Growing Mosaics Garden, Annual Report 2012

Peter Christine & Tessa Buono

Introduction:

History of Dilmun Hill and the Growing Mosaics Garden

Dilmun Hill is the student organic farm at Cornell, run entirely by and for students. Day to day decisions are handled by paid student managers (5 managers were hired in 2011) while the steering committee of around 15 students develops long term planning. Our mission is to empower students to learn about ecological agriculture in an experiential context. In the spirit of our educational mission, we have research goals in addition to production goals. The eastern half of the farm was formerly orchard land that was sprayed with lead arsenate, a common insecticide prior to the development of synthetic organic pesticides. Both lead and arsenic persist in our heavy clay soil, so this land will remain contaminated into the foreseeable future. Major exposure pathways for these heavy metals include breathing in airborne dust (e.g. dust created by tillage) and consumption of the soil, either through contamination on hands, or on food crops grown in the soil. For this reason, the contaminated half of the farm is unsafe for traditional field agriculture, and is the site of various research projects, including the Growing Mosaic Garden (GMG), a permaculture project.

The GMG has evolved and expanded in scope and complexity since it began with Toward Sustainability Foundation funding in 2008. The original project was an alley cropping experiment demonstrating an agroforestry technique applicable to the Northeast, and examines the production of two crops: maples for coppicing to produce logs for shiitake mushroom cultivation, and hybrid hazelnuts. In 2009, we added a perennial polyculture garden to two of the alleys in block 3 (see map in Appendix A).

First conceived as an edible forest garden, the GMG has shifted its focus to providing beauty, cut flowers, and ecosystem services, in response to concerns of lead and arsenic contamination in food from the site. In 2010 we implemented the Achillea beneficial insect study in block 4. This study examined the potential of yarrow to attract beneficial insects to control pests. In 2011 we expanded the GMG and began to collect data in the Achillea beneficial insect study but learned that our space was not well suited for conducting the agroecological research that was intended for the Achillea beneficial insect study. We also learned that the established approach to producing beauty was not economically sustainable. 2012 was the first year that the GMG did not expand. One full time and one part time manager were hired to maintain and monitor the garden. In response to the lessons learned in 2011, the 2012 managers increased the diversity of yields by including more food crops, propagating existing plants in the garden for sale, and planting more ornamentals specifically selected for use in flower arrangements. We also shifted the research focus of the GMG project from a plant pest interaction study to one that addresses issues of perennial food crops on contaminated soil.

This past year our work on the Permaculture project related to three main different kinds of goals: Education and Outreach, Farm Landscape, and Research. We report on our progress towards these goals, as stated in our grant proposal to the Cornell University Agricultural Experiment Station.

Education/Outreach

Goals

- Maintain a field classroom for Cornell courses and community workshops to learn about permaculture and soil contamination issues
- Create appropriate curricula and educational materials for outreach programs
- Maintain the Yarrow plot and the GMG as a site for teaching students data collection techniques (using sweep nets to search for beneficials, systematic scouting for pests) and integrated pest management techniques
- Empower students to design gardens that explore alternative land management systems, as well as the functionality and profitability of edible, medicinal and ornamental polycultures
- Develop student garden managers' leadership, outreach, horticultural skills, and research skills

Curriculum/Activities

Most of the education in the GMG took place in the context of tours. Managers are encouraged to develop a tour curriculum so that key points are always clearly portrayed to visitors.

The main goal of the GMG is to demonstrate permaculture. However, permaculture is such an abstract concept that it can be difficult to explain in a short tour. Accordingly, in 2012, we chose to focus on the concrete differences between what happens in the GMG and what happens in the Market garden. Specifically, the GMG is a perennial polyculture while the market garden is an annual, rotated monoculture. Other concepts that we tried to drive home were stacking of functions, and maximizing beneficial interactions. These concepts are well illustrated by the three sisters polyculture and the hops trellis/mushroom laying yard.

We also discussed the now completed Best Management Practices for growing vegetables on contaminated soil project. Our main points were the history of lead and arsenic contamination on the site, and Dilmun Hill's efforts to mitigate the problem. In addition to educating people about heavy metals contamination, teaching visitors about our mitigation efforts is positive PR for Dilmun, because it shows that we are making an effort to ensure that all food we sell is safe, over and above the legal restrictions for selling food from contaminated sites.

In order to make the tours a good educational experience, managers are encouraged to make an effort to engage the visitors as much as possible in the learning process. Rather than simply lecturing on the key points listed above, we tried to ask provocative questions that lead the visitors to make discoveries for themselves (e.g. What do you notice about this garden that is different from the market garden? Why do you think we would want to grow these plants on raised beds? etc.)

In addition to these tours, we conducted educational activities with many of the visitors. In the GMG, the main activity was an observation exercise, where visitors were instructed to sit in one place in the garden and observe any interactions that were occurring. Other popular activities that were not necessarily conducted in the GMG, included hand cleaning of kale seed, and threshing and winnowing of rye grain, and monitoring insect populations with sweep nets. Visitors were also involved in the work of the garden, transplanting perennials and sheet mulching new beds.

Results

Throughout the growing season, a broad diversity of workshops, youth groups, and classes made use of the GMG as a teaching garden for observation exercises. The site serves as an example to promote thinking about alternative land use strategies.

Cornell University classes that visited the GMG during the 2012 growing season included: Practicum in Forest Farming, Soil Science, Sustainable Landcare, Exploring the Small Farm Dream, Horticultural Science and Systems, & Special Topics in Horticulture: Permaculture.

In addition to Cornell classes, the GMG was a venue for educational programs including the 4H Career Explorations Conference, Cornell Outdoor Education Outdoor Odyssey farming pre-orientation trip, Cornell Outdoor Education's Summer Camp, the Plantations Environmental Education Program in Sustainability (PEEPS), Cornell Sustainability Youth Camp, and Chess Nuts an inner-city program designed to expose city kids to farming.

When exposed to the GMG, students are better able to understand principles of permaculture, including selection of elements with multiple functions, integration of all elements of the system based on needs, outputs, and properties, and fostering synergy to decrease waste and work. These design principles can be applied to a wide scale of human activities from small gardens to expansive bioregions.

In addition to formal workshops, the GMG welcomes visitors to explore at all times. Although the garden is not in a very prominent location for most traffic, occasional day hikers and dog walkers pass through the farm and enjoy the garden. The garden also serves as a resource for the students who volunteer at work parties. By helping with the construction of the raised beds, planting, weeding and mulching, students learn basic horticultural techniques that apply both to permaculture and to any gardening project. Students are also exposed to the philosophies within the GMG by attending our annual social events where farm tours are given, such as the Dilmun Hill Field Day.

Manager Testimonials:

Peter Christine – Agricultural Science '13

Working in the GMG has been a great experience for me. Working intimately with the garden every day for a season, I learned so many things about the plants and the human systems that support them (and what can go wrong with the human part) that would be impossible to even conceive of otherwise. Having a leadership role in the garden forced me to develop my ability to make decisions and to coordinate groups of volunteers. Dilmun Hill as a community has been very supportive of me personally and given me a context in which to grow and develop my communication and cooperation skills.

Tessa Buono -- Science of Natural and Environmental Systems '14

Managing the GMG taught me more about myself and about working with others than I could have ever imagined. In addition to learning a great deal about permaculture, farming, and different agricultural perspectives from my co-Managers, faculty advisors, and community members, I had an incredible opportunity to explore my passion for education and leadership. I thoroughly enjoyed planning and leading educational programs for youth groups about

permaculture, sustainability, and the fruitful rewards of the life of a farmer. Working with my co-Managers was a fantastic experience, as it taught us all to be sensitive to each other's ideas during collaboration, while maintaining direction and focus on our agenda. Coming from different backgrounds agriculturally, academically and socially enhanced each of our experience as we worked together at the student-run farm we call Dilmun Hill.

Farm/landscape

Goals

- Create diverse habitats that will expand biological resources and services for pest management at Dilmun Hill
- Maintain alley cropping as an intermediate agroecosystem between the MacDaniels Nut Grove and the Market Garden
- Maintain a safe environment for managers and visitors to work, despite the soil contamination, by ensuring that the Best Management Practices are followed
- Expand Dilmun Hill's potential for production by determining the safety of perennial and annual crops grown on contaminated soils

Procedure

This was the first year that we did not expand the GMG. Our main activities this year were maintaining the garden and making some alterations in problem areas. There has been a continuous discussion on the best way to manage this garden. Ideally, the garden should be largely self-maintaining, and not require weeding. However, the garden is still establishing, and vulnerable to weed competition. This year we weeded the entire new section (that was planted last year) in the spring, and periodically weeded throughout the season. With the exception of the strawberry patches, we did not weed the old beds at all, although we did remove weeds that could cause problems in other areas if they were allowed to produce seed, like honeysuckle or bull thistle. We also weeded the paths and added new woodchips periodically throughout the season to make the garden more inviting. In general weed growth was low because of the drought.

Although we did not expand the area of the GMG this year, we continued to enrich the existing garden. We used sheet mulching to renovate parts of the old beds that seemed overly dominated by weeds. Throughout the season we created three new beds this way: a three sisters patch, a woody florals patch, and a cut flower patch. With the help of the permaculture class, we sheet mulched the row of hazelnuts between the GMG and the neighboring new Market Garden bed. This will reduce the encroachment of perennial weeds like quack grass and serve as a space for future GMG managers to expand the garden.

Results

Production: Flowers

Each week we made bouquets of flowers from the GMG, as well as wildflowers from around the farm, to sell at the market stand. At the market stands, the flowers were appreciated as a colorful addition to the stand but rarely appreciated for more than decoration as flower bouquets were rarely purchased. There is definitely potential here for new managers to improve the cut flower production and marketing.

Production: Strawberries
This was the first year we were able to sell strawberries from the GMG, because they were found to be free of heavy metals in previous years. Although the season for strawberries was brief and our yields were not very high, the strawberries were very popular at the market. Future managers are encouraged to find ways to increase strawberry production while still maintaining the other yields of the GMG.

Transplants:
Many of the plants in the older beds are now sufficiently established such that there is potential to divide them and sell the transplants. Yarrow and sorrel in particular are starting to become overly aggressive in some places and need to be thinned and divided. Unfortunately the transplants that we brought to market did not sell; however, there is definitely a market for permaculture plants if the GMG is able to tap into it. Steve Gabriel could be an important resource for this.

Monitoring:
There has been an ongoing struggle to understand the GMG, and to communicate this understanding in a way that is useful to future managers and designers. To this end, we created scale maps of the garden showing features such as weed pressure, canopy cover, and soil depth. These maps have been uploaded onto the internet for future Dilmunites to use.

Soil Contamination Research
Goals

- Test future Market Garden crops for tissue levels of lead and arsenic in order to evaluate the effectiveness of our best management practices
- Explore the effectiveness of the current GMG bed design for safely growing edible perennials on contaminated sites

Procedure
Sixteen different crops growing in the GMG or new Market Garden beds (formerly the Best Management Practices for growing vegetables on contaminated soils project -- BMP) were monitored for lead and arsenic contamination. The crops we grew in the Market Garden beds were vegetables that had not been tested by the BMP project. Many of these crops were only sampled once, but several were sampled three times. For beets, we sampled the greens of beet thinnings, the mature beet root and the mature beet leaves separately. For hazelnuts, we tested the nuts of the four most productive bushes individually using the nuts from 2011 as well as the nuts from 2012 (although in 2012 only three of the top producers from 2011 had nuts). We also sampled the soil in the GMG. Because we found that the GMG has two different bed compositions (100% compost, and mixed compost and topsoil) as well as some areas of native soil, we took one composite sample and three to four point samples for each kind of bed.

Samples were prepared in Murray McBride's lab and analyzed by the Cornell Nutrient Analysis Laboratory (CNAL) using ICP-AES. Although this method was adequate for the purposes of monitoring our crops in 2012, in future managers are encouraged to order tests using ICP - Mass Spectrometry, as the detection limits for this method are lower and more reliable. CNAL does not charge extra for this process, but they do not list it on the form for submitting samples; managers need to request ICP-MS as a special test.

Results

The results from our monitoring are presented in Appendix B. In most of the crops we monitored, levels of lead and arsenic were below levels of concern. In four samples, however, arsenic was found at levels higher than .25 mg/kg fresh weight. These samples were early beet greens, beet roots, corn, and one of three mint samples. In the 18 samples that had detectable levels of heavy metals, all but one had higher levels of arsenic compared to lead (in many of these samples only arsenic was detectable). This is surprising given that the concentration of arsenic in the native soil is lower by about an order of magnitude compared to lead. These results suggest that it is plant uptake, not soil splash, that is accounting for the arsenic contamination in these samples. We suspect that the very dry summer caused crop roots to grow deeper, potentially through the raised bed and into the native soil. It is also possible that the dry conditions caused the arsenate to migrate into the beds with capillary action. We will test this possibility in 2013 by testing soil samples taken at varying depths in the beds for arsenic content. In the meantime, we recommend that Market Garden managers restrict the new Market Garden beds to the production of fruiting crops since these appear to carry the least risk. At present much of the BMP is planted in garlic. However, the alliums (scallions) we tested in 2012 did not have detectable concentrations of lead or arsenic, and garlic grown in native soil in the Healthy Soils Healthy Communities section of the farm was previously found to be safe. We are recommending that managers prepare and test a sample of next season's garlic before bringing it to market.

Conclusion

This was the first year we did not expand the GMG. Our energy was thus more directed to monitoring the system and educating the community about permaculture and best management practices. Some key lessons we learned in the 2012 season include:

- Our best management practices for growing vegetables on contaminated land remain adequate for lead, but may not be sufficient for mitigating arsenic contamination.
- The safest crops are fleshy fruit crops (though not dry seed crops, like grain corn). Any other crops grown in the contaminated area of the farm should be tested before they marketed.
- Strawberries were the most lucrative crop grown in the GMG, and they also comply with our revised BMPs for growing on contaminated land. Future managers should expand the GMG's production of perennial berries and fruits.
- The GMG yields a surplus of plant propagation material, but additional markets need to be found in order to realize this potential economic asset.
- The main yield of the GMG is education, and future managers should continue to develop the garden as an outreach facility.

Literature Review

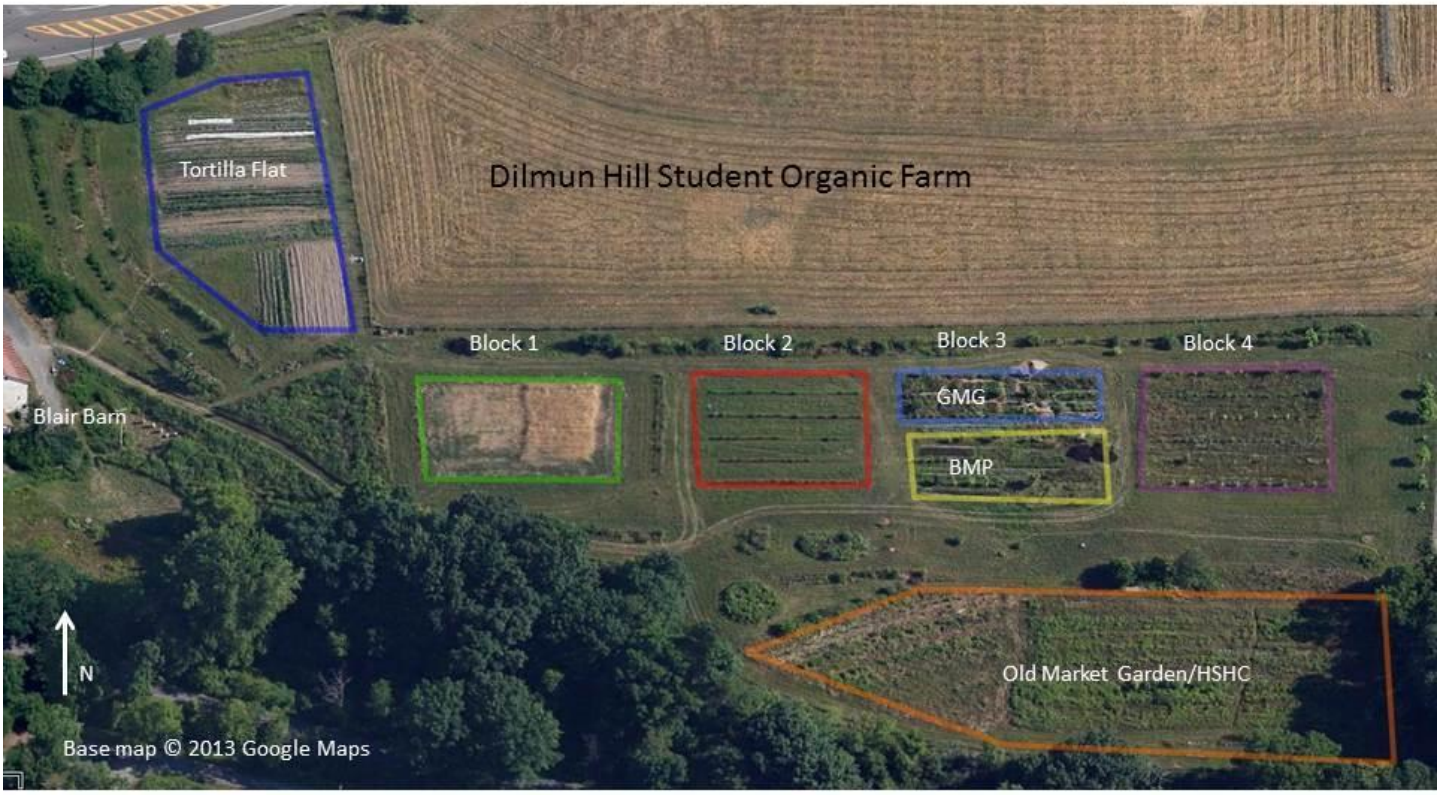
The following literature was read in book clubs, consisting of student managers, faculty, and the organic farm coordinator, throughout the season, informing our approach.

Jacke, Dave, and Eric Toensmeier. "Edible Forest Gardens, Volume One: Ecological Vision and Theory for Temperate Climate Permaculture." *White River Junction, VT: Chelsea Green Publishing* (2005).

Burrichter, Liz, and Peter Christine. The Growing Mosaics Garden: Examining Permaculture in a Student Research Environment Dilmun Hill Student Organic Farm. Report to the Towards Sustainability Foundation. (2011).

Goodwin, Elizabeth. Soil Best Management Practices Project 2011 Report. (2012).

Appendix A


Tortilla Flat
Dilmun Hill Student Organic Farm
Block 1
Block 2
Block 3
Block 4
GMG
BMP
Blair Barn
N
Old Market Garden/HSHC
Base map © 2013 Google Maps

Appendix B

Lead and arsenic concentrations in vegetable tissue by fresh weight and dry weight (using ICP-AES).

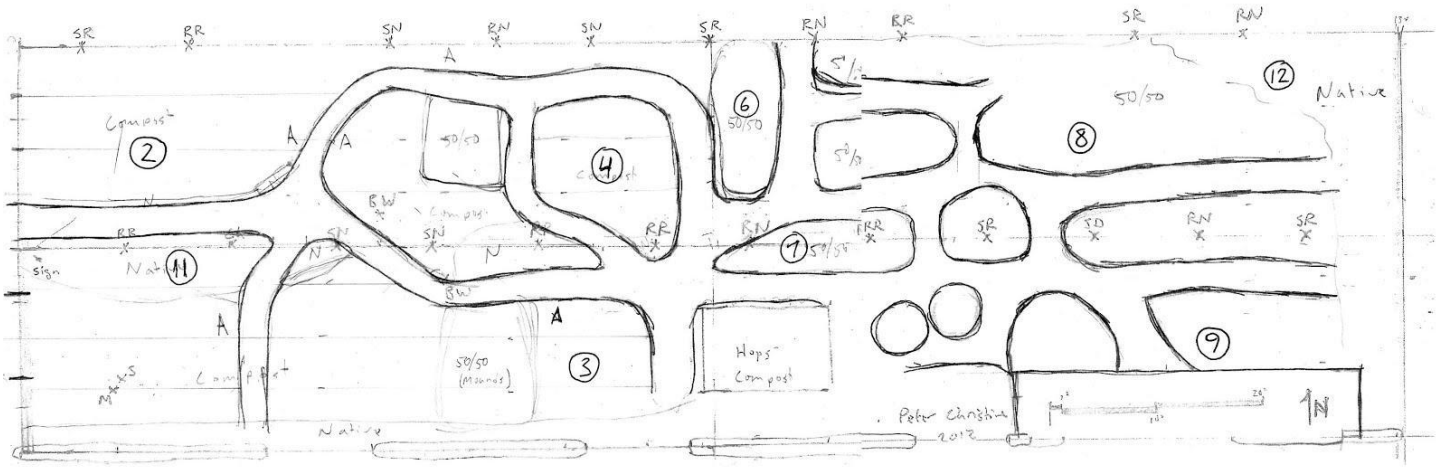
Crop composite samples	Sample Number	Location	Fresh weight (g)	Dry weight (g)	proportion dry weight	Dry weight As (mg/kg)	Fresh weight As (mg/kg)*	Pb (mg/kg)	Fresh wt Pb
scallions	1	BMP	83.4	5.17	0.0620	0	0.0000	0	0.0000
beet leaf early	2	BMP	61.8	12	0.1942	1.56	0.3029	0	0.0000
beet leaf late	3	BMP	81.1	7.5	0.0925	1.11	0.1027	0	0.0000
beet root	4	BMP	68	7.5	0.1103	2.39	0.2636	0	0.0000
cucumber 1	5	BMP	185.6	6.6	0.0356	0	0.0000	0	0.0000
cucumber 2	6	BMP	180	5.8	0.0322	0.61	0.0197	0	0.0000
lettuce 1	7	BMP	72.1	3.8	0.0527	1.45	0.0764	0	0.0000
lettuce 2	8	BMP	79	4.5	0.0570	0.16	0.0091	0.64	0.0365
lettuce 3	9	BMP	42	3	0.0714	2.17	0.1550	0	0.0000
basil 1	10	GMG	31.8	3.9	0.1226	1.04	0.1275	0	0.0000
basil 2	11	GMP	42.4	6.3	0.1486	0	0.0000	0	0.0000
broccoli	12	BMP	82.8	6.8	0.0821	0	0.0000	0	0.0000
sorrel 1	13	GMG	37	3.5	0.0946	1.5	0.1419	0.59	0.0558
sorrel 2	14	BMP	40.2	3	0.0746	1.38	0.1030	0	0.0000
sorrel 3	15	GMG	55.2	3.9	0.0707	0	0.0000	0	0.0000
chamomile 1	16	GMG	N/A	20.5	NA	1	NA	2.06	NA
green beans 1	17	GMG	31.8	2.96	0.0931	0.96	0.0894	0	0.0000
corn	18	GMG	130	98.2	0.7554	0.54	0.4079	0	0.0000
dry beans	19	GMG	6	4	0.6667	0	0.0000	0	0.0000
winter squash	20	GMG	65	11.7	0.1800	1.13	0.2034	0	0.0000
mint 1	21	GMG	96.7	18	0.1861	0	0.0000	0	0.0000
mint 2	22	GMG	47.4	10.8	0.2278	1.77	0.4033	0	0.0000
mint 3	23	GMG	52.2	7.8	0.1494	1.15	0.1718	0	0.0000
oregano 1	24	GMG	61.8	12	0.1942	0	0.0000	0	0.0000
oregano 2	25	GMG	31.8	7.2	0.2264	0.92	0.2083	0	0.0000
oregano 3	26	GMG	50.6	12.9	0.2549	0	0.0000	0	0.0000
hops	27	GMG	N/A	N/A	NA	1.11	NA	0.7	NA
							*Orange cells are values above our level of concern (0.25)		
Note: where metals concentration is listed as 0, this means that the concentrations were below the detection threshold for our analysis									

Lead and arsenic concentrations in hazelnut tissue and in soils (using ICP-AES)

Plant & Soil Pairing		Dry weight As (mg/kg)	Dry weight Pb (mg/kg)
hazelnuts 185 2011	28	0	0
hazelnuts 144 2011	29	0	0
hazelnuts 91 2011	30	0	0
hazelnuts 93 2011	31	0	0
hazel 91 2012	32	0	0
hazel 93 2012	33	0	0
hazel 144 2012	34	0	0
SOIL		**As (mg/kg)**	**Pb (mg/kg)**
100% compost	1	5.35	0.46
discrete 100	2	6.35	36.83
discrete 100	3	32.08	97.43
discrete 100	4	48.29	156.24
50% compost	5	33.2	123.65
discrete 50	6	53.76	204.85
discrete 50	7	30.8	111.72
discrete 50	8	45.92	139.99
discrete 50	9	33.06	135.24
discrete native	10	32.76	115.85
discrete native	11	18.86	74.5
discrete native	12	44.07	161.4
hazelnuts 185	13	27.13	86.37
hazelnuts 144	14	88.92	320.75
hazelnuts 91	15	70.86	216.89
hazelnuts 93	16	74.34	242.08
Note: where metals concentration is listed as 0, this means that the concentrations were below the detection threshold for our analysis			

Appendix C:

Map of the GMG showing the condition of the raised beds, as well as the approximate locations of the point soil samples



Dark lines indicate path borders. Light lines indicate transitions to different bed compositions. Beds are labeled “Compost” for 100% compost beds, “50/50” for part compost, part topsoil beds, “Native” or “N” for areas where the native soil is exposed or covered only by plant groundcover. The capital “A”s refer to areas where anthills have brought native soil to the surface. The circled numbers indicate the locations of the soil samples with the corresponding numbers listed in Appendix B. All other abbreviations refer to trees in the garden.