the Cayuga Inlet Dredging Project?

The GWLF estimates 7,028,190 kg/yr of sediments move through the South Cayuga Lake Inlet Complex. This equates to approximately 4,167 yd3 annually. Though this volume is not all deposited in the inlet complex, it provides a conservative number to conduct a mass balance of the inputs versus the outputs over some period of time.

The high-end estimate for material needed to be dredged is 660,000 yd3. Given that the decided upon dewatering site at Southwest Park has a capacity to process 80,000 yd3/yr, if conducted on a continuous schedule, the dredging project will take over 8 years. During that time the inlet will accumulate additional material (though not the total estimate of 4,167 yd3/yr). That means the net removal of material will not actually be 80,000 yd3/yr, thus extending the timeframe of the dredging project. These rough calculations demonstrate the limitations of the dewatering facility and suggest that alternative processing methods in conjunction with the site at Southwest Park should be investigated accelerating the extraction of material and potentially demonstrating other beneficial re-uses of dredged material. The ultimate challenge is to develop a continued maintenance and management regime for dredging and the dredged material.

Figure 2.9 - Sediment plume in South Cayuga Lake, 1993 (G/FLRPC and Ecologic, 2001a, Figure 4.2.8)

Conclusions and Lessons Learned

This section posed the questions of what the hydrologic and material inputs to the inlet system are. Additionally, it sought to articulate whether anything could be done about preventing sediments from reaching the South Cayuga Lake Inlet Complex. From the findings presented above, there are four (4) main conclusions:

(1) The Lake is an accreting system
  a. In-stream and channel erosion and sedimentation is the result of large-scale geomorphologic processes, a geologic legacy of glaciations
  b. Human land use practices have historically aggravated upland soil erosion contributing to sediments in the hydrologic system, a process known as legacy sediment development
(2) Accretion is a natural process (modified by human activity) and unlikely mitigated
(3) Continuous sedimentation creates a maintenance issue
(4) Sediment in the inlet is a resource: SPOILS→SOILS

Acknowledging that the sediment will continue to move to and/or through the system and that interventions in the landscape are not likely to halt the process should not be discouraging.

Once dredged, the material should be viewed as a resource, as parent material or "soil in the making". This stresses that this is a maintenance and management issue and opportunity for considering alternative beneficial re-uses of the material, changing the mind-set that this material is a waste product (spoil), but is in fact a resource (soil).

To better understand the potentials of the dredged material as a resource, the team conducted numerous physical, biological, and chemical tests on samples from the watershed, as well as other reference projects and disposal sites.

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Acknowledgements

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Dredge Material Analysis

Jamie Nassar & Hayden Stebbins

KEYNOTES:

(1) Nutrients found in dredge material are self stabilizing based on its chemical characteristics.

(2) Dredge material is low in Organic Matter and contains High pH levels.

(3) Previous testing indicated that inlet sediment was mostly clay, based on our findings inlet sediment is a sandy loam.

(4) Dredge material has the ability to sustain plant life.

(5) Aggregate Stability of Dredge material demonstrates a low quality for structural material.

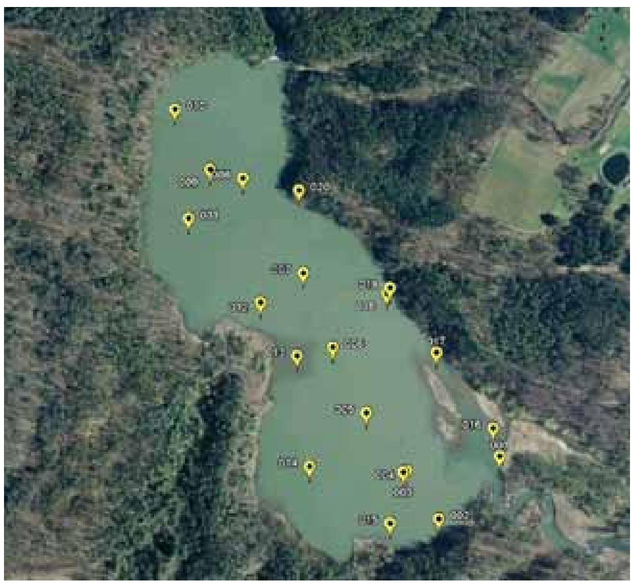


Figure 3.1 - Location of sample sites in Six Mile Creek Reservoir

Introduction

The purpose of performing tests on dredge material was to find out what quality dredge in the Cayuga Inlet is so that we could recommend potential beneficial uses for it. The goal was to establish if the dredge material is able to sustain plant life and if there are any limitations with potentially using the dredge material for various productive uses.

Sample Sites

Six Mile Creek Reservoir

The original plan was to collect samples from the Cayuga Inlet, but the Inlet was closed once Hydrilla verticillata was discovered. We made the decision to use the Six Mile Creek Reservoir as a sample site because dredging is already planned to increase the depth of the reservoir, and it is very similar as it is simply upstream. It is also used by the City of Ithaca as a reservoir for drinking water, so it would provide a useful data set. A total of 16 samples were gathered. 10 samples were tested; 3 from the left transect, 4 from the center, and 3 from the right [Fig 3.1].

Cayuga Inlet and Flood Control Channel

Once the inlet was reopened, this sample site was selected because it is the location of the dredging project. These samples were intended to provide a better understanding of what the dredge material consists of and what it could be used for. Three samples were tested throughout the Inlet and Channel, as denoted by the red tags in the photo below [Fig 3.2].

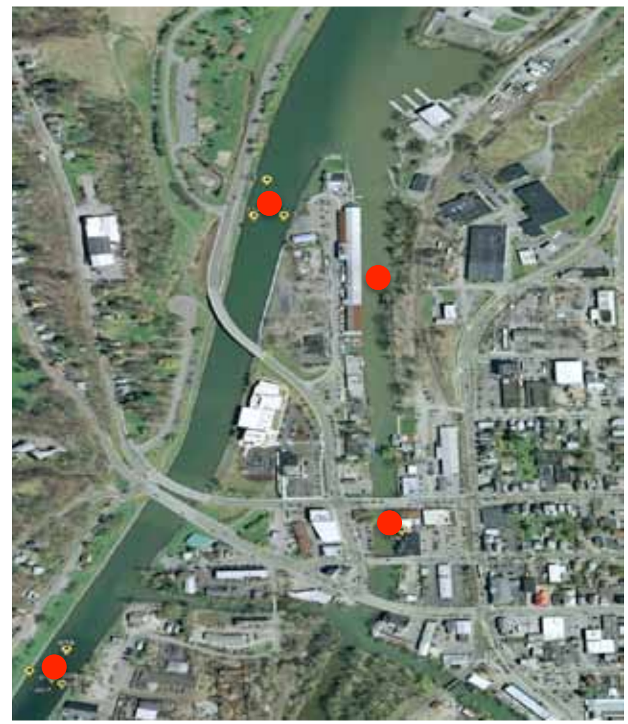


Figure 3.2 - Location of sample sites in Cayuga Inlet

Figure 3.3 - Dredge and Non-dredge sample sites

Lake Source Cooling Dredge Disposal Site, Dryden, NY
(Intersection of Hanshaw Rd. & Niemi Rd.)

This sample site was chosen as a reference site to assess what happens to dredge that is left on a field and treated with a zero-order restoration approach. This was the site where Cornell spread dredge material from the Lake Source Cooling project on Cayuga Lake in 2000. Dredge material was spread onto an old cornfield and left undisturbed.

Six samples were taken from the dredge material and six samples were taken from the field directly adjacent [Fig 3.3]. Three samples from each side were tested. Species diversity was also studied and compared between the dredge field and the non-dredge field. This site provided an opportunity to test whether there are persistent, long-term differences in soil characteristics and plant community composition between dredge and non-dredge material.

Materials and Methods

The Materials and Methods section for soil analysis has been adapted from the Cornell Soil Health Assessment Training Manual, since the tests were carried out in the Cornell Soil Health Lab. The samples from the Inlet and the Reservoir were taken using an Eckman dredge dropped from a canoe onto the substrate [Fig 3.4]. The samples at the Dryden site were taken by digging up soil samples.

Cornell Soil Health Labs

The Cornell Soil Health Test was performed on the samples from the Dryden, Inlet, and Six Mile Creek sample sites with the help and guidance of Extension Associate Bob Schindelbeck. Tests were performed on the physical, biological, and chemical characteristics of the soil samples. The physical tests included testing rapid soil texture, wet aggregate stability, available water capacity, and field penetration. Biological tests included an active carbon test, potentially minerizable nitrogen, and root health rating. Chemical tests included organic matter and nutrient analysis.

Figure 3.4 - Students harvesting dredge material from inlet

Figure 3.6 - Critical tests performed on the dredge material

Soil Texture

Purpose

Soil particles are the building blocks of the soil skeleton. Most of a soil's particles are a mixture of variously sized minerals that define its texture. A soil's textural class—such as clay, clay loam, loam, sandy loam, or sand—is perhaps its most fundamental inherent characteristics. It affects many of the important physical, biological, and chemical processes in a soil and changes little over time. The textural class is defined by the relative amounts of sand (0.05 to 2 mm particle size), silt (0.002 to 0.05 mm), and clay (less than 0.002 mm), as seen in the textural triangle. Particles that are larger than 2 mm are rock fragments (pebbles, cobbles, stones, and boulders), which are not considered in the textural class because they are relatively inert.

Methods

• A portion of the soil sample is oven-dried at 60 C and sieved past 2mm.
• About 14g (+/- 0.1g) of sieved soil is added to a 50ml centrifuge tube containing 42ml of 3% soap (sodium hexametaphosphate) solution.
• Shake vigorously on reciprocating shaker for 2 hours to fully disperse soil into suspension.
• Entire contents of centrifuge tube are washed onto a 0.053mm soil sieve assembly. Sieve assembly consists of 0.053mm sieve on top of a plastic funnel above a 600ml beaker.

Figure 3.7 - Students performing Soil Texture test

Rinse all material through the sieve using fingers or rubber policeman. Sand captured on top of the sieve is washed into a tarred metal can and set aside.

- Silt and clay particles collected in the 600ml beaker are re-suspended by stirring and allowed to settle for 2 hours. The clay in suspension is then carefully decanted. The settled silt at the bottom of the beaker is washed into a second tarred can. Both tarred cans (one containing the sand fraction and the other the silt fraction) are dried overnight at 105 C to constant weight before weighing.
- Calculate percent sand, silt clay from:

Sand (%) = dry wt. sand (g) / dry wt. (g) soil added to centrifuge tube

Silt (%) = dry wt. silt (g) / dry wt. (g) soil added to centrifuge tube

Clay (%) = 100% - Sand (%) - Silt (%)

Conclusion

Another preconceived notion about the dredge material was that it would be predominantly clay and fine particle material. However, our testing found that the Cayuga Inlet is a sandy loam, which contains very little clay (only 6.82%) [Table 3.1].

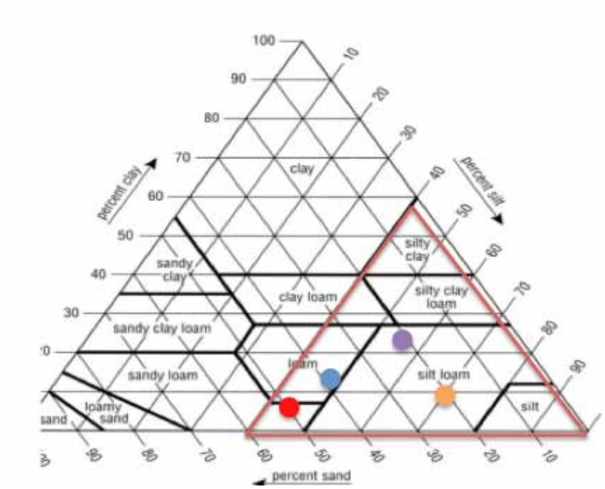
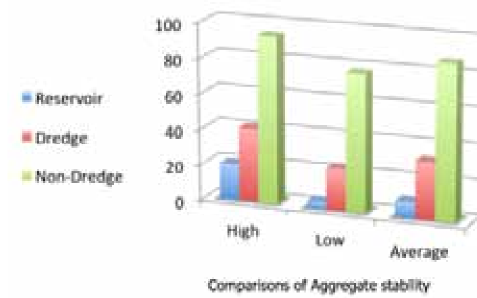


Table 3.1 - Soil Texture Triangle with Inlet, Dryden, and Reservoir soil range in red.

Aggregate Stability

Purpose

This tests the soil's physical quality with regard to its capacity to sustain its structure during most impacting conditions: a heavy rainstorm after surface drying weather. Soils with low aggregate stability tend to form surface crusts, which can reduce both water infiltration and air exchange. This poor soil aggregation also makes the soil more difficult to manage, and reduces its ability to dry off quickly. In heavy soils, enhanced friability and crumbliness from good aggregation makes the soil seem lighter.



Indicators		Resevoir	Dryden Dredge Site	Dryden Control Site
Aggreate Stability	High	20.2	41.1	93.8
	Low	3.6	23.3	77.2
	Average	8.91	32.3	87.3

Table 3.2 - Graph of Aggregate Stability results between the reservoir and Dryden samples.

*Method***s**

- A portion of the soil is oven-dried at 40 oC.
- Using stacked sieves of 2.0 mm and 0.25 mm with a catch pan, the dried soil is shaken for 10 seconds on a Tyler Coarse Sieve Shaker to separate it into varied size fractions; small (0.25 - 2.0 mm) and large (2.0 - 8.0 mm).
- A single layer of small aggregates (0.25 - 2.0 mm) is spread on a 0.25 mm sieve (sieve diameter is 200 mm (8 inches)) (A).
- Sieves are placed at a distance of 500 mm (20 inches) below a rainfall simulator, which

delivers individual drops of 4.0 mm diameter (B).

• The test is run for 5 minutes and delivers 12.5 mm depth of water (approximately 0.5 inches) as drops to each sieve. This is equivalent to a heavy thunderstorm. See soils starting to wet in (C). A total of 0.74 J of energy thus impact each sieve over this 5-minute rainfall period. Since 0.164 mJ of energy is delivered for each 4.0 mm diameter, it can be calculated that 15 drops per second impact each sieve.

• The slaked soil material that fell through the during the simulated rainfall event, and any stones remaining on the sieve are collected, dried and weighed, and the fraction of stable soil aggregates is calculated using the following equation:

WSA = Wstable / W total, where
Wstable = Wtotal - (Wslaked +Wstones)
where W = weight (g) of stable soil aggregates (stable), total aggregates tested (total), aggregates slaked out of sieve (slaked), and stones retained in sieve after test (stones). Corrections are made for stones.

Conclusion

Aggregate Stability of the Reservoir was much lower than the control site, 8.91% compared to 87.33%. This means that the dredge material will probably have a very weak ability to sustain its physical structure. This can be attributed to many things, but mainly its low organic matter content. Organic matter helps soils maintain physical structure, so adding organic matter to the dredge material, which will be discussed in the Alternatives section, could ameliorate this (Refer to appendix B for charted results).

Available Water Capacity (AWC)

Purpose

Water storage in soil is important for plant growth. Water is stored in soil pores and in organic matter. In the field, the moist end of water storage begins when gravity drainage ceases (field capacity). The dry end of the storage range is that the "permanent wilting point." Water held in soils that is unavailable to plants is called hygroscopic water. Clay soils tend to hold more water than sandy soils. Sandy soils tend to lose more water to gravity than clay soils

Methods

• Soil is placed on ceramic plates that are inserted into high-pressure chambers to extract the water at field capacity (10 kPa) and at the permanent wilting point (1500 kPa) (A and B).

• After the sample equilibrates at the target pressure; the sample is weighed and then oven-dried at 105oC overnight (C).

• The sample dry weight is then determined and soil water content at each pressure is calculated. The available water capacity is the soil water loss between the 10 and 1500 kPa pressures.)

Conclusion

In the end the results showed that the dredge material that was taken from the reservoir had a higher AWC than that of the dredge material that was tested on from the Dryden site. The samples that had the highest AWC were the ones from the control site in Dryden. Several factors could be contributed to the results but one should look at the soil texture to understand the numbers. The fact that the non-dredge material has the highest percentage of clay in the soil would confirm that this soil has the highest AWC rating. Next the dredge material in Dryden has the highest percentage of sand, which would allow the water to flow through the soil profile, thus lower the AWC. (Refer to appendix B for charted results)

Organic Matter

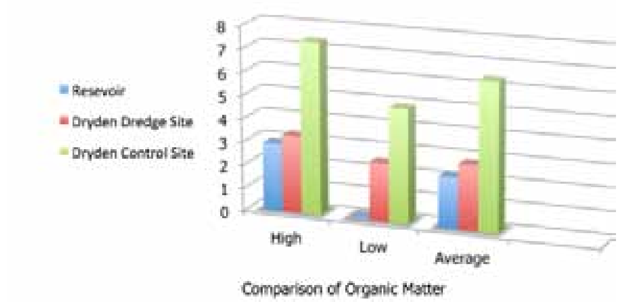
Purpose

Organic matter is any material that is derived from living organisms, including plants and soil fauna. Total soil organic matter consists of both living and dead material, including well-decomposed humus. The percent organic matter is determined by loss on ignition, based on the change in weight after a soil is exposed to approximately 950°F in a furnace. Organic matter content is often provided by soil analysis laboratories in conjunction with the analysis of major and minor nutrients.

Methods

- The Cornell Nutrient Analysis Laboratory measures the percent organic matter using loss on ignition.
- A sample is dried at 105°C to remove all water.
- The sample is then ashed for two hours at 500°C and the percent of weight lost is calculated.
- The % loss on ignition (LOI) is converted to % organic matter (OM) using the following equation:

% OM = (% LOI * 0.7) - 0.23



Indicators		Reservoir	Dryden Dredge Site	Dryden Control Site
	High	2.9	3.3	7.4
Organic Matter	Low	0.07	2.5	4.9
	Average	2.2	2.8	6.4

Table 3.3 - Graph of Organic Matter results between the reservoir and Dryden samples.

Conclusion

Originally, it was thought that there would be no organic matter in the dredge material, however we found that there was 2.2% organic matter in the Reservoir site samples. This is not a very high amount, but around a 5% OM content is recommended for agricultural uses, and it is much higher than the expected content of 0%. [Table 3.3] (Refer to appendix B for charted results)

Active Carbon

Purpose

Active carbon is an indicator of the fraction of soil organic matter that is readily available as a carbon and energy source for the soil microbial community (i.e., food for the soil food web). The soil is mixed with potassium permanganate (deep purple in color) and as it oxidizes, the active carbon the color changes (becomes less purple), which can be observed visually, but is very accurately measured with a spectrophotometer.

Methods

- From the larger thoroughly mixed composite bulk soil, a subsample is collected and allowed to air dry. The soil is ground and sieved to 2 mm.
- A 2.5 g sample of air-dried soil is placed in a 50 ml centrifuge tube filled with 20 ml of a 0.02 M potassium permanganate ($KMnO_4$) solution, which is deep purple in color
- The soil and $KMnO_4$ are shaken for exactly 2 minutes to oxidize the “active” carbon in the sample. The purple color becomes lighter as a result of this oxidation.
- The sample is centrifuged for 5 minutes, and the supernatant is diluted with distilled water and measured for absorbance at 550 nm.

• The absorbance of a standard dilution series of the KMnO4 is also measured to create a calibration curve for interpreting the sample absorbance data.
• A simple formula is used to convert sample absorbance value to active C in units of mg carbon per kg of soil.

Conclusion

Active Carbon was low in both the reservoir and the Dryden dredge material; the non-dredge material was in range of a healthy level according the Cornell Soil Health Test. This could be expected by looking back at the levels of the organic matter and aggregate stability in the soil, which is an indicator of Active Carbon levels in a soil, the lower the levels of organic matter the lower levels of active carbon. The fact that the dredge material has lower levels of active carbon would result in prolong periods of management to increase the organic matter content (Refer to Appendix B for charted results).

Potentially Mineralizable Nitrogen

Purpose

Potentially Mineralizable Nitrogen (PMN) is an indicator of the capacity of the soil microbial community to convert (mineralize) nitrogen tied up in complex organic residues into the plant available form of ammonium. Soil samples are incubated for 7 days and the amount of ammonium produced in that period reflects the capacity for nitrogen mineralization.

Methods

• As soon as possible after sampling, the mixed composite bulk soil sample (stored at 40°F) is sieved and two 8-g soil samples are removed and placed into 50 ml centrifuge tubes.
• 40 ml of 2.0 M potassium chloride (KCl) is added to one of the tubes, shaken on a mechanical shaker for 1 hour, centrifuged for 10 minutes, and then 20 ml of the supernatant is collected and analyzed for ammonium concentration ("time 0" measurement).
• 10 ml of distilled water is added to the second tube, it is hand shaken and stored (incubated) for 7 days at 30°C (86°F).
• After the 7 day anaerobic incubation, 30 ml of 2.67 M KCl is added to the second tube (creating a 2.0 M solution), the tube is shaken on a mechanical shaker for 1 hour, centrifuged for 10 minutes, and then 20 ml of the supernatant is collected and analyzed for ammonium concentration ("time 7 days" measurement).
• The difference between the time 0 and time 7-day ammonium concentration is the rate at which the soil microbes are able to mineralize organic nitrogen in the soil sample. Results are reported in units of micrograms nitrogen mineralized per gram dry weight of soil per week.

Conclusion

The PMN results were unforeseen due to the fact every other test has been in line with conventional wisdom, which would lead you to think that since the reservoir material is low in organic matter, aggregate stability and active carbon it would have a low PMN. So when the results showed that the reservoir had almost double the amount of PMN compared to that of the non-dredge material it seemed like an anomaly. This high score tells us that the reservoir has a higher amount nitrogen rich organic matter, as a result an abundant amount of soil microbes.

Further tests would be needed to confirm these findings since they are not in line with conventions (Refer to appendix B for charted results).

Root Health Assessment

Purpose

Root health assessment is a measure of the quality and function of the roots as indicated by size, color, texture and the absence of symptoms and damage by root pathogens including the fungi Fusarium, Pythium, Rhizoctonia, Thielaviopsis, and plant-parasitic nematodes such as northern root-knot. For vegetable production systems, a soil bioassay with beans was shown to be highly effective in assessing root health as a component of overall soil health. Beans are susceptible to the major pathogens that impact vegetable, legume, and forage crops grown in New York and the Northeast region, thus their suitability as an indicator plant. The selection of other indicator plants might be needed for the proper assessment of root health of soils under different production systems.

Methods

- A sub-sample from the composited bulk soil sample is thoroughly mixed.
- Approximately 200 cubic cm of soil is placed in each of 7 cone-tubes (A), which have a light cotton ball, paper towel, or small rock placed in the bottom to prevent soil loss through the drainage holes.
- Each tube is planted with one snap bean seed such as cv. 'Hystyle' or others. The seeds are treated with a combination of fungicides to prevent seed decay and seedling diseases (B). The helium (curved side) of the seed is placed flat/horizontally to encourage successful seed germination and emergence (straight vertical shoots).
- The plants are maintained in a greenhouse under supplemental light or in a screen house and watered regularly for 4 weeks (C).
- The plants are removed from their containers and the roots washed under running water and rated for root health on a scale of 1 to 9. For example:

1 = white and coarse textured hypocotyl and roots; healthy (D);
3 = light discoloration and lesions covering up to a maximum of 10% of Hypocotyl and root tissues (E);
5 = approximately 25% of hypocotyl and root tissue have lesions, but the tissues remain firm. There is little decay or damage to the root system (F);
7 to 9 = 50 to ≥ 75% of hypocotyl and roots severely symptomatic and at advanced stages of decay (G).

Conclusion

Root Health Assessment is measured on a scale of 1 -9, with 1 being the most and 9 being the least functional. All three-sample sites (reservoir, Dryden dredge and Dryden non-dredge) fell with in the 5-6 ranges with the Dryden dredge being the lowest at 5.1 and the Dryden non-dredge being the highest at 5.9. The results show us that all three of these soil fall within the average, which was a little unexpected at least for the Dryden non –dredge material (Refer to Appendix B for charted results).

Chemical Analysis

Purpose

The chemical analysis as part of the Cornell Soil Health Test is a traditional soil fertility test analysis package that measures levels of pH and plant macro- and micronutrients. Measured levels are interpreted in the framework of sufficiency and excess but are not crop specific.

Conclusion

Nutrients (see appendix C)

pH was also found to be high in the Reservoir samples. Luckily, this acts as a buffer to the uptake of unusually high levels of Manganese, Aluminum, Iron, Copper, and Zinc also found in the samples, as shown in Table 3.5.

Calcium and Magnesium were also found in high levels, however Calcium acts as a buffer to the uptake of Magnesium, so they shouldn't be of concern. The dredge material is suitable for plant growth, but should be made more stable by adding organic matter if it is to be used for planting medium.

Metals

According to the Ecologic LLC report, several hotspots were found for Lead, Copper, PAHs, and PCBs, qualifying the dredge material from Cayuga Inlet as Class B [Fig 3.9/3.10]. However, the majority of the samples tested at Class A levels, and when the Inlet is dredged, these hotspots will be dispersed.

Also, if the dredge material is mixed with organic material such as compost, the concentrations of these toxins will be diluted and the organic matter could make much of it biologically unavailable, according to Murray McBride. The high pH level also means copper will not be very biologically available [Fig. 3.9].

Chemical Analysis Methods

Plant Available Nutrients:	
Extractable phosphors *Extractable potassium* *Magnesium* *Iron* *Manganese* *Zinc*	*The available nutrients are extracted with Morgan's solution, a sodium acetate/acetic acid solution, well buffered at pH 4.8. Activated carbon is added to the extraction to aid in the removal of organic matter and to help decolorize the extraction solution. After shaking, the extraction slurry is filtered and analyzed for K, Ca, Mg, Fe, Al, Mn, and Zn on the ICP (Jyobin Yvon). The plant available PO4-P is measured using an Alpkem Automated rapid flow analyzer.*
pH	*The pH of a suspension of one part water to one part soil is determined either manually, using standard pH meter and electrodes, or automatically using a Fisher CATTM titrimeter.*

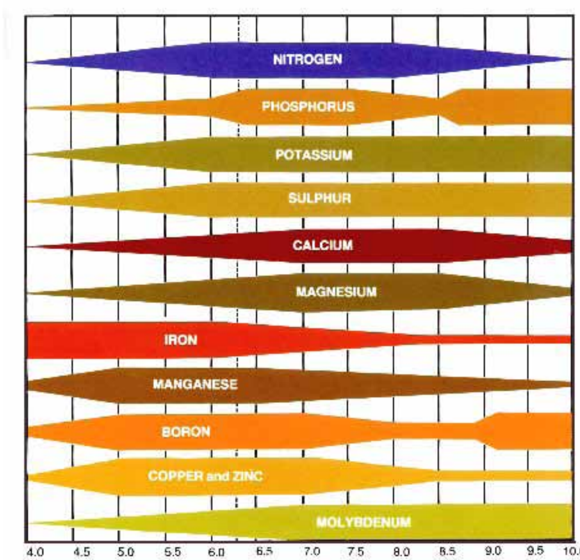


Figure 3.8 - pH Nutrient Chart

Measurements	Reservoir	Dryden Dredge Site	Dryden Control Site
Phosphorus(P)(lbs./A)	10.2	5.3	11.3
Potassium (K)(lbs./A)	473.5	401.7	446.7
Magnesium(Mg)(lbs./A)	1107.5	498.3	570.0
Iron(Fe)(lbs./A)	116.9	16.0	14.7
Manganese(Mn)(lbs./A)	1048.3	108.0	68.3
Zinc (Zn)(lbs./A)	8.1	5.0	2.6
Calcium (Ca)(lbs./A)	84597.0	12846.7	4363.3
Aluminum(Al)(lbs./A)	90.1	34.0	135.3

Table 3.5 - Nutrient Levels of site samples

Location ID *Sample Date* *Sample Depth (ft)* Chemical Name	TOGS 5.1.9 Class A	 Class B	CLI03T *8/12/2003* *0-3.6*	CLI03B *8/12/2003* *3.6-4.0*	CLI04T *8/12/2003* *0-2.2*	Ich-2 *Nov. 2008* *6-10*
Metals						
Copper	<33	33 - 207(270)	38.7	33.2	35.1	16
Lead	<33(47)	33(47) - 166(218)	77.4	59.8	54.1	11
PAHs						
Total PAHs*	<4	4 - 35(45)	1.79	2.34	16.6	8.53
PCBs						
Total PCBs*	<0.1	0.1 - 1	0.071	0.110	0.054 U	0.0294

Concentration units in mg/kg (ppm). Samples collected August 2003 by NYSDEC; samples collected November 2008 by ERM.

* indicates the sum of detected parameters

Shaded values exceed the Class A Sediment Quality Threshold Values (TOGS 5.1.9). Other analytes were tested in these and other samples; no other analytical results exceeded the Threshold Values.

Figure 3.9 - EcoLogic's Metal Test Results: Analytes detected in Cayuga Inlet sediments exceeding TOGS 5.1.9 Class A Sediment Quality Threshold values (Courtesy

Figure 3.10 - Location of samples on Cayuga Inlet by ECOLOGIC for metals testing

Dryden Site Plant Communities

Jamie Nassar & Hayden Stebbins

Purpose

This study was performed at the Dryden dredge disposal site. The study of plant communities looks at one of the pressing questions when analyzing the dredge material: can dredge material sustain plant growth with out any additional management practices? The answer to this question could have a direct influence on how the dredge material can be used in the future. We tested to see what plants would be found in the dredge material compared to the non-dredge material, and which plant would be shared between the two sites.

Methods

- The rarefaction method was used in setting boundaries for establishing the respective plant communities for the dredge and non-dredge material.
- A location was selected at each site
- Starting with a .25 meter square quadrant, the quadrant were progressively enlarged according to the chart [Fig 4.2]
- Species in each quadrat were recorded and collected in the field
- Species collected from each quadrat were keyed out to the most precise taxonomic name possible

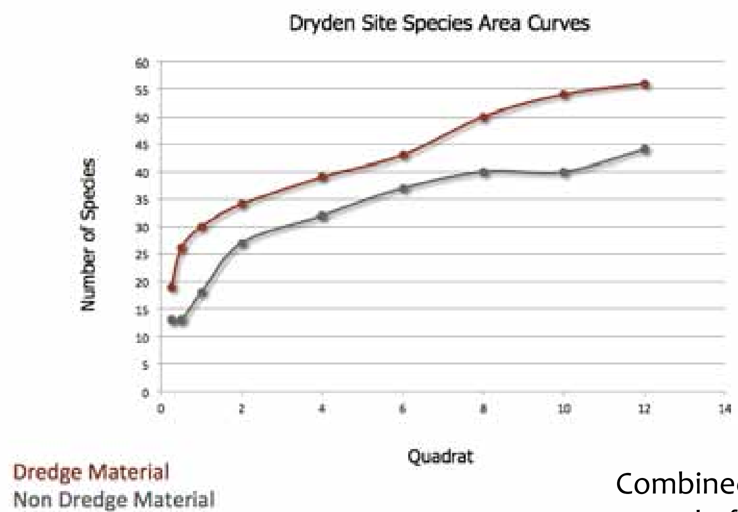


Figure 4.1 - Dryden Site Species Area Curve

Conclusions

It was found that dredge material left untouched to a zero order management practice does have the ability to sustain plant growth on its own. The dredge sediment was found to have roughly 20 identifiable plant species with 12 of those species being exclusive to the dredge material. Out of the 12 species half of them were non-native plants. The non-dredge or Old Field Site had 25 total plant species with 17 species being exclusive to the non-dredge material. Out of those 17 species 7 of them were non-native.

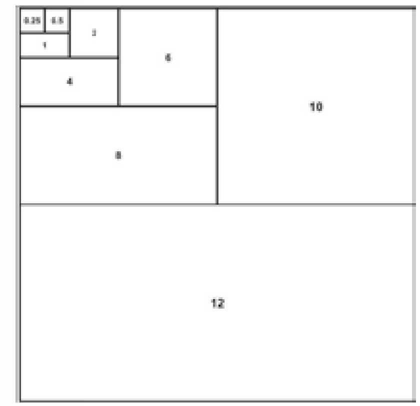


Figure 4.2 - Nested Quadrant

Combined between the two sites there was a total of 37 identifiable species with 8 of the species shared between the two sites and a total of 17 species being non-native [Fig 4.1].

Looking closer at the plant communities, there is a difference not just in the numbers, but in the actual plants that were found with the site. The dredge material has a different plant community that the non-dredge, which could be due to the fact that dredge material has different parent material and possibly carried some seeds with it when it was removed from the lake. No conformation was gained into weather or not the dredge material contains a seed bank.

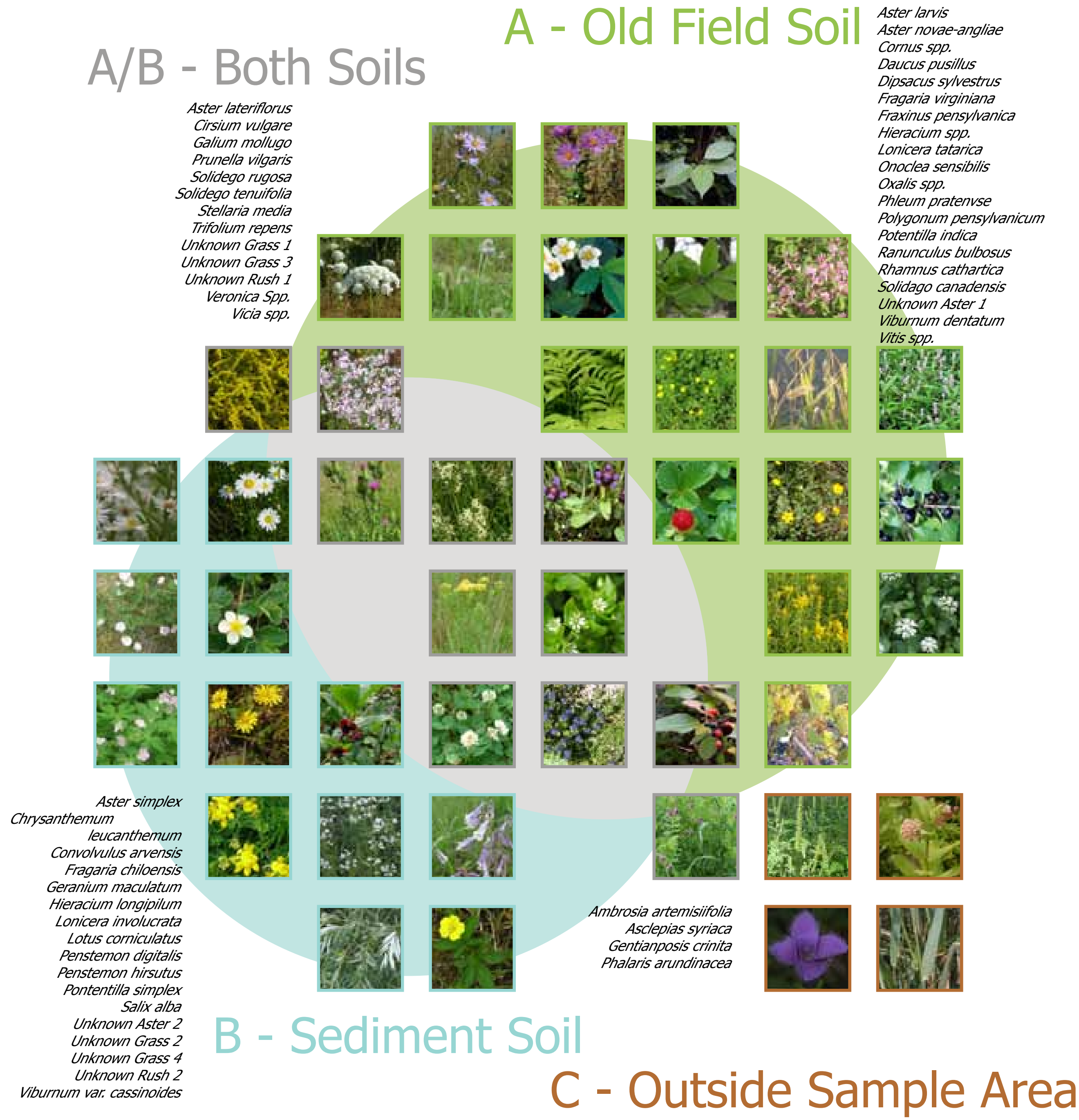


Figure 4.3 - Dryden Plant Communities

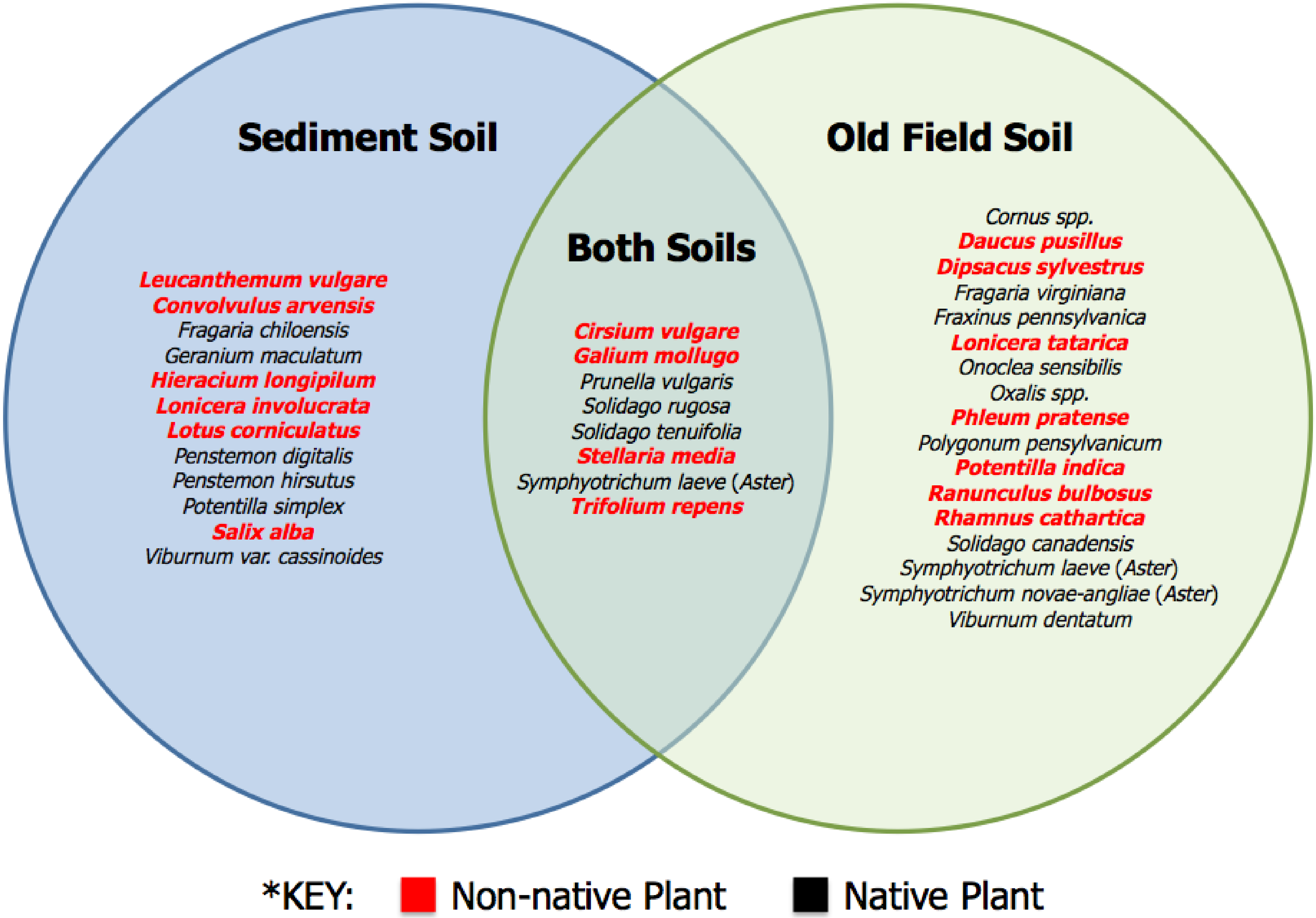


Figure 4.4 - Dryden Plant Communities

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Students Identifying Plant Samples from the Dryden Site

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