CGM Gallagher Group
Brokers To The Caribbean

Wind and Rainfall Risk Modelling for the Blue Mountain Coffee Region

World Bank contract # 7153672

Third Interim Report: Update on Probabilistic Hazard Assessment

12 May 2010

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1 INTRODUCTION

This third interim report provides an update on outputs from Component 2 of the project and a proposed timeline for completion of project work.

On assessing the practical implications of producing wind and rain hazard exceedance curves for each of the 859 1-km grid cells in the BMCR and correlations between each cell, we have reached the following conclusions:

- It is computational challenging to complete such an analysis;
- It would be analytically almost impossible to utilise all of the data produced; and
- From a statistical perspective, variations in hazard levels from cell to cell are below the confidence threshold of the data, as are correlation factors for neighbouring cells.

Given these factors, and considering the actual distribution of coffee production in BMCR, we have concluded that a zone-based analysis is a much more practical approach. This report presents the initial results of the zonal analysis for wind hazards. While there are differences between wind and rain hazard spatial distribution at the probabilistic level, they share the same fundamental driver, topography, and we therefore believe that the wind zones presented here will be equally valid for rain hazard/risk.

We have utilised probabilistic wind hazard modelling undertaken by Kinetic Analysis Corporation at 30-arcsecond resolution as a basis for delimiting and characterising the proposed meteorological zones. Once the zones are approved by the World Bank project team and Coffee Industry Board collaborators, we will undertaken a focussed wind hazard analysis utilising the most appropriate wind model and aimed at producing hazard exceedance curves (with confidence limits representing both model uncertainty and intra-zone variability) and correlation factors for all zones (currently numbering 13.)

Due to delays in finalising the rainfall model which Kinetic Analysis Corporation has developed for the Caribbean Basin, we have not yet had an opportunity to complete the full probabilistic analysis of model-based rainfall. While the modelled rainfall totals for past historical events (presented in an earlier interim report and generated from a multi-hazard hurricane model) are felt to be reasonable, we believe that the 60-year modelled rainfall climatology will provide the best basis for comparison with ground-based data and for assessing probabilistic hazard curves. We aim to replicate the hazard curve and correlation dataset described above (for wind) utilising the 60-year rain climatology for the same meteorological zones as for wind hazard.

2 DELIMITING OF METEOROLOGICAL ZONES

We have utilised the following information as a basis for delimiting 13 meteorological zones which we believe represent homogenous conditions for extreme wind and rain hazards and which take in all of the currently identified coffee production areas. Most, but not all, have an active or have previously had a rain gauge which would be reasonably representative of the zone.

- Clusters of coffee estates;
- Geographical location;
- Elevation;
- General topographic setting (including general facing direction); and
- Probabilistic wind hazard level.

Figure 1 shows the overall distribution of the zones, and Annex 1 contains more detailed maps of each zone.

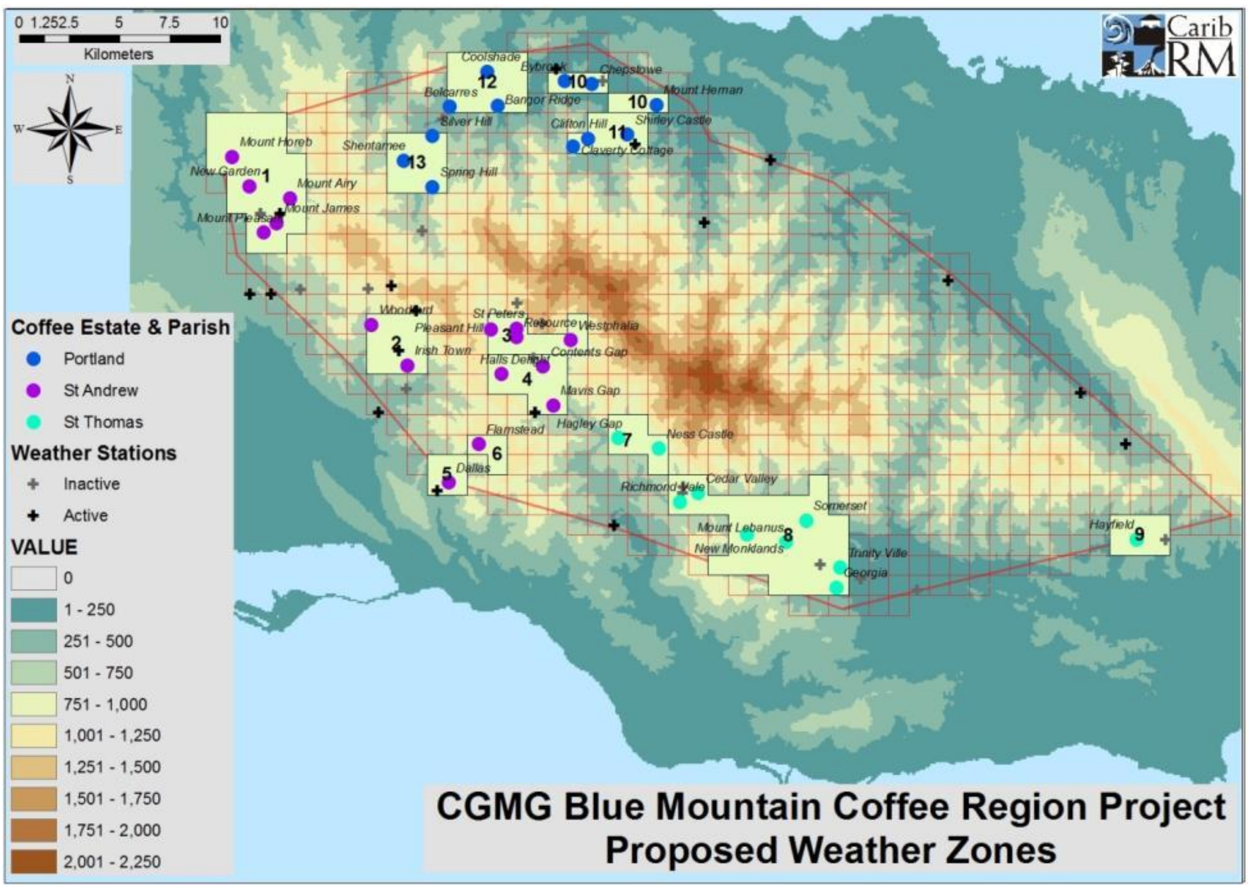


Figure 1 Proposed meteorological zones, with coffee estates and weather stations marked. Topography from SRTM 90m data.

Table 1 provides the basic characteristics of each zone in terms of the elevation range and any weather station(s) within the zone. The elevation range covers the main 250m bands included in each zone (thus coinciding with Figure 1); however, the range of elevations of the actual coffee estates within each zone is substantially lower than the full range of elevations within the zone.

Zone number	*Zone name*	*Elevation range*	*Weather station*
1	St Andrew Northwest	250-750m	Langley
2	St Andrew West-central	750-1250m	Irish Town
3	St Andrew Central-North	750-1250m	(Chinchona Gdns)
4	St Andrew Central-South	500-1000m	Mavis Bank
5	St Andrew Southwest	250-750m	Dallas
6	St Andrew South	750-1250m	None
7	St Thomas Northwest	500-1000m	None
8	St Thomas South-central	250-750m	(Cedar Valley, Trinityville)
9	St Thomas Southeast	250-500m	(Barretts Gap)
10	Portland Northeast	0-500m	Bybrook
11	Portland Southeast	250-750m	Shirley Castle
12	Portland Northwest	0-500m	(Balcarres)
13	Portland Southwest	250-750m	None

Table 1 Basic zone characteristics. Note weather station names in brackets denotes an inactive station.

As described above, we have used probabilistic wind hazard maps to assist in delimiting the zones, and Table 2 provides a listing of the average, standard deviation and range of wind hazard with a 50% probability of exceedance in 50 years (~72-year return period.) Note that these probabilistic hazard levels may not precisely match those which will be generated within the final wind model, but the relative distribution of the hazards will remain very similar.

Zone Number	*Average peak wind (mph)*	*Standard Deviation*	*Range (mph)*
1	126	3.0	13
2	129	1.1	4
3	128	2.3	9
4	114	14.1	33
5	128	1.0	2
6	130	0.9	2
7	129	1.2	4
8	119	8.7	29
9	119	5.3	18
10	105	10.0	25
11	116	14.0	42
12	118	7.6	35
13	126	5.3	17

Table 2 Probabilistic wind characteristics by zone.

Figure 2 shows the average wind with error bars at one standard deviation. A significant amount of the variation is caused by inclusion of 1-km grid cells which do not have coffee estates within them but which share certain general characteristics of the zone as a whole.

It is also interesting to note that the largest zones do not necessarily have the largest variability; Zones 4 and 11 for example, show the highest variability but are both amongst the smaller zones, indicating that both have complex topography. The actual topographical situation of the estates within these zones appears to be significantly more consistent than the zone as a whole (largely because coffee growing occurs in areas of relatively uniform topographical character.)

Annex 2 provides wind and rain footprints (three of each) with the defined Meteorological Zones superimposed. These maps demonstrate the consistency of both wind and rain hazard at the event-specific level within the defined zones.

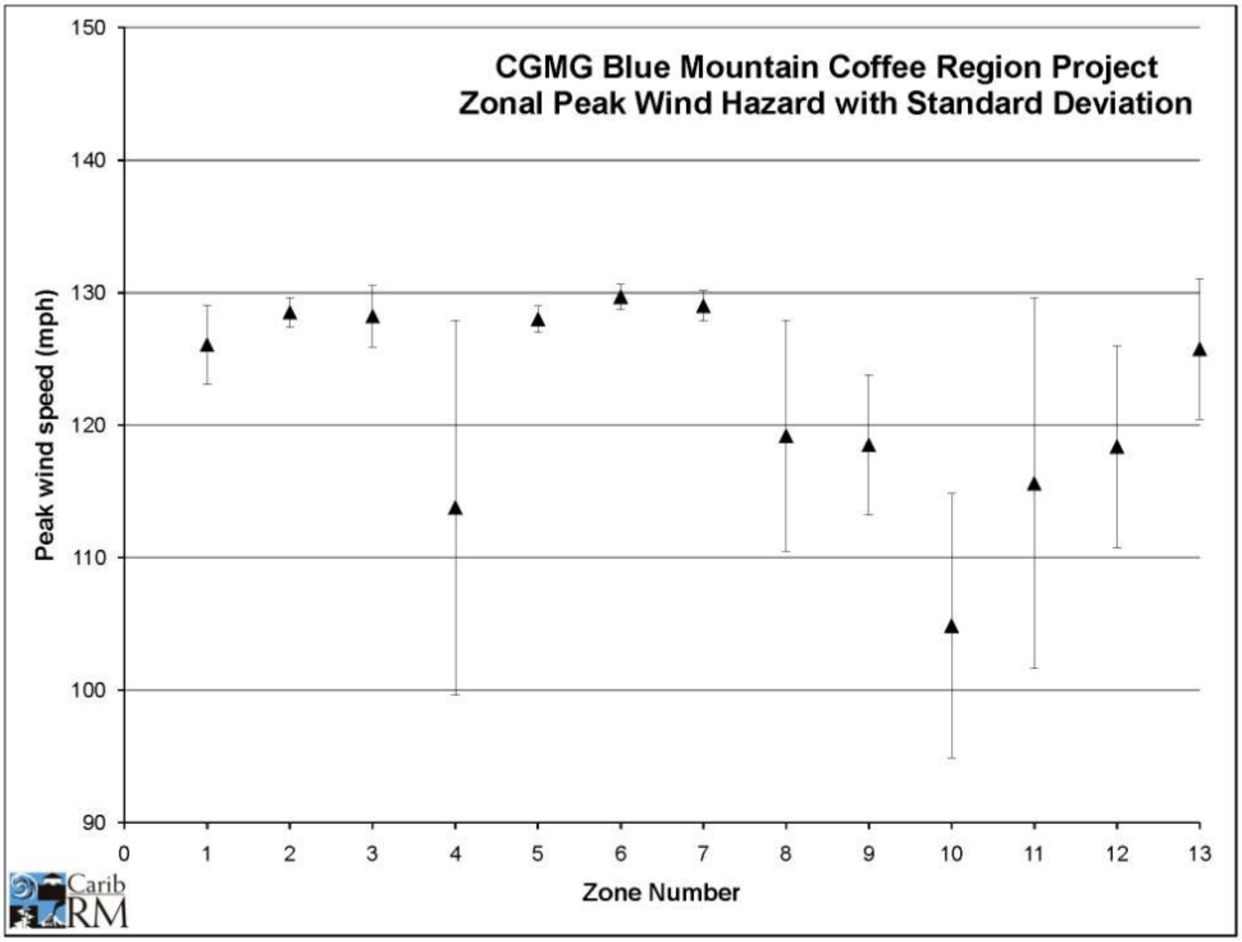


Figure 2 Average and standard deviation for peak 72-year wind in each defined Meteorological Zone.

3 PRELIMINARY HAZARD EXCEEDANCE CURVES

Based on the zones defined above and utilising Kinetic Analysis Corporation's initial probabilistic wind hazard assessment results, Figures 3 and 4 show the peak wind hazard exceedance curves for each of the 13 zones.

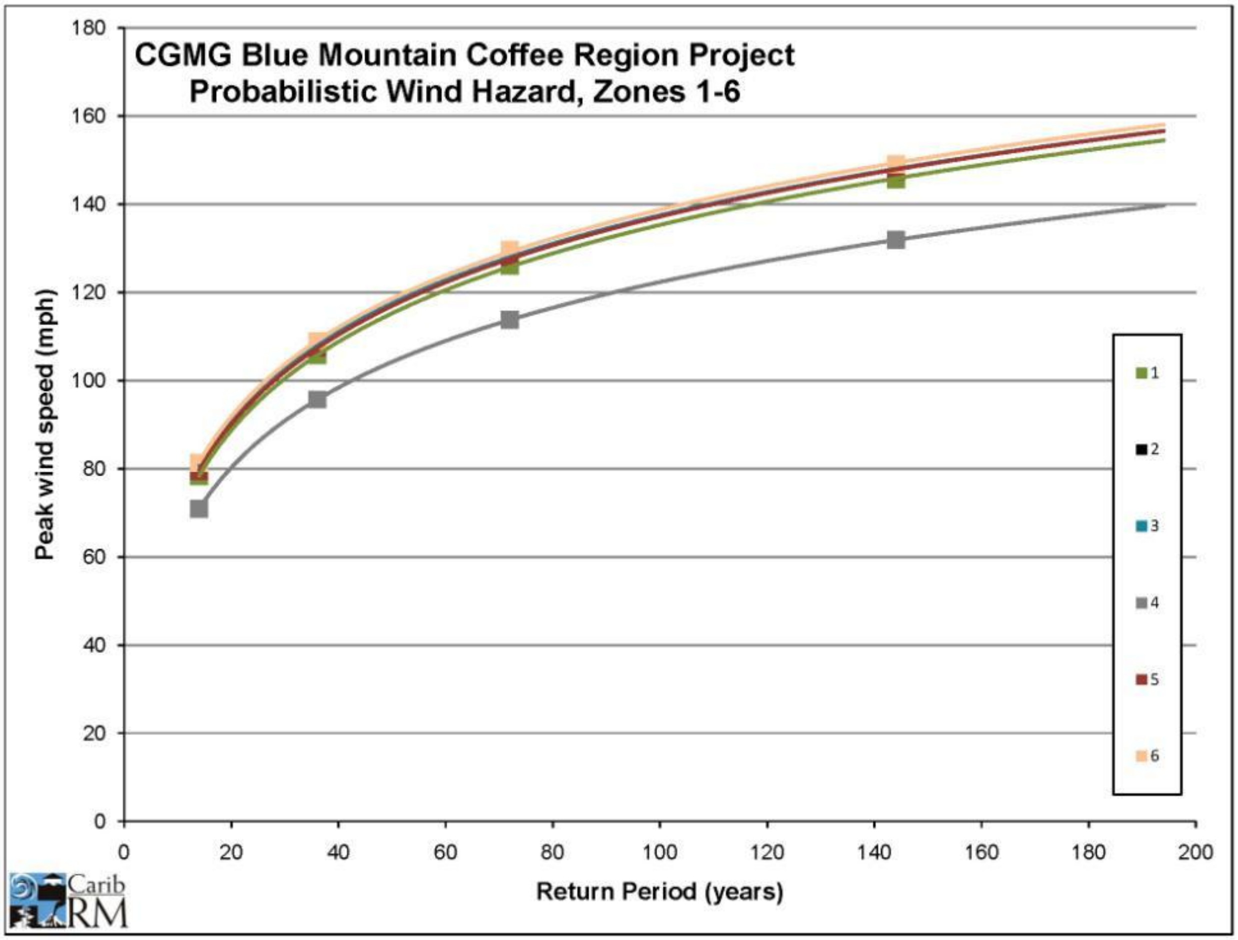


Figure 3 Preliminary wind hazard exceedance curves for Zones 1 to 6.

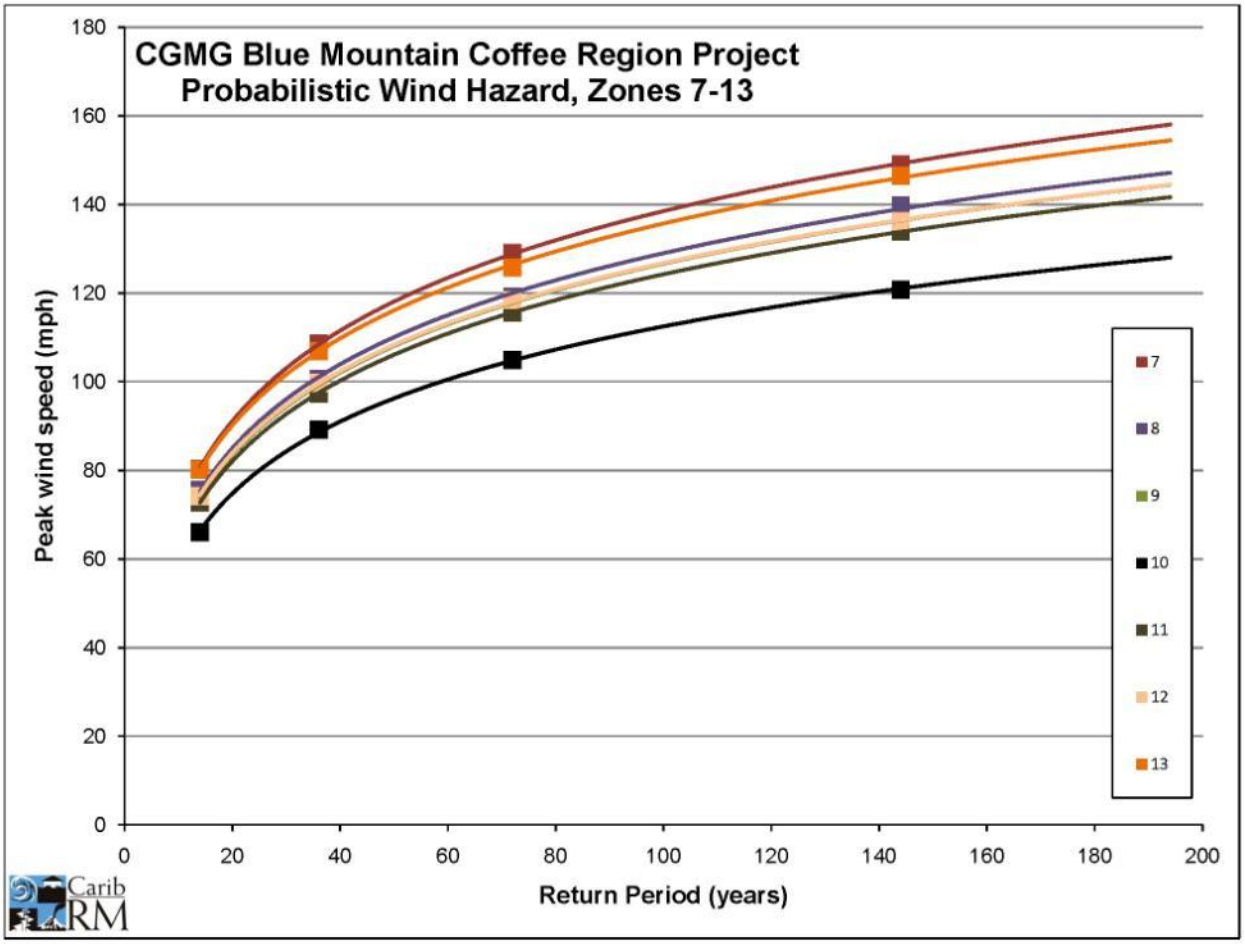


Figure 4 Preliminary wind hazard exceedance curves for Zones 7 to 13.

As would be expected in such a small geographical area, the wind hazard level varies only modestly, by a little less than 20mph at low return periods to a little more than 30mph at high return periods. The shape of the hazard curves does not change in any significant way.

4 TIMETABLE FOR COMPLETION OF COMPONENT 2

We see three remaining tasks to complete this project:

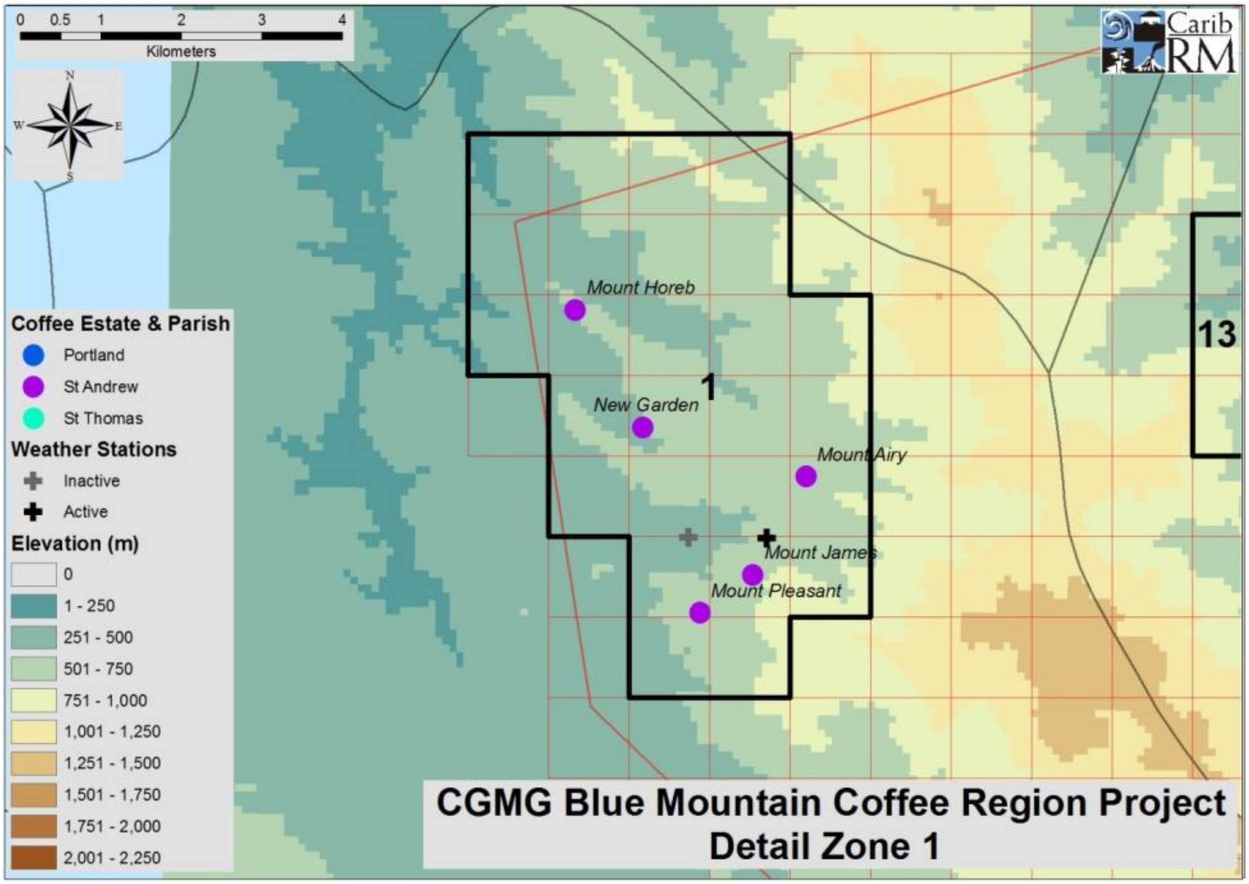
1. Approval of the Meteorological Zones as defined here by the broad project team, and if changes are required, integration of those changes.

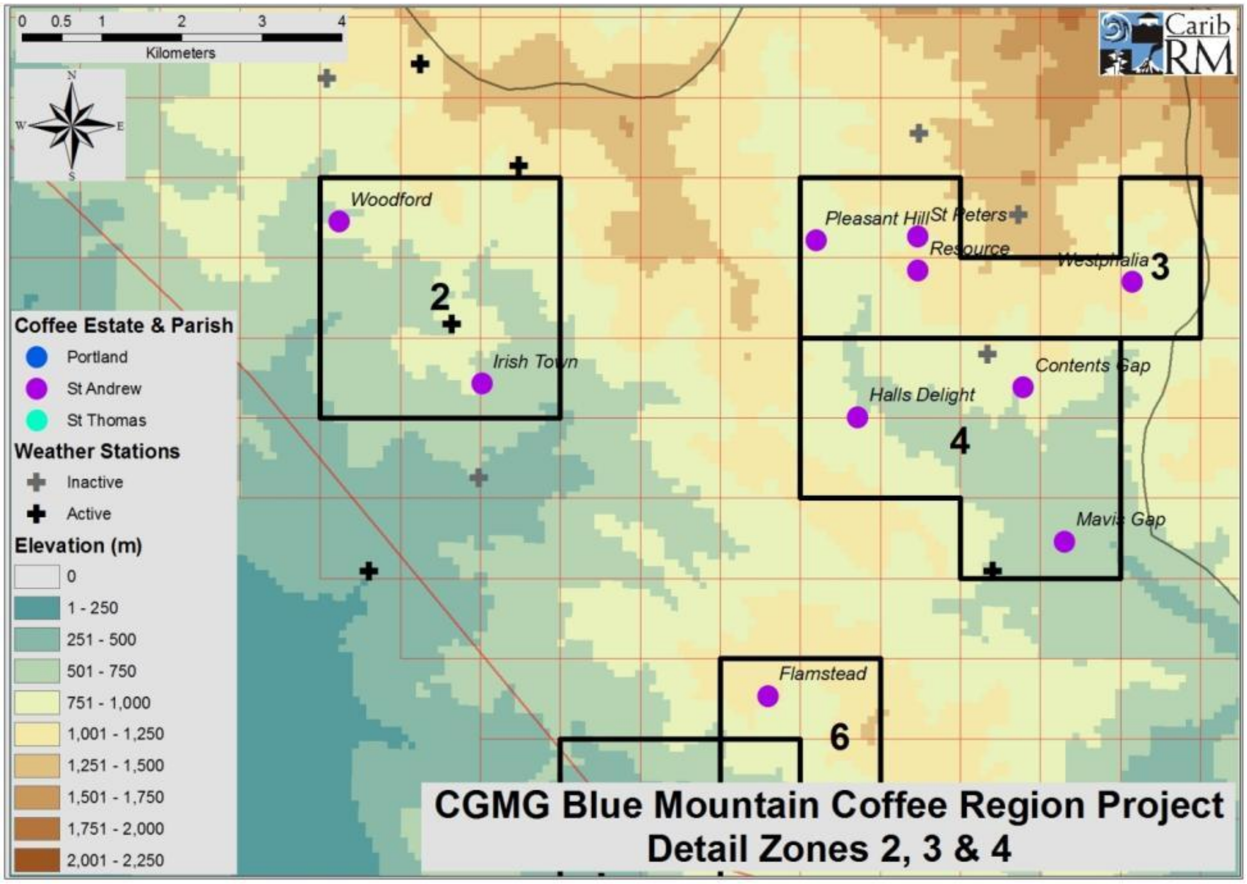
2. Production of extreme rain hazard exceedance curves and correlation matrix for the agreed zones.

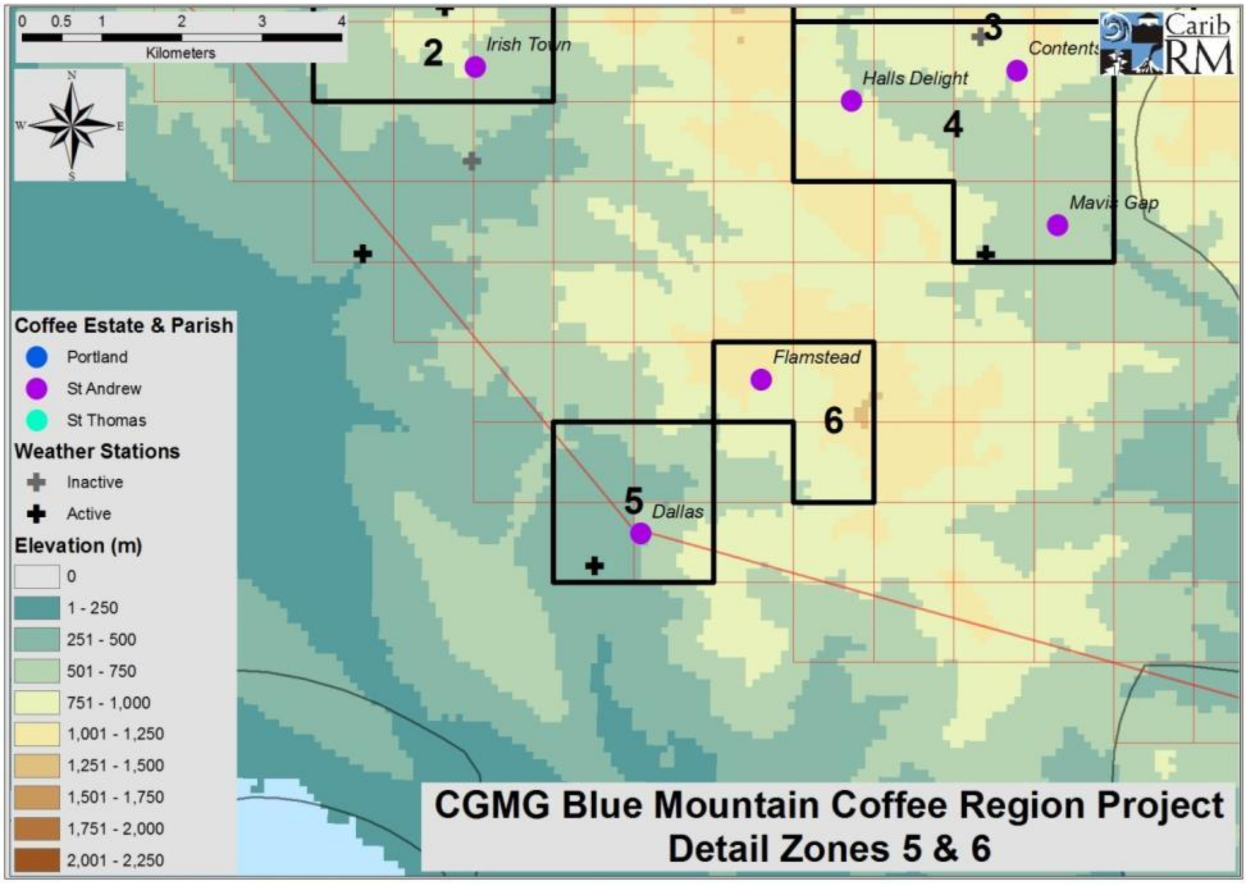
3. Production of wind hazard exceedance curves and correlation matrix for the agreed zones.

Presuming approval of final Meteorological Zones by early-June, we anticipate completion of rain and wind curves and correlation matrices by mid-July.

ANNEX 1: DETAILED ZONE MAPS




0 0.5 1 2 3 4
Kilometers
Coffee Estate & Parish
Portland
St Andrew
St Thomas
Weather Stations
Inactive
Active
Elevation (m)
0
1 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,500
1,501 - 1,750
1,751 - 2,000
2,001 - 2,250
Woodford
2
Irish Town
Pleasant Hill
St Peters
Resource
Westphalia
3
Contents Gap
Halls Delight
4
Mavis Gap
Flamstead
6
Carib RM
CGMG Blue Mountain Coffee Region Project
Detail Zones 2, 3 & 4


0 0.5 1 2 3 4
Kilometers
N
W
E
S
Carib RM
2
Irish Town
3
Contents
Halls Delight
4
Mavis Gap
Flamstead
6
5
Dallas
Coffee Estate & Parish
Portland
St Andrew
St Thomas
Weather Stations
Inactive
Active
Elevation (m)
0
1 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,500
1,501 - 1,750
1,751 - 2,000
2,001 - 2,250
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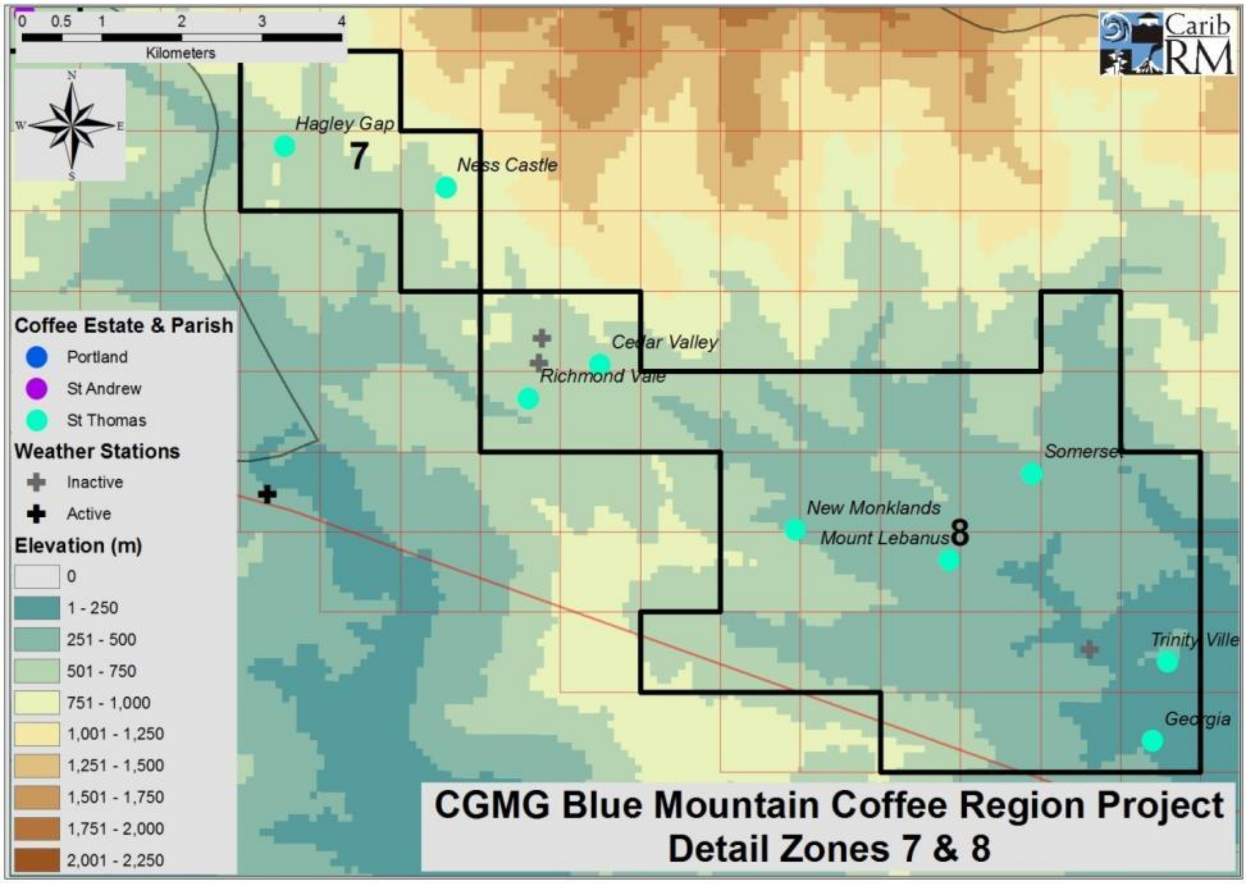
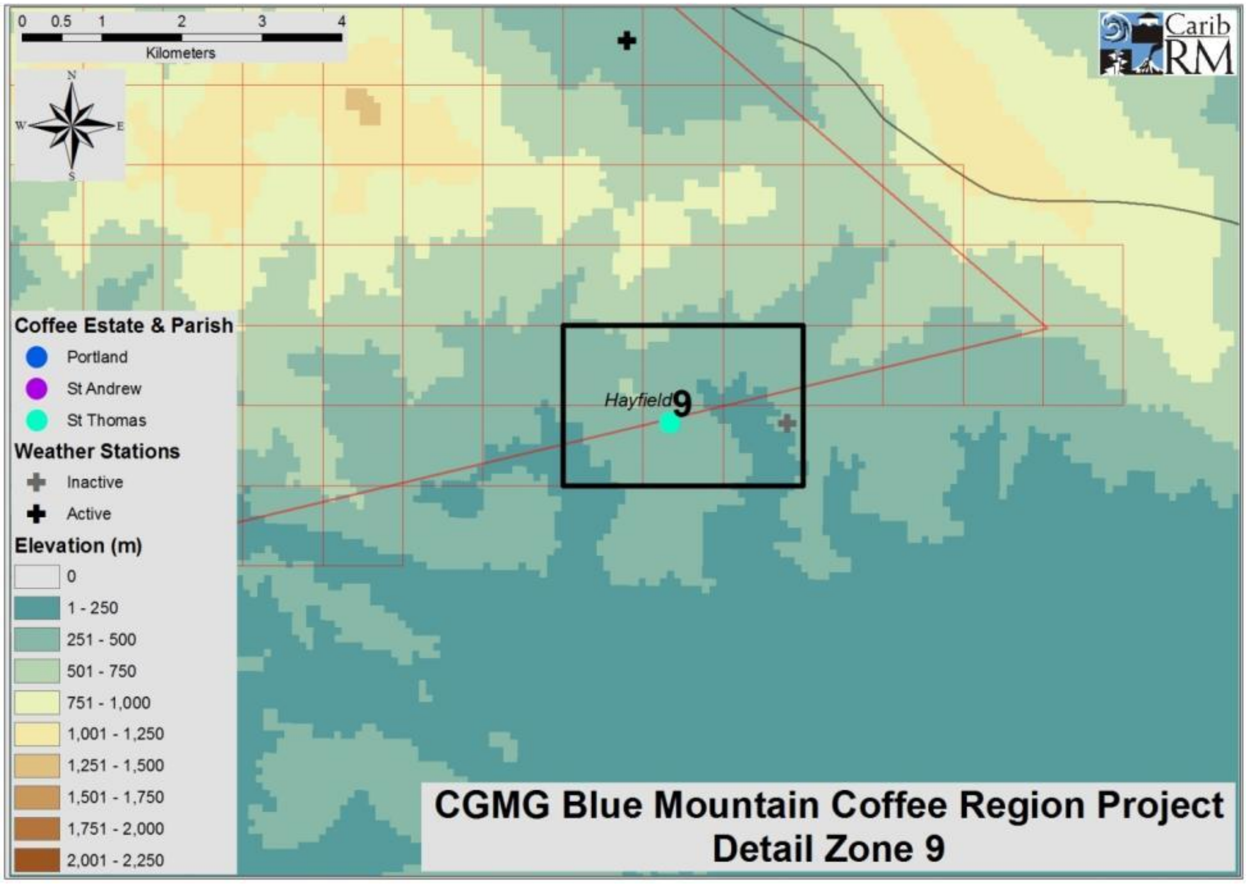
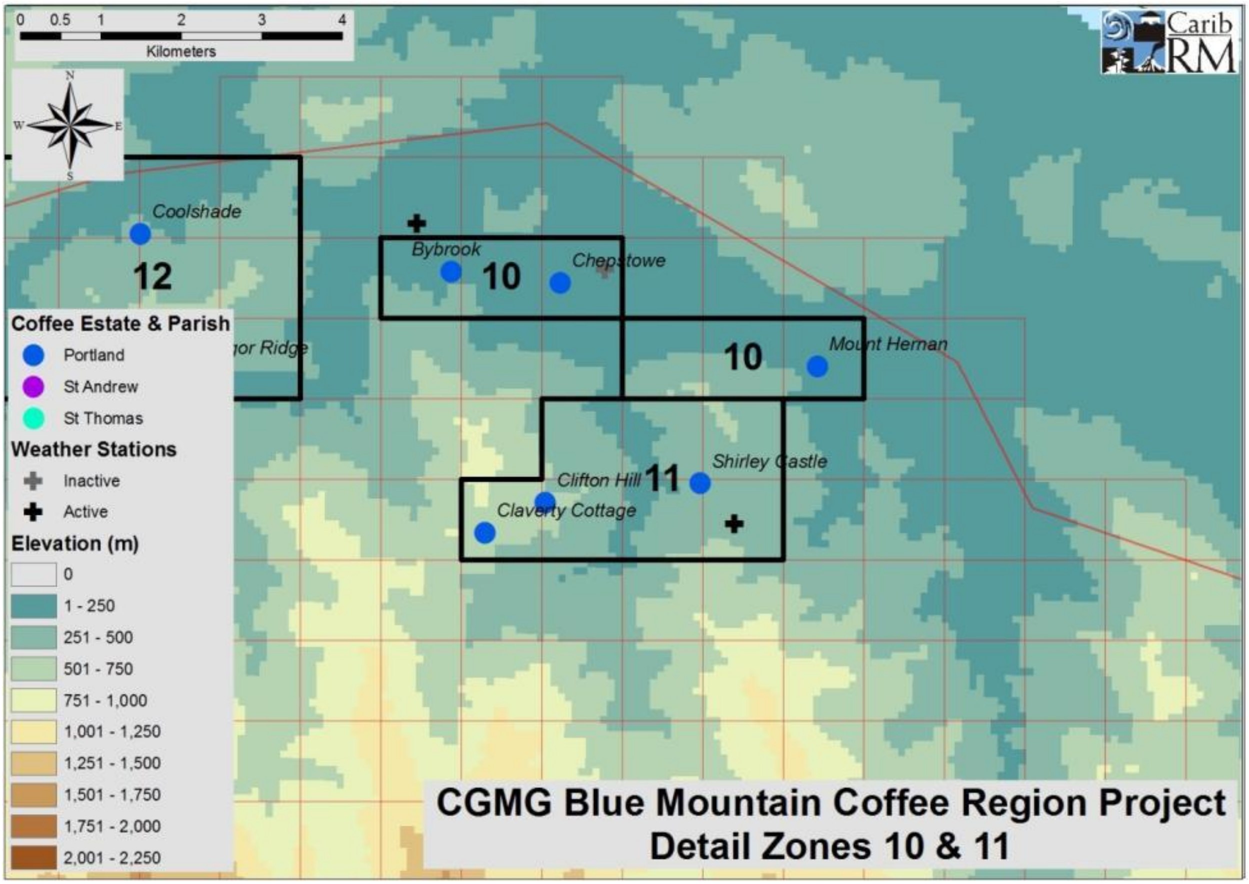
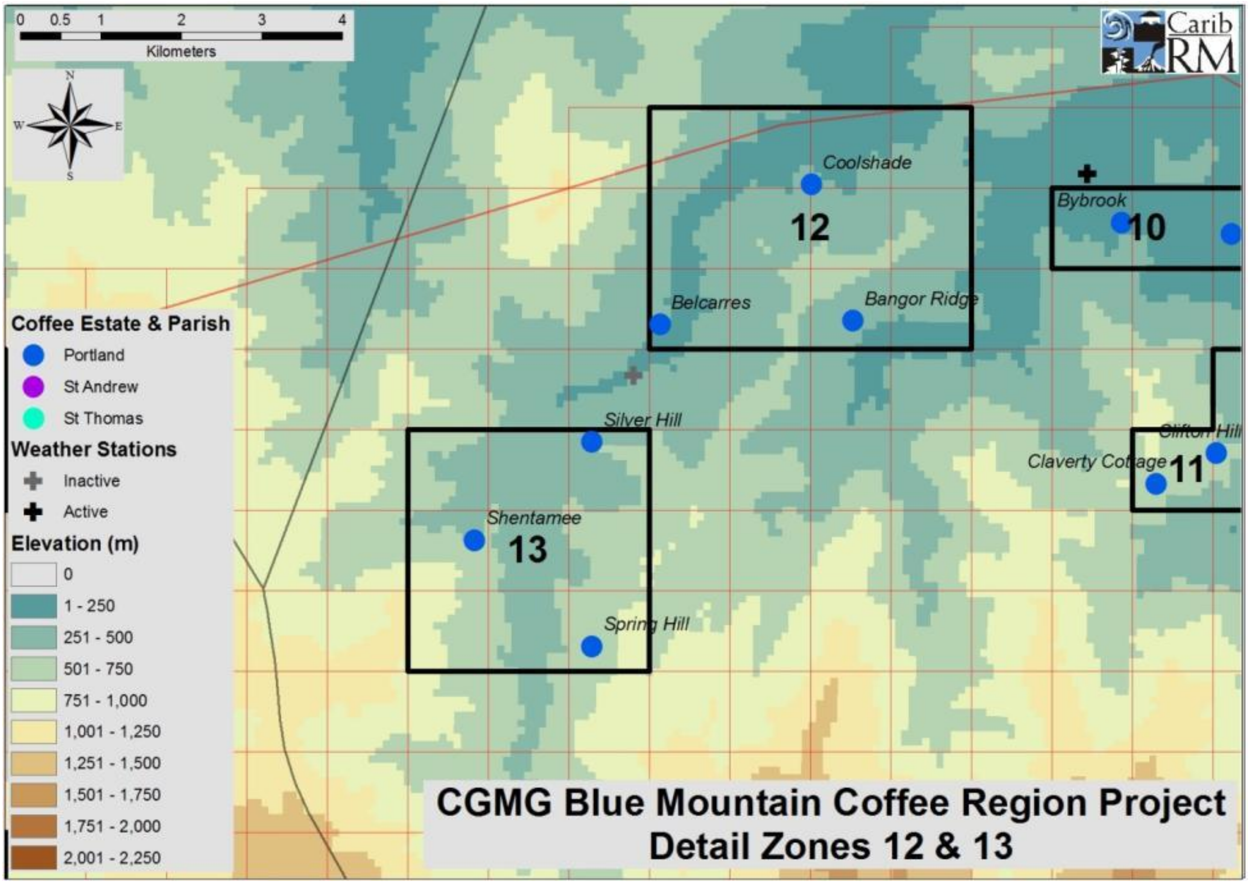
Detail Zones 5 & 6

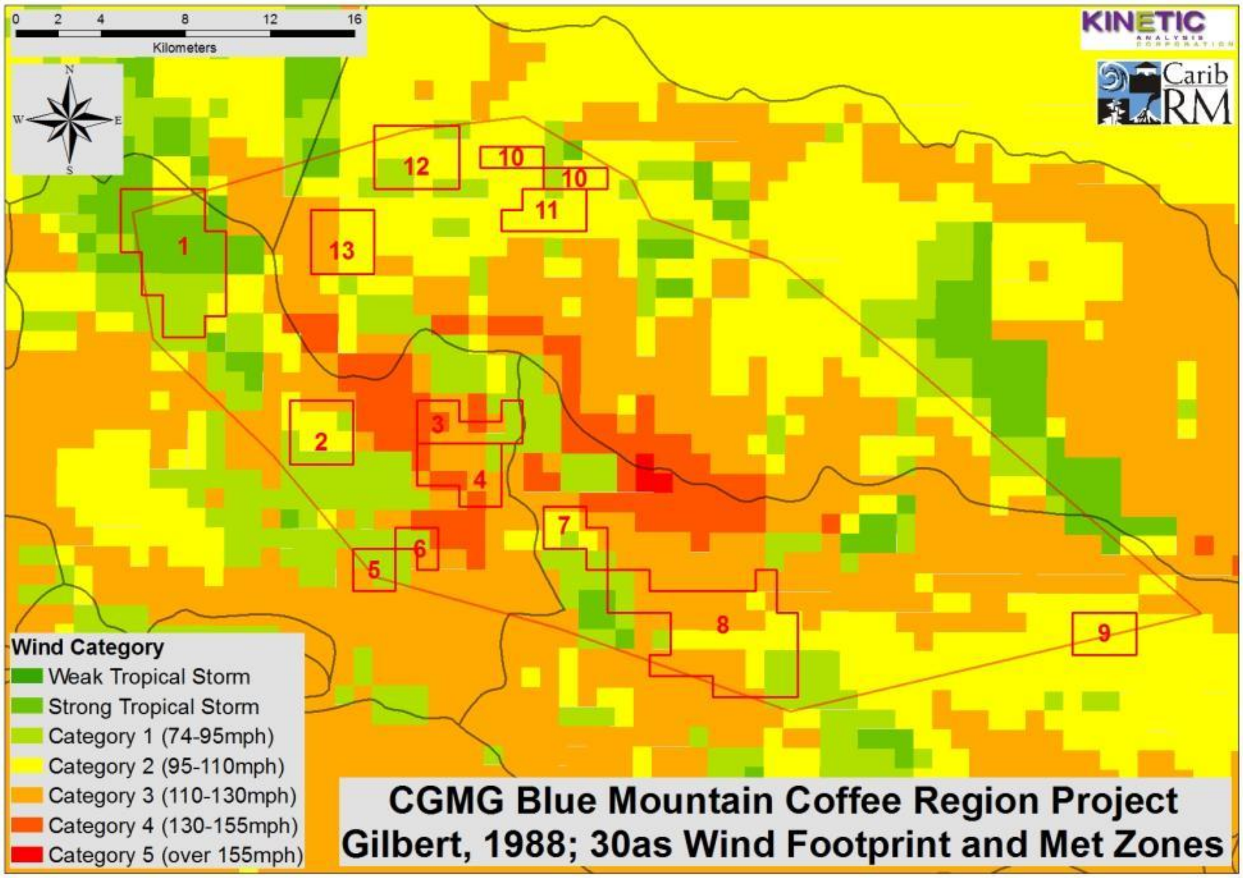

0 0.5 1 2 3 4
Kilometers
N
W
E
S
Carib RM
Hagley Gap
7
Ness Castle
Cedar Valley
Richmond Vale
Somerset
New Monklands
Mount Lebanus
8
Trinity Ville
Georgia
Coffee Estate & Parish
Portland
St Andrew
St Thomas
Weather Stations
Inactive
Active
Elevation (m)
0
1 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,500
1,501 - 1,750
1,751 - 2,000
2,001 - 2,250
CGMG Blue Mountain Coffee Region Project
Detail Zones 7 & 8

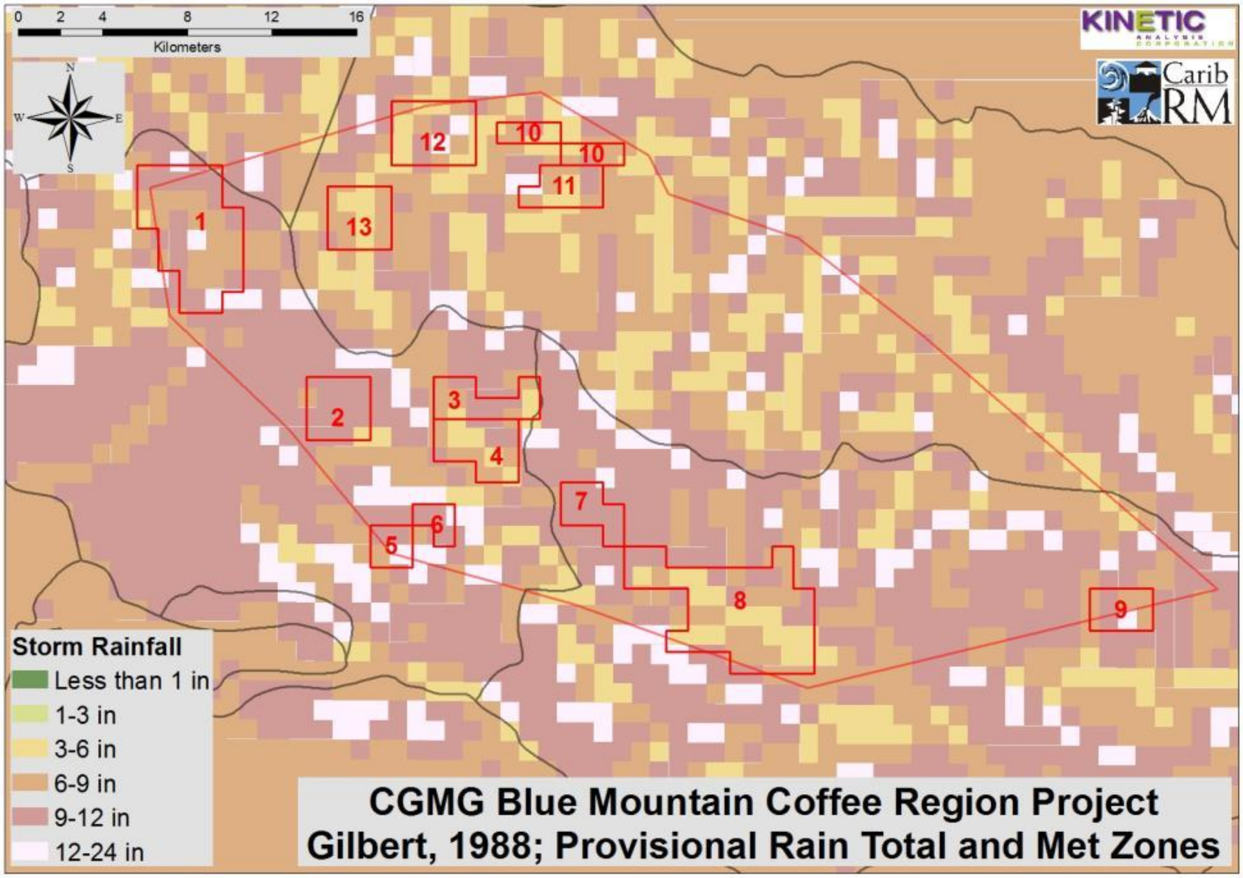

0 0.5 1 2 3 4
Kilometers
N
W
E
S
Carib RM
Coffee Estate & Parish
Portland
St Andrew
St Thomas
Weather Stations
Inactive
Active
Elevation (m)
0
1 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,500
1,501 - 1,750
1,751 - 2,000
2,001 - 2,250
Hayfield
9
CGMG Blue Mountain Coffee Region Project
Detail Zone 9


0 0.5 1 2 3 4
Kilometers
Carib
RM
Coolshade
12
Bybrook
10
Chepstowe
10
Mount Hernan
Clifton Hill
11
Shirley Castle
Claverty Cottage
Coffee Estate & Parish
Portland
St Andrew
St Thomas
Weather Stations
Inactive
Active
Elevation (m)
0
1 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,500
1,501 - 1,750
1,751 - 2,000
2,001 - 2,250
CGMG Blue Mountain Coffee Region Project
Detail Zones 10 & 11


0 0.5 1 2 3 4
Kilometers
Carib RM
Coolshade
12
Bybrook
10
Belcarres
Bangor Ridge
Silver Hill
Clifton Hill
Claverty Cottage
11
Shentamee
13
Spring Hill
Coffee Estate & Parish
Portland
St Andrew
St Thomas
Weather Stations
Inactive
Active
Elevation (m)
0
1 - 250
251 - 500
501 - 750
751 - 1,000
1,001 - 1,250
1,251 - 1,500
1,501 - 1,750
1,751 - 2,000
2,001 - 2,250
CGMG Blue Mountain Coffee Region Project
Detail Zones 12 & 13

ANNEX 2: EVENT FOOTPRINTS WITH METEOROLOGICAL ZONES




0 2 4 8 12 16
Kilometers
N
W
E
S
KINETIC
Carib RM
12
10
10
11
1
13
2
3
4
7
6
5
8
9
Storm Rainfall
Less than 1 in
1-3 in
3-6 in
6-9 in
9-12 in
12-24 in
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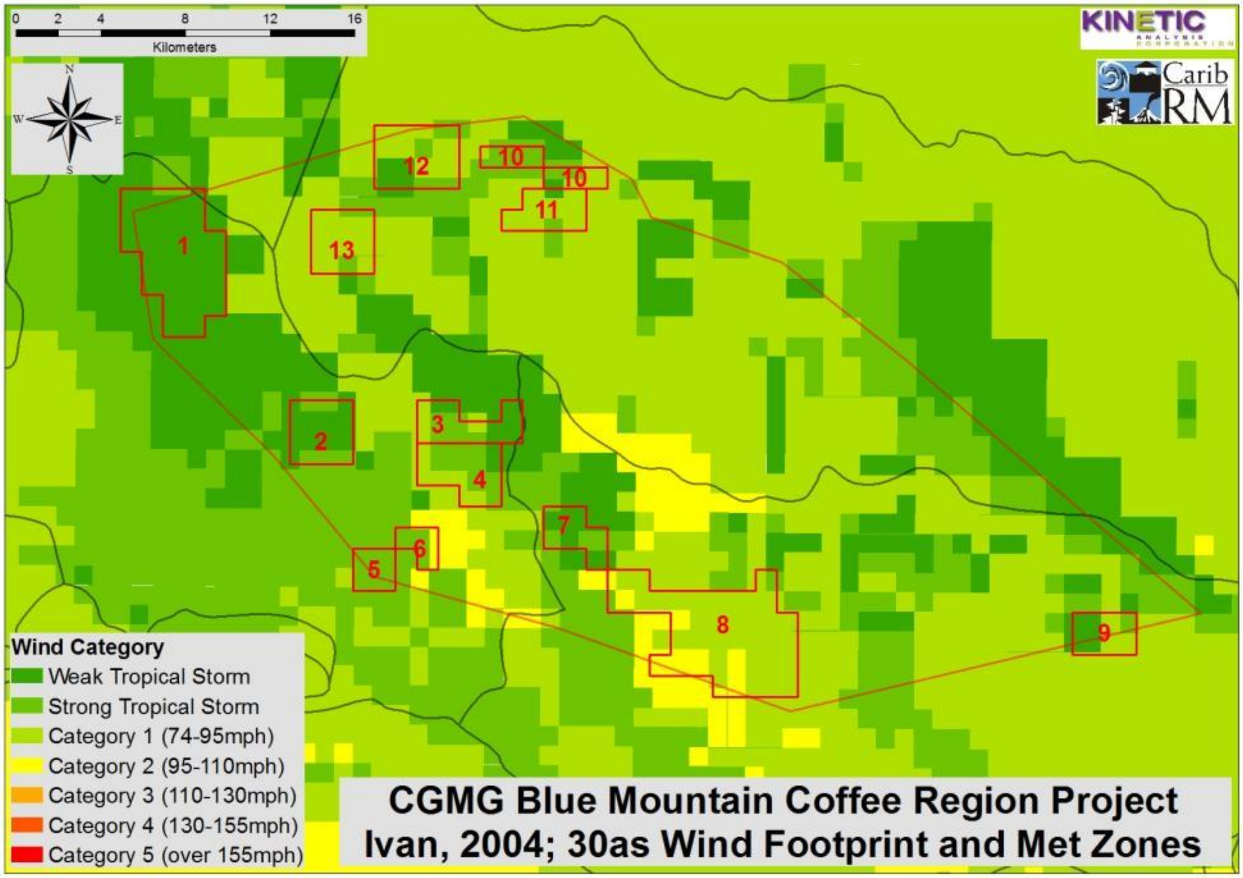
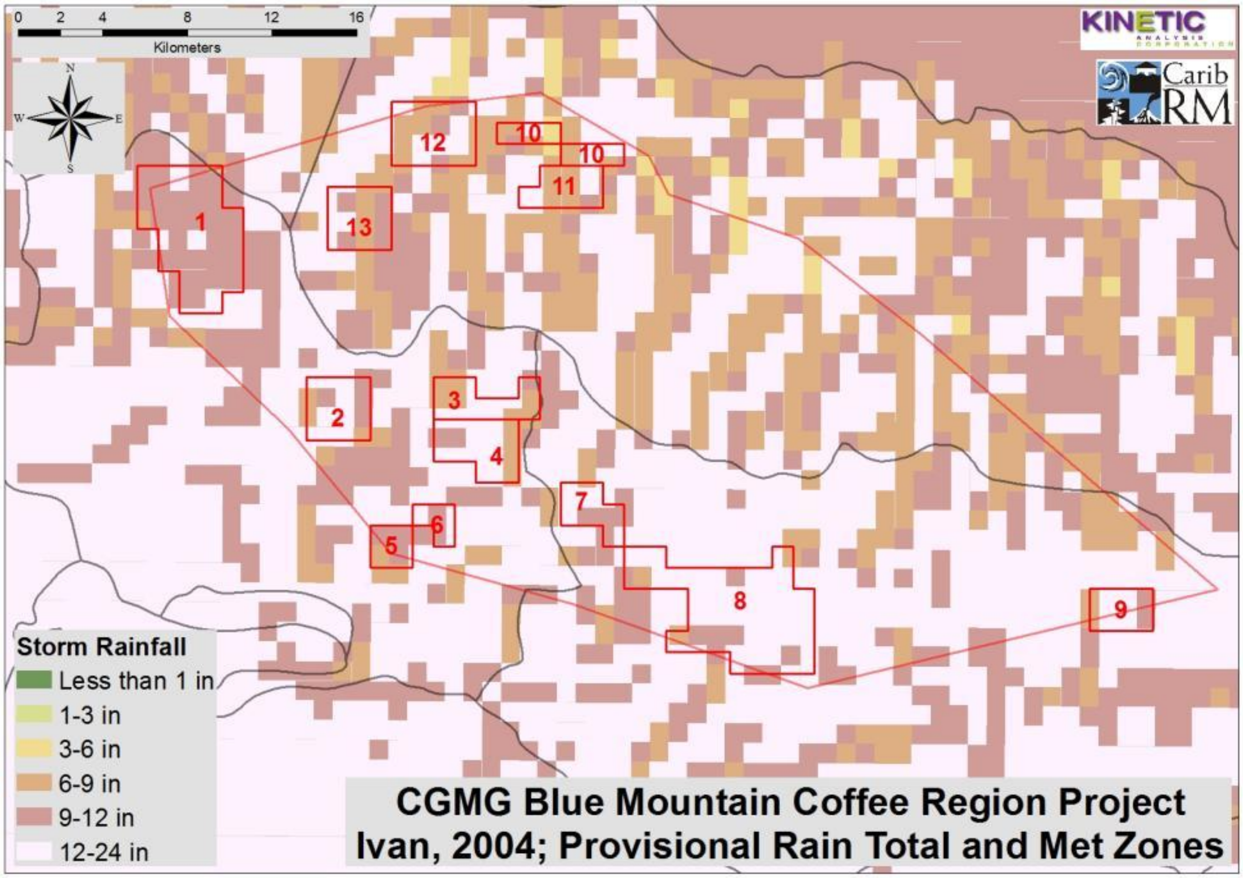
Gilbert, 1988; Provisional Rain Total and Met Zones


0 2 4 8 12 16
Kilometers
N
W
E
S
KINETIC
Carib RM
1
2
3
4
5
6
7
8
9
10
10
11
12
13
Wind Category
Weak Tropical Storm
Strong Tropical Storm
Category 1 (74-95mph)
Category 2 (95-110mph)
Category 3 (110-130mph)
Category 4 (130-155mph)
Category 5 (over 155mph)
CGMG Blue Mountain Coffee Region Project
Ivan, 2004; 30as Wind Footprint and Met Zones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KINETIC
Carib RM
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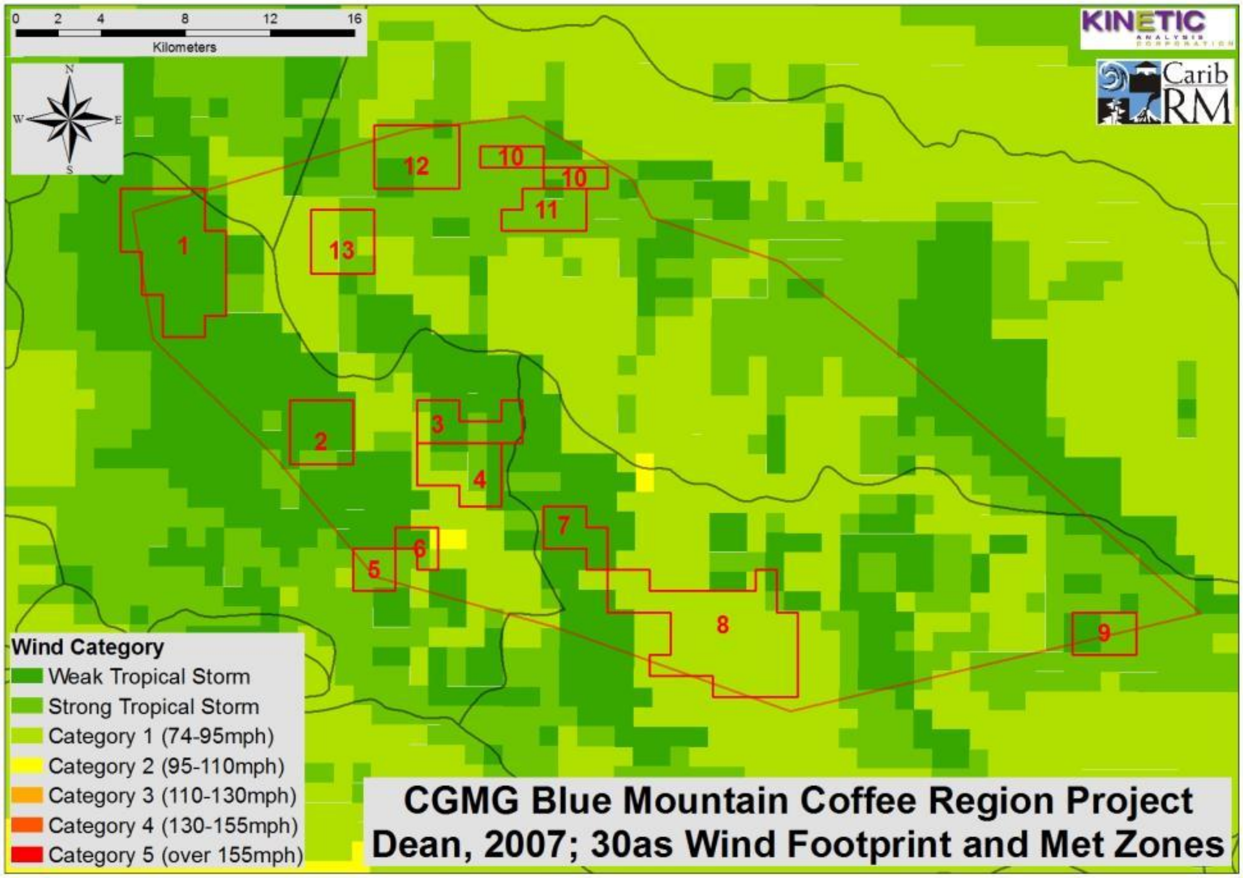
6
5
8
9
Storm Rainfall
Less than 1 in
1-3 in
3-6 in
6-9 in
9-12 in
12-24 in
CGMG Blue Mountain Coffee Region Project
Ivan, 2004; Provisional Rain Total and Met Zones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Kilometers
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Carib RM
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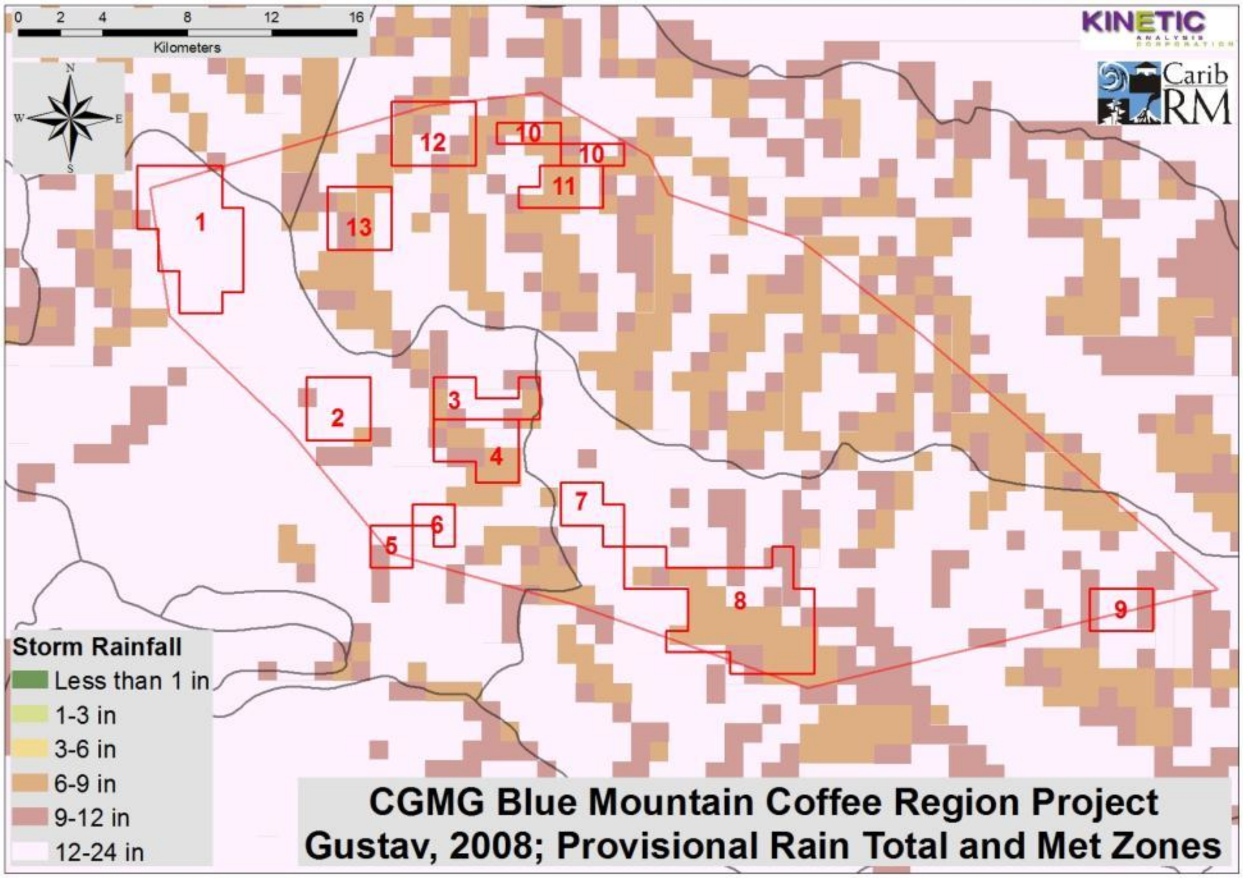
5
6
7
8
9
Wind Category
Weak Tropical Storm
Strong Tropical Storm
Category 1 (74-95mph)
Category 2 (95-110mph)
Category 3 (110-130mph)
Category 4 (130-155mph)
Category 5 (over 155mph)
CGMG Blue Mountain Coffee Region Project
Dean, 2007; 30as Wind Footprint and Met Zones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10
11
12
13
Storm Rainfall
Less than 1 in
1-3 in
3-6 in
6-9 in
9-12 in
12-24 in
CGMG Blue Mountain Coffee Region Project
Gustav, 2008; Provisional Rain Total and Met Zones