Re: Lewis and Clark Fund award to Dr. Mark Claire
"Searching for the Driest Place on Earth"

Project Report:

My trip to the Atacama for my Lewis and Clark award took place over two weeks in early June 2012. Originally, the trip was planned at 10 days, but I found out through Astrobiology networks that Brian Shirey also obtained a Lewis and Clark award for a six day trip. We were able to combine our funds and plan/execute a 17 day trip together. With each others help, we were each able to sample more materials than we had initially hoped, and collected additional samples for new research projects we hope to carry out in the future. In all, this value-added component added dramatically to both the social and scientific output of the excursion. We were also joined by Kyle Costa, a microbiologist from the University of Washington and Aubrey Zerkle, a microbiologist from (then) Newcastle University in the UK. These additional team members contributed to the logistics while carrying out their own scientific agendas, using funds secured from alternate sources. In particular, Kyle was working with me on an "Astrobiology research rotation" which is required as part of the Astrobiology PhD certificate at the University of Washington. Kyle stayed for 6 days only, and carried out *in situ* rain experiments shown in Figures S7 and S8, which complemented work previously funded by an NAI Director's Discretionary Fund award "Perchlorate, Water, and Life" made to Mark Claire. Kyle also built a numerical model of rainfall in the Atacama, and successfully defended his AB research rotation in Sept 2012.

In addition to the "km 40" site targeted in the proposal (Figure S6), I collected vertical and horizontal transect data (described below) from 8 other sites, spanning 1700 km and the rainfall gradient in the Atacama. In total, 424 samples were obtained from the 9 field sites listed in Table 1 and shown on Figure S1.

Table 1 – Sampling Locations:

Location	***GPS coordinates***	***Samples obtained***	***Notes***
"km 40"	S20 XXX W70 XXX 763m elevation (coords redacted)	horizontal (25), vertical (19), polygons (18) rain expt (11)	Vertical was 3 pits to 50 cm, one a resample of 2010, two fresh, Fig S6
Lomas Bayas	S23 24.594 W69 30.833 1488m elevation	horizontal (25) vertical 1 (21) vertical 2 (17)	Vertical 2 from near Maria Elena mine
Yungay	S24 05.529 W69 59.857 1003m	horizontal (25) vertical (27) polygons(22) rain expt(32)	Vertical samples are resamples of 2010 pit, which we then used for rain expt, Figs S2,S5
NO1 – 100 km north of Copiapo	S27 0.2'57.5" W69 55'25" 1665m elevation	horizontal (25) Brian (5) vertical(8)	Vertical is pit to 70 cm, Fig S3
NO2	S27 36.442 W70 27.020 576m elevation	horizontal (25) Brian (5)	First appearance of plant life in sample regions

NO3 – near "El Donkey"	S28 25.367 W70 42.907 681m elevation	horizontal (25) Brian (5) vertical (14)	Vertical is two pits to 60 cm, 1 m apart for heterogeneity test
NO4 -	S29 16'56.8" W71 02'12.4" 604m elevation	horizontal(7) Brian (5)	Only time for a quick horizontal transect
NO5 – near "El Sauce"	S29 50.209 W70 50.153	horizontal (25) Brian (5)	(no, I am not making these names up)
NO6	S30 05'55.2" W70 43'01.0"	horizontal (25) Brian (5)	First appearance of cactus! Fig S4

In the interim between receiving this award and the present day, I've been through a number of large personal and professional upheavals. I've moved to the UK, first taking up a faculty position at the University of East Anglia, and very recently (July 1) moved to the University of St Andrews in Scotland, for what I hope will be a long term stay. As a result of these movements (and with only minimal access to sample analysis funds at UEA), I've been unable to analyze the bulk of the samples collected on my Lewis and Clark trip. This should all change shortly, as I have sufficient start up funds to purchase an ion chromatography device and have a laboratory under construction with an estimated completion date of Dec 2013.

As a result, I have only preliminary data from one of the projects to report. The long term goal of the project is calibration of a new type of "rain gauge" more suitable for describing centennial scale events. One hypothesis we are testing for this project is that soil surface homogeneity is correlated with increasing rainfall. In hyper-arid regions, atmospherically-produce salts (such as nitrate, sulfate, and perchlorate) build up in soils, and are only flushed to depth in extremely rare rainfall events. In the absence of rainfall then, our hypothesis would suggest that areas with less rain would have both higher amounts of soluble salts, in addition to greater sample to sample variability

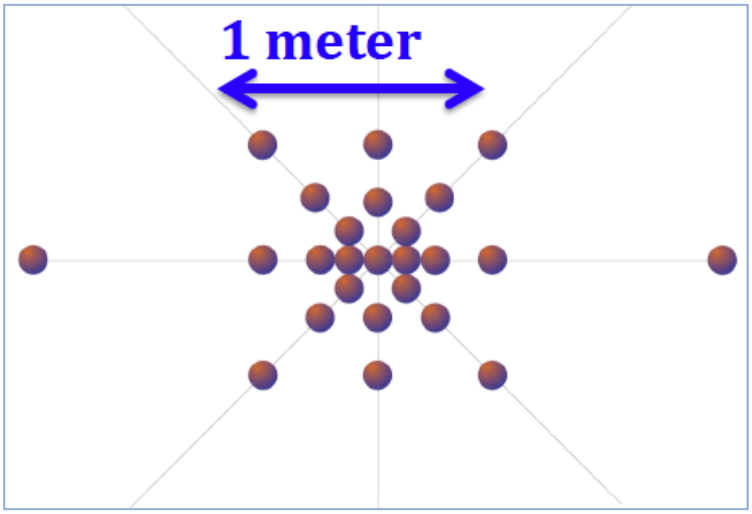

Figure 1 - Radial grid for our "horizontal" heterogeneity sampling

In order to systematically investigate heterogeneity in soils, we collected what we labeled as "horizontal" transects in Table 1. These transects involved collecting 25 samples in the radial pattern (Figure 1) from multiple sites. The field layout of this

transect at the Yungay site is shown in Figure S2. We have analyzed the soluble salts from 3 of our transect sites, shown as Figure 2. This preliminary data reflects chlorine and nitrate measurements from Yungay (plotted as 1 mm/year), NO2 (plotted as 10 mm/year) and NO5 (plotted as 80 mm/year)

Examining Figure 2 (a small subset of the data we plan to analyze), we find that our hypothesis generally hold. The dryer site (Yungay, 1mm/year rainfall) has both a larger absolute value of soluble salt concentrations, as well as large variability, as indicated by the error bars which represent the standard deviation of the samples about the average value. The values of nitrate at the surface do increase from an average of 1 ppm to an average of 4 ppm in the 80 mm/year site, which we hypothesize is due to the increased number of desert plants which have a well known "nitrate harvesting" effect.

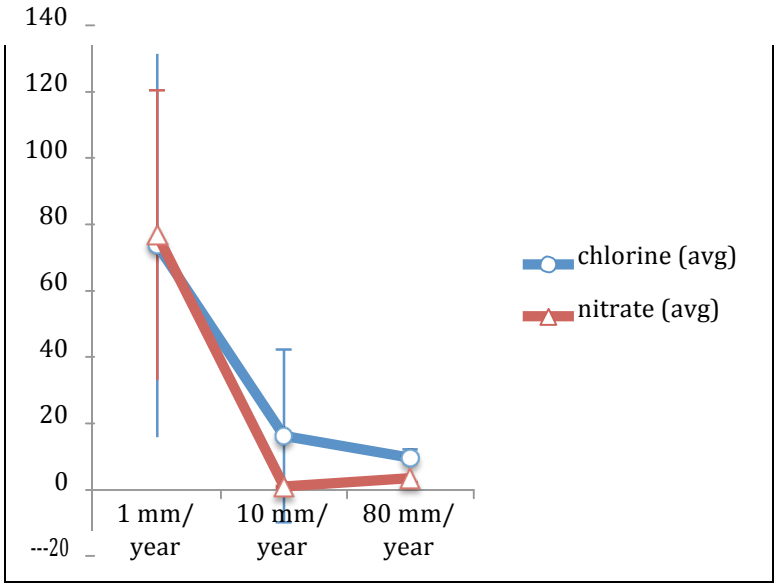

Figure 2 – Preliminary Data from our horizontal transect

While we have not yet obtained the transect data for the km 40 site, we have some preliminary data from a different (linear) horizontal transect collected in 2010. While from a lesser number of points in a different configuration, Figure 3 indicates that, as surmised in the grant application, that this site exhibits far different behavior to that of Yungay (which holds the current title of the "driest place on Earth"). Km 40 contains even an additional order of magnitude more soluble salt in the surface soils as well as huge standard deviations across cm scales. Although far from proven, we are making strides towards our proposed goal of locating far drier locations than Yungay within the Atacama.

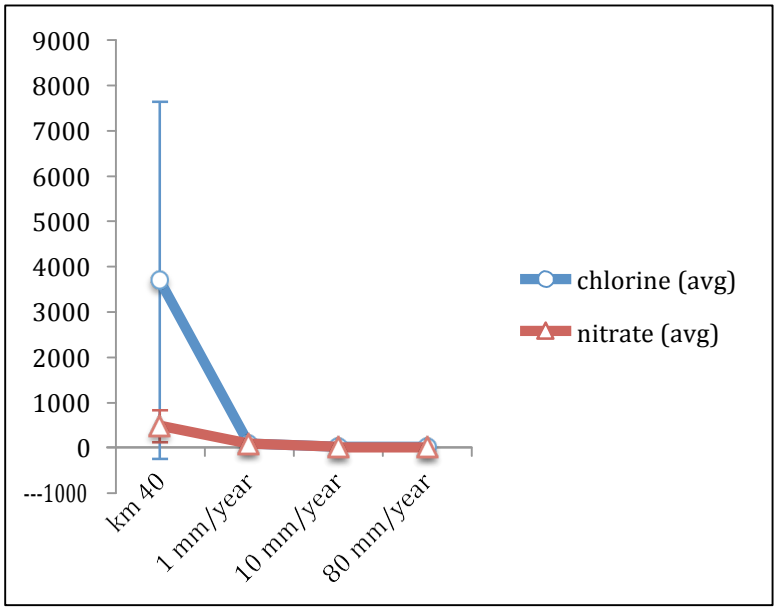

Figure 3 – Preliminary data from Figure 2, but also including data from km 40

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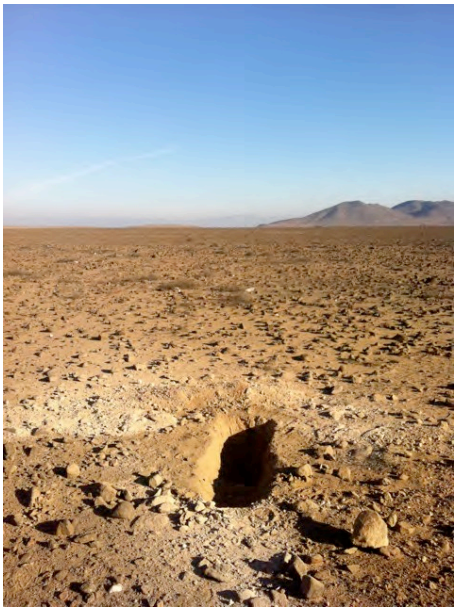
Project Report - Supplemental Figures

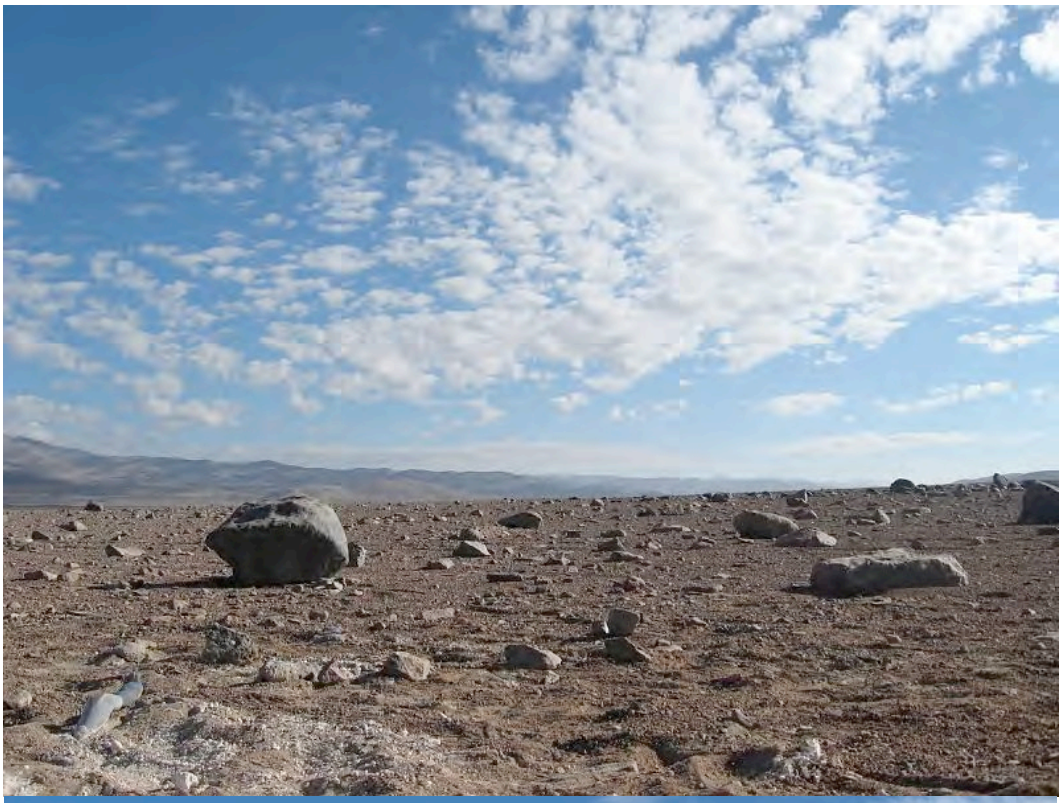
Figure S1: Sample Locations

From North to South, the locations are "km 40", Lomas Bayas, Yungay, NO1-6 as identified in Table 1. The blue pins are in the hyper-arid core of the desert (rainfall < 1mm/yr) while the green and yellow pins represent our sampling sites across the rainfall gradient. From north to south along the green pins, the rainfall increases from ~10 mm/year to 100 mm/year, with a corresponding increase in (desert) planet life, including cactus at the southernmost site.

Figure S2 - hyper arid site with no visible macroscopic life other than Dr. Aubrey Zerkle (<1 mm rainfall per year – near Yungay)



Figures S3 (left) and S4 (right) – 3) NO1 site (approximately 10 mm/year rainfall. Note the appearance of (mostly dead) scrub brush, indicating that sufficient water/nutrient activity to support plant life, at least for a few weeks a year following rainfall. One of many vertical pits to 70 cm was dug at this site 4) NO6 site (approximately 100 mm/year rainfall) Trees, cactus, and even a desert fox were present at this site.



Figures S5 (top) and S6 (bottom) 5) Mars-like terrain near the Yungay location. There is a garden trowel in the lower left for scale. 6) Regolith near km 40, candidate “driest place on Earth”

Figures S7 (top) and S8 (bottom) 7) Action shot from our rainfall simulation experiment. We simulated an 80 mm rainfall event. 8) We logged the soil moisture, temperature, and conductivity for a one week period, as well as the air temperature and relative humidity above the rainfall patch and on a control patch