GSA DR item **2013353** accompanies Herrick, J.A., Siebert, L., and Rose, W.I., 2013, Large-volume Barriles and Caisán debris avalanche deposits from Volcán Barú, Panama, *in* Rose, W.I., Palma, J.L., Delgado Granados, H., and Varley, N., eds., Understanding Open-Vent Volcanism and Related Hazards: Geological Society of America Special Paper 498, p. 141–162, https://doi.org/10.1130/2013.2498(09).

Figure A1

Geologic Unit Descriptions:

Holocene

Hc

Hc – Fluvial deposits of the Río Chiriquí Viejo drainage; continental sediment dominated by well-sorted sand and rounded gravel-to-cobble clasts of reworked volcaniclastic material. Deposits overlie the volcanic debris avalanche deposits (VDAs) from Volcán Barú and spread south to reach the Pacific Ocean (Herrick, 2011). Lake sediment is found on the valley floor of Cerro Punta (Stewart, 1978) and among the Barriles hummocks near Volcán town (personal communication, Ángel Rodriguez).

Hal

Hal – Alluvial deposits of the coastal plain reaching east to Panama's boundary with Costa Rica (French and Schenk, 2004).

Hbp

Hbp – Pyroclastic flows from Volcán Barú; includes tephra, block-and-ash, and volcaniclastics on the flanks and in proximal, low-lying areas. Tephra fall deposits extended from the crater west and southwest but are not mapped separately; tephra has been found as far west as Laguna Zoncho and Laguna Santa Elena in Costa Rica (Clement and Horn, 2001; Anchukaitis and Horn, 2005). Radiocarbon ages from these deposits near Volcán Barú are as young as 316 calendar years before present (Sherrod et al., 2007).

Hbd

Hbd – Volcán Barú dome complex; three distinct domes of hornblende-rich andesite; SiO_2 52-63 wt% . This unit is confined within the 6x10 km, summit amphitheater (Sherrod et al., 2007; Herrick, 2011).

Hvda

Hvda – Barriles Deposit, Volcán Barú volcanic debris avalanche deposit. Total area: 990 sq km; maximum extent N-S: 43 km; Maximum extent E-W: 29 km.
Hummocks, >3,000 individual hummocks; Height range: 3-97 m
Deposit thickness: 1.0-38 m
Radiocarbon Ages: 8764 & 9490 calendar years before present (95.4% probability)
An agglomeritic deposit with a block and mixed facies; the dominant lithology is subround-angular, fine-grained, glassy plagioclase-phyric, hornblende-rich andesite. Contains rip-up clasts of well-sorted alluvium, clasts from the basement limestone and schist, andesitic jigsaw-fractured blocks; a substantial amount of hydrothermally-altered clasts, and mottled, very-fine-grained matrix. This deposit is often the modern surface with overlying tephra deposits proximal to Volcán Barú's edifice (Siebert et al., 2006; Sherrod et al., 2007; Herrick, 2011).

Pleistocene

Pvda

Pvda – Caisán Deposit, Volcán Barú volcanic debris avalanche deposit. Total area: 1160 sq km; maximum extent N-S: 50 km; Maximum extent E-W: 29 km.
Hummocks, >1,000 individual hummocks; Height range: 3-10 m
Deposit thickness: 3.0-90 m
Radiocarbon Ages: 45,224 calendar years before present (95.4% probability)
An agglomerate deposit with block and mixed facies; the dominant lithology is subangular, fine-grained, glassy plagioclase-phyric, hornblende-rich andesite. Contains rip-up clasts of well-sorted alluvium; clasts from the basement limestone and schist; andesitic jigsaw-fractured blocks; a substantial amount of hydrothermally altered clasts; and a mottled, very-fine-grained matrix. This deposit is often located below 0.2-3.0 m of unconsolidated sediment and thin tephra units; outcrop exposures demonstrate this unit is stratigraphically older than the Barriles Deposit (Herrick, 2011).

Pbl

Pbl – Volcaniclastics from Volcán Barú; undivided lahar units with interbedded pyroclastic flows. Without observations of contacts, age relationships could not be determined, but proximity and degree of weathering suggest these deposits are older than the volcanic debris avalanche deposits Pvda and Hvda (Herrick, 2011).

Pbe

Pbe – Volcán Barú edifice; K/Ar age 0.46 Ma±0.15 (IRHE, 1985). Undivided andesitic lavas (SiO_2 52-63 wt%), hornblende-rich, and associated pyroclastics interrupted by a major breach in the structure opening to the west. The southern contact is poorly defined due to overlapping lahar and pyroclastic flow units of Pbl (Restrepo, 1987; Siebert, 2004).

Quaternary

Qtd

Qtd – Tisingal dome complex; hornblende-rich, andesitic lavas (Restrepo, 1987). Radiometric age 1.6-0.9 Ma (UTP, 1992).

Quv

Quv – Undivided volcanics from Tisingal and potentially from Volcán Barú. Block-and-ash flows, pyroclastic flows, volcaniclastics, and tephra. Found north of the Río Chiriquí Viejo; contacts are poorly defined (Stewart, 1978; Herrick, 2011).

Qte

Qte – Tisingal edifice; hornblende-rich andesitic lava domes and flows (Stewart, 1978; Restrepo, 1987). Radiometric ages in range 1.0-0.9 Ma (UTP, 1992).

Tertiary

Tpr

Tpr – Paso Real Lahars (Pliocene to Pleistocene); Up to 900 m thick; lahars, breccias, and andesitic lava flows from the Cordillera de Talamanca (Morell et al., 2008). Age 4.3-1.2 Ma (de Boer et al., 1995); found in the north-western section of map area.

Tca

Tca – Charco Azul Group (Late Pliocene)
Subunits:
1. Armuelles Formation – Pliocene-to-Pleistocene; up to 370 m thick; shallow marine sediments with pebbly conglomerates of unconsolidated greenish-blue siltstone; and litharenite with rare beds rich in oyster shells and corals.
2. Burica Formation – Late Pliocene; up to 2,800 m thick; dominantly fine-grained volcaniclastic turbidite sediments with associated megabreccias; contains the La Chancha Member, a 2-4 m thick, auto-brecciated unit that overlies 1-2 m of basal, coarse volcanic conglomerate.
3. Peñita Formation – Early Pliocene; up to 1,200 m thick but laterally variable; shallow marine clay sediments and turbidites. The base is coarse, greenish-blue litharenite with locally channeled basal volcanic conglomerate. Also contains the La Vaca Member; up to 900 m thick, dominated by coarse, grayish-green volcanic conglomerate with large-scale crossbeds; channels, armored mud balls, and locally, large thick-shelled oysters, other bivalves, and wood.
4. Cenozoic Seamount Complex – restricted to the western shore of the Burica Peninsula (Coates et al., 1992; Buchs et al., 2009).

Tt

Tt – Térraba-Curré Formations (Oligocene-Miocene); Up to 2 km thick with an associated, unnamed marine mudstone visible only in the central northwest portions of the Fila Costeña Thrust Belt. These formations and the Eocene Brito Formation have been distinguished as fore-arc basin units (Morell et al., 2008).
1. Térraba Formation – Oligocene-Miocene; is a bioclastic/volcaniclastic turbidite sequence composed primarily of interbedded mudstone and volcaniclastic sandstone with minor black shales, marls, and conglomerates (Morell et al., 2008). Rare intrusions of 15-11 Ma gabbro (de Boer et al., 1995).
2. Curré Formation – Miocene; is a thin, coarsening upwards volcaniclastic sandstone and conglomerate (Morell et al., 2008).

Tb

Tb – Eocene; up to 1 km thick; associated with the thrust faults within the Fila Costeña Thrust Belt region; Bioclastic limestone and turbidite sequence (Morell et al., 2008) with rare intrusions of 15-11 Ma gabbros (de Boer et al., 1995).

Ti

Ti – Intrusives – coarse-grained gabbro exposed locally in the Cordillera (Stewart, 1978). These units may include: granodiorites, quartz-diorite, diorite, and gabbro (Anonymous, 1976).

TK

TK – Cretaceous-to-Paleogene – Accreted volcanic seamounts and associated marine sedimentary units; dominates Panama's interior western highlands (Buchs et al., 2009).

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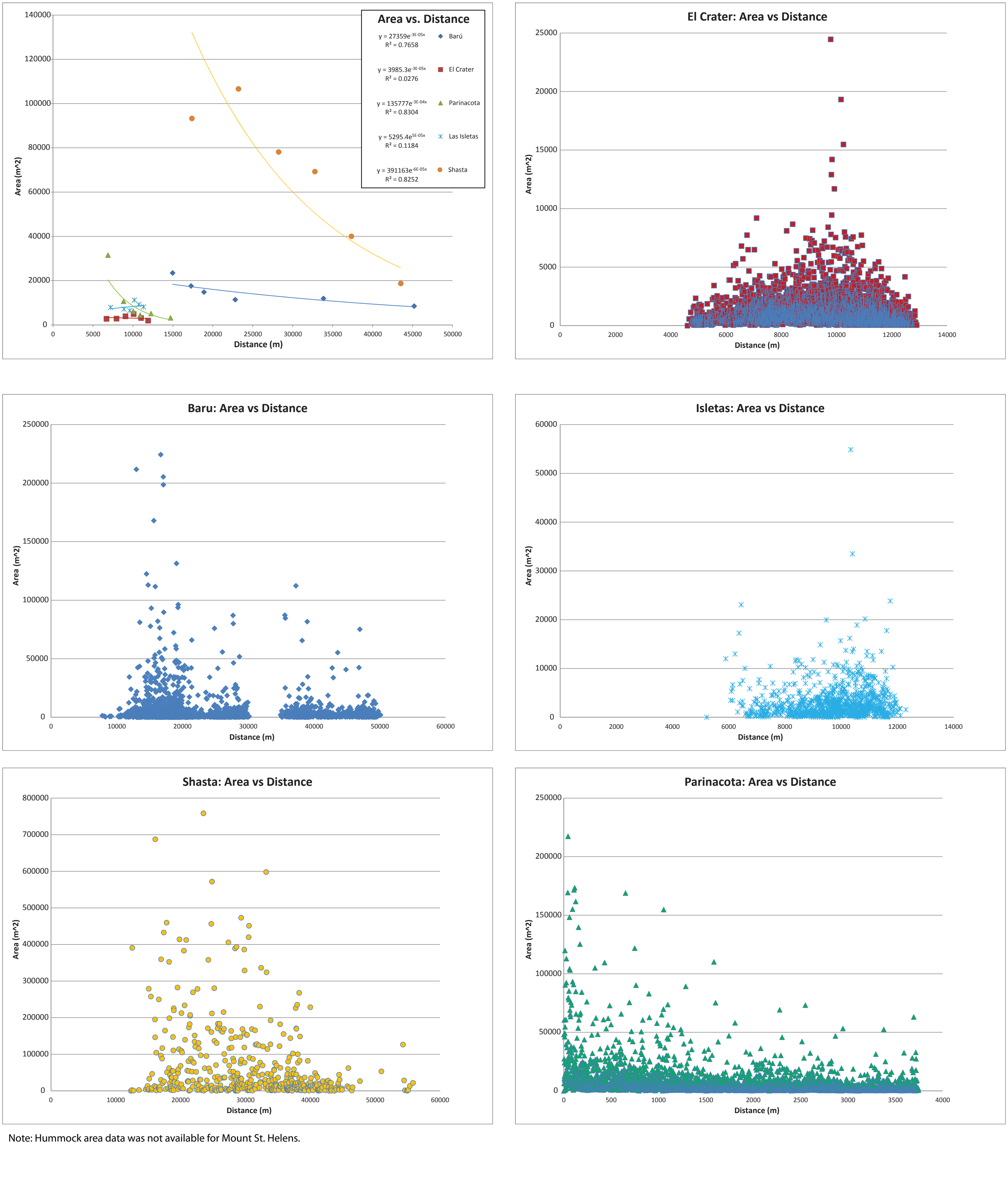
Figure A2

Hummock Distribution: Area (m^2) vs Distance (m)



Note: Hummock area data was not available for Mount St. Helens.

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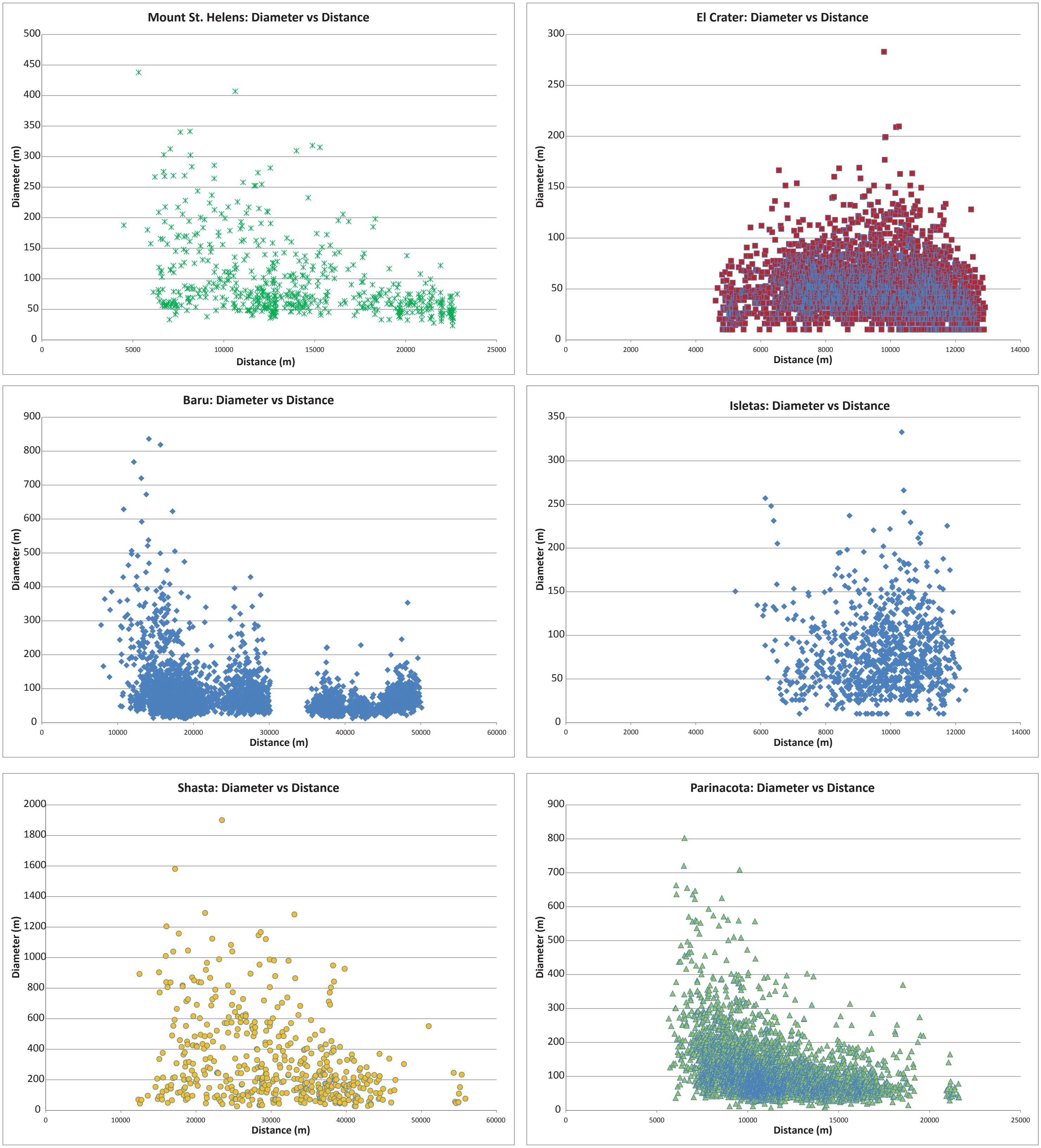
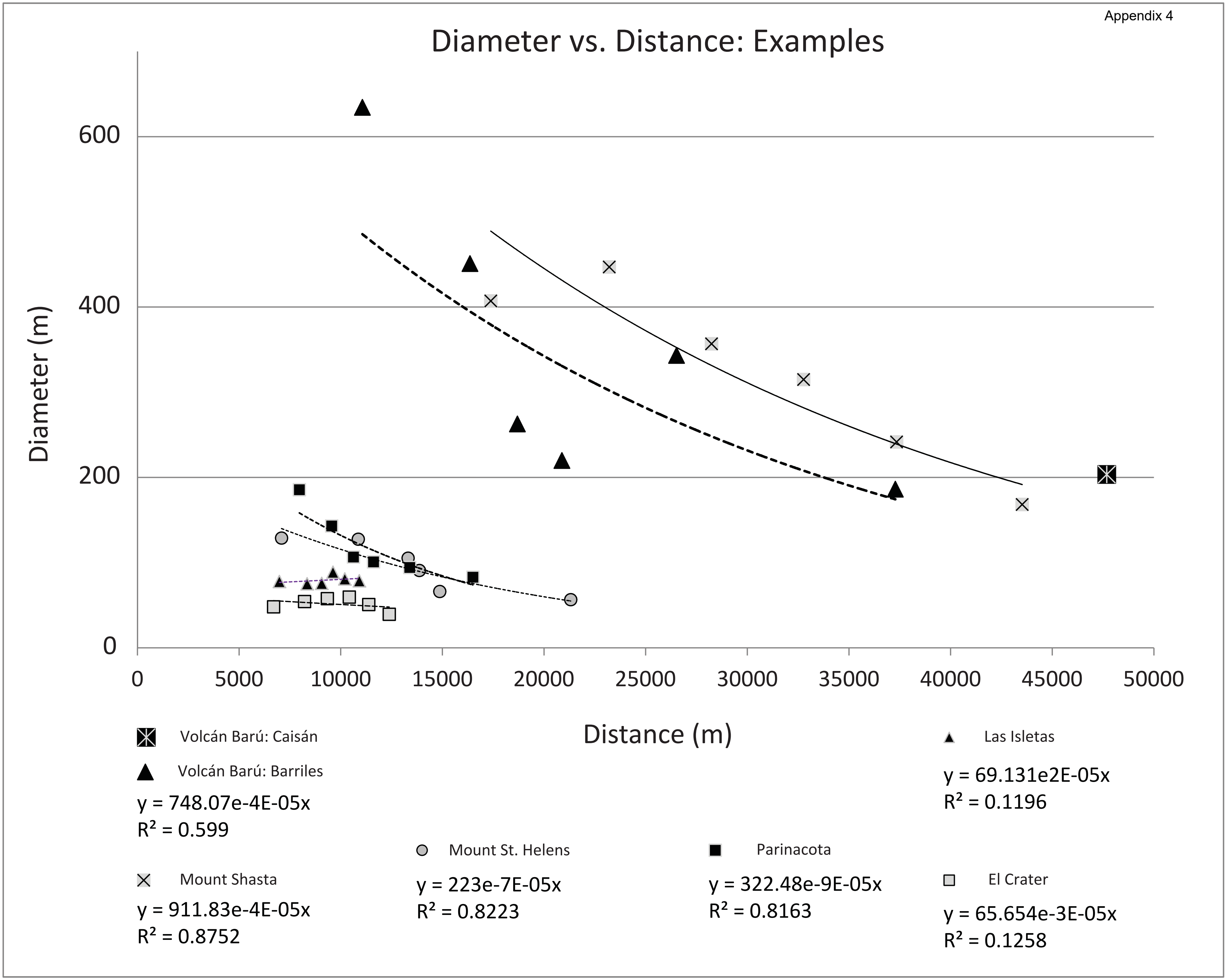
Figure A3

Hummock Distribution: Diameter (m) vs Distance (m)




Appendix 4
Diameter vs. Distance: Examples
600
400
200
0
Diameter (m)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Distance (m)
Volcán Barú: Caisán
Volcán Barú: Barriles
y = 748.07e-4E-05x
R² = 0.599
Mount Shasta
y = 911.83e-4E-05x
R² = 0.8752
Mount St. Helens
y = 223e-7E-05x
R² = 0.8223
Parinacota
y = 322.48e-9E-05x
R² = 0.8163
Las Isletas
y = 69.131e2E-05x
R² = 0.1196
El Crater
y = 65.654e-3E-05x
R² = 0.1258

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