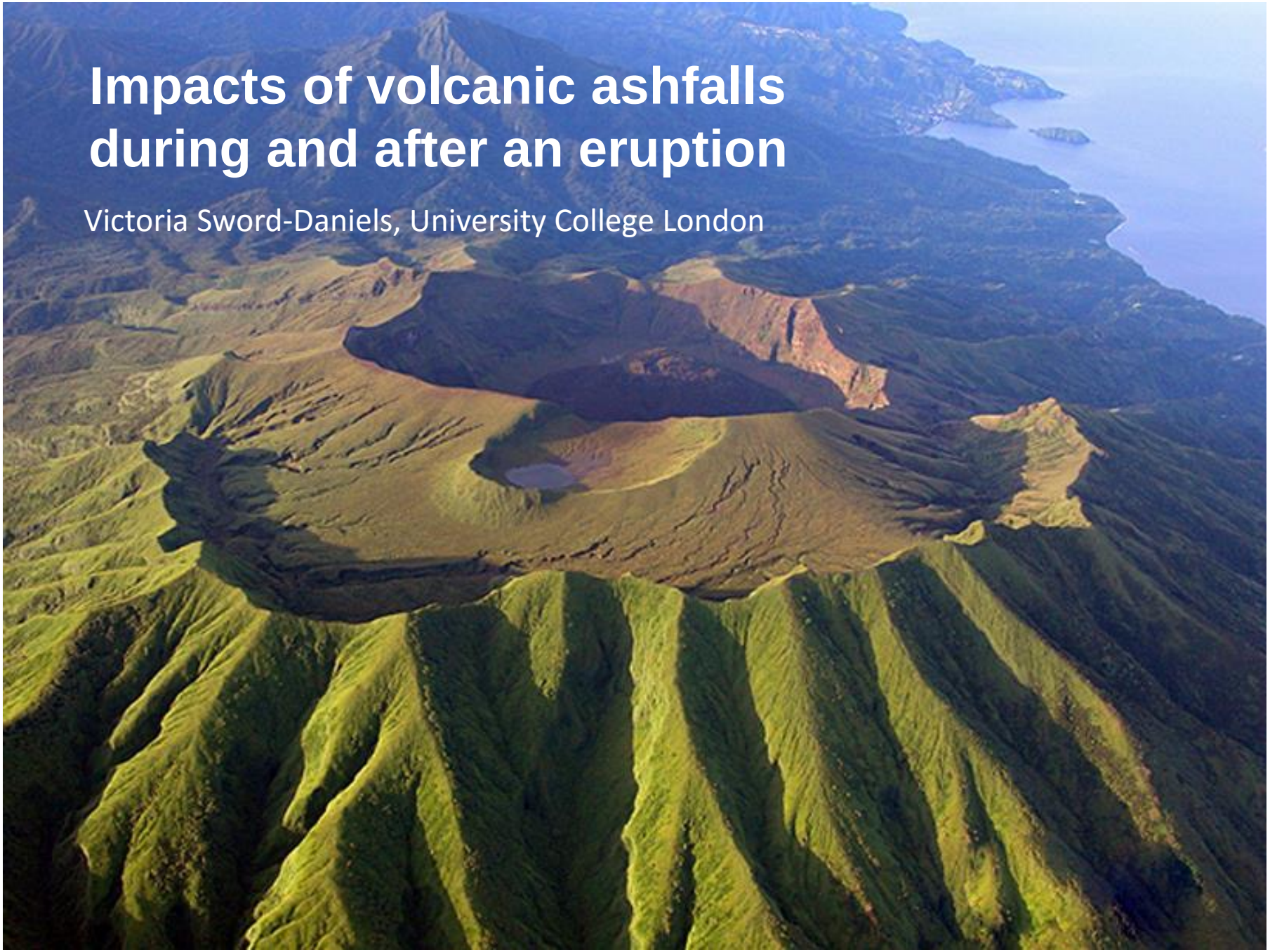
STREVA Project: Strengthening Resilience in Volcanic Areas

Image: Luke Su

Victoria Sword-Daniels, University College London

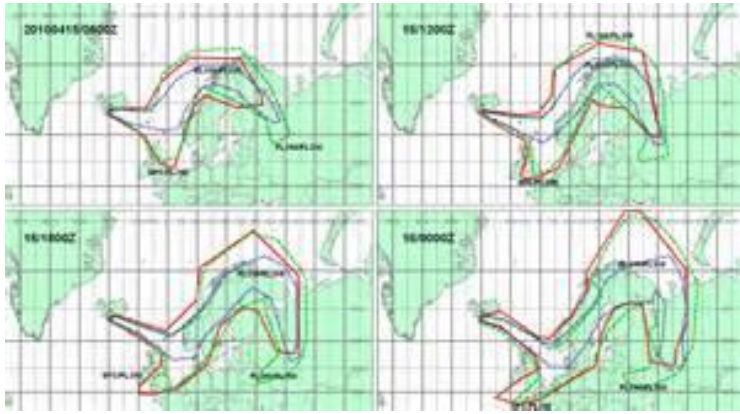


Impacts of volcanic ashfalls during and after an eruption

Victoria Sword-Daniels, University College London

International context – costs of ashfall impacts

- Eyjafjallajökull in Iceland reported airline losses of €1.5-2.5 billion
- Ruapehu, New Zealand 1995/6 Rangipo hydroelectric power station damage cost an estimated $12 million NZD in loss of power generation and $6 million NZD in replacing damaged blades
- Crop losses from Mount St Helens ash fall at $100 million in 1980



Above: Eyjafjallajökull, Iceland 2010
Below: Mt St Helens, USA 1980

Direct costs incurred from ashfalls

- Costs of damage (loading, corrosion, blockages)
  - Structures
  - Equipment
  - Mechanical parts
- Agricultural crop or livestock losses
- Airport disruption
- Tourism industry disruption
- Costs of emergency response and clean-up
- Many losses are unquantifiable

Structure

Ashfall thicknesses in 1979, 1902

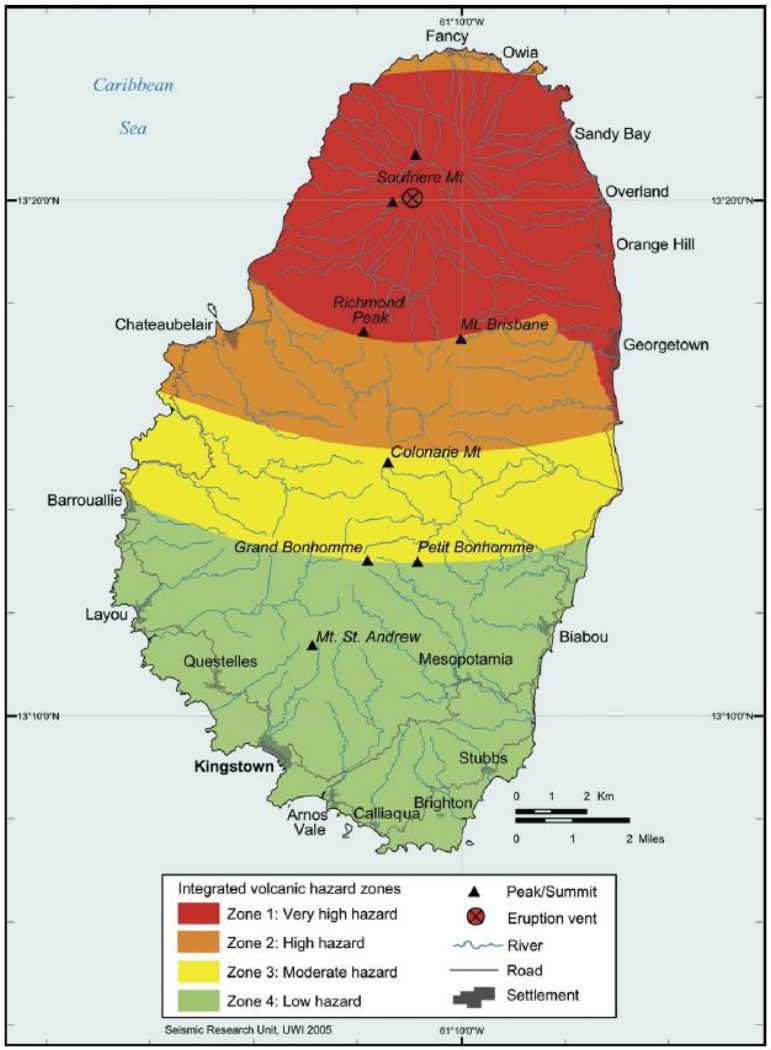
Infrastructure in St Vincent

Ash impacts during an eruption

- Visibility, road and driving conditions, public health effects

Ash impacts after an eruption

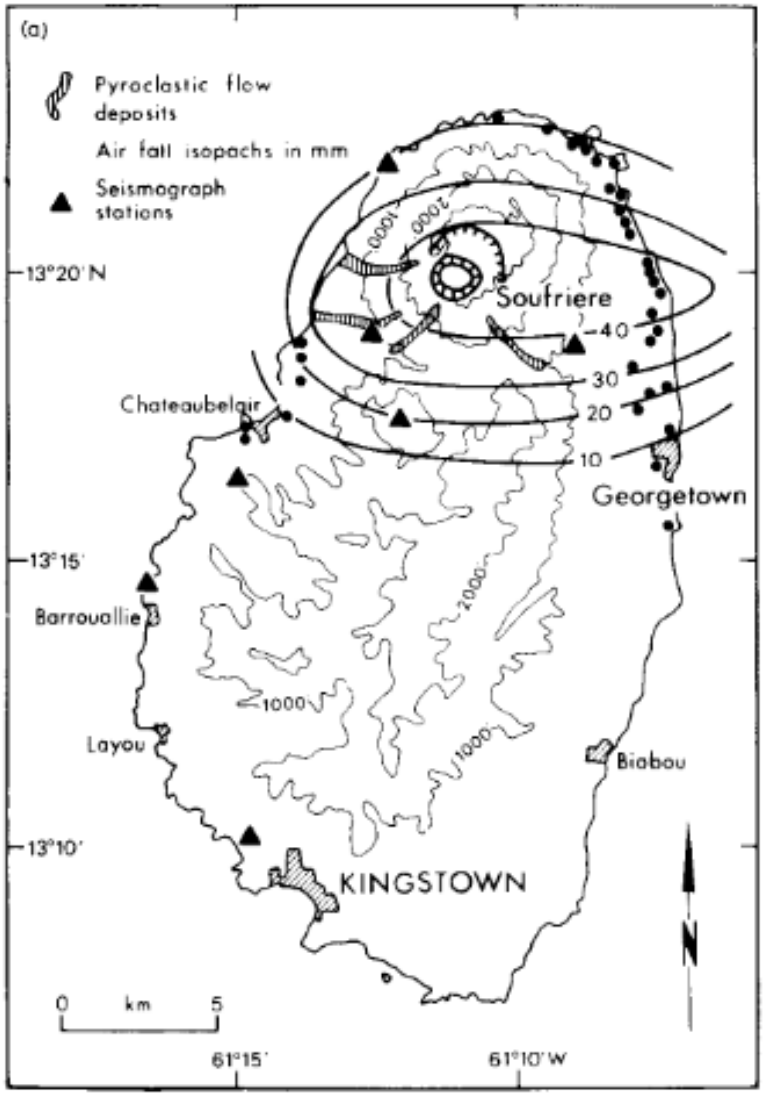
- Vegetation and agriculture
- Water supply and contamination
- Infrastructure



St Vincent integrated volcanic hazard map Robertson (2005)

Ashfall thicknesses

1979

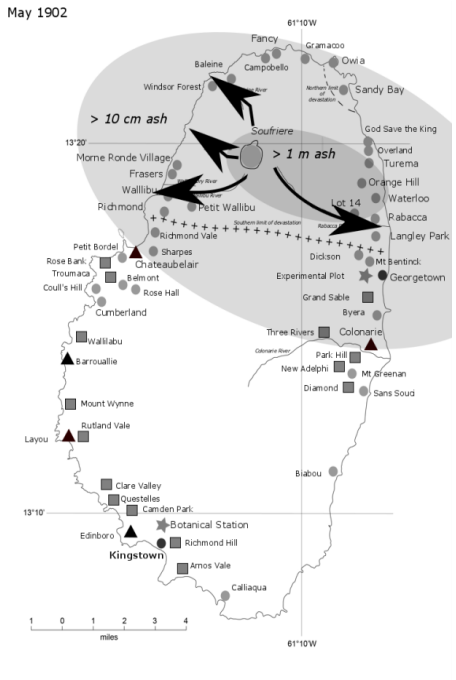


Brazier et al., 1982

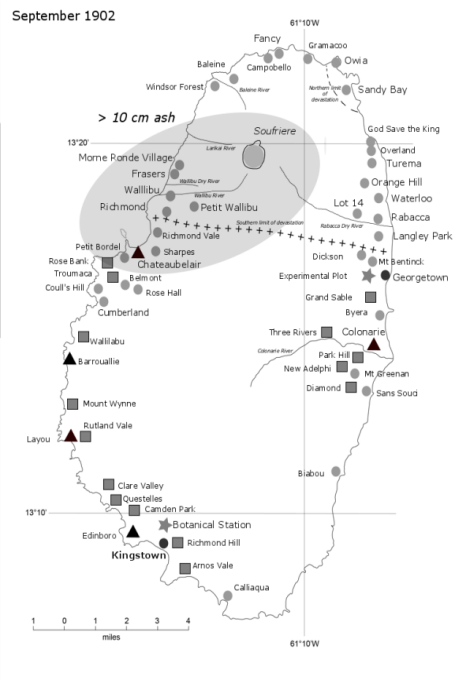
1902

Sugden, 2015

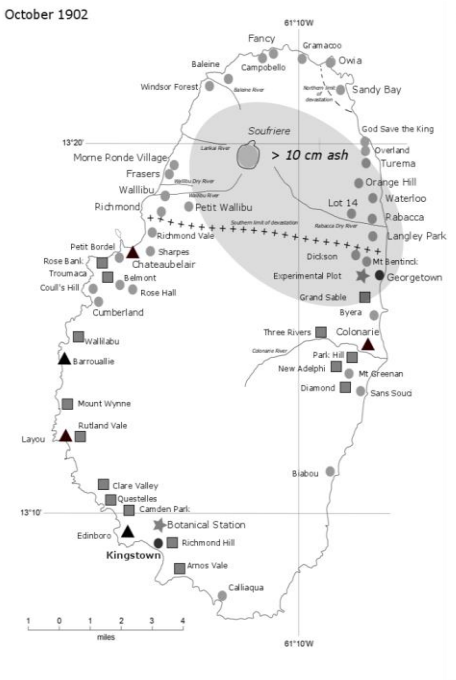
Illustration of variability from differing prevailing wind conditions



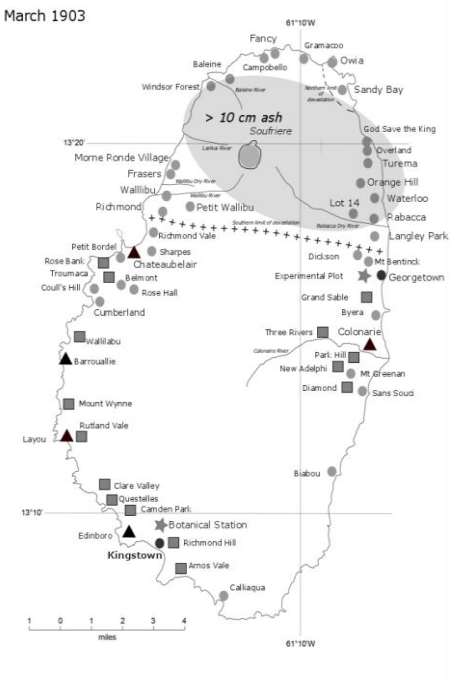
May 1902



Sept.1902

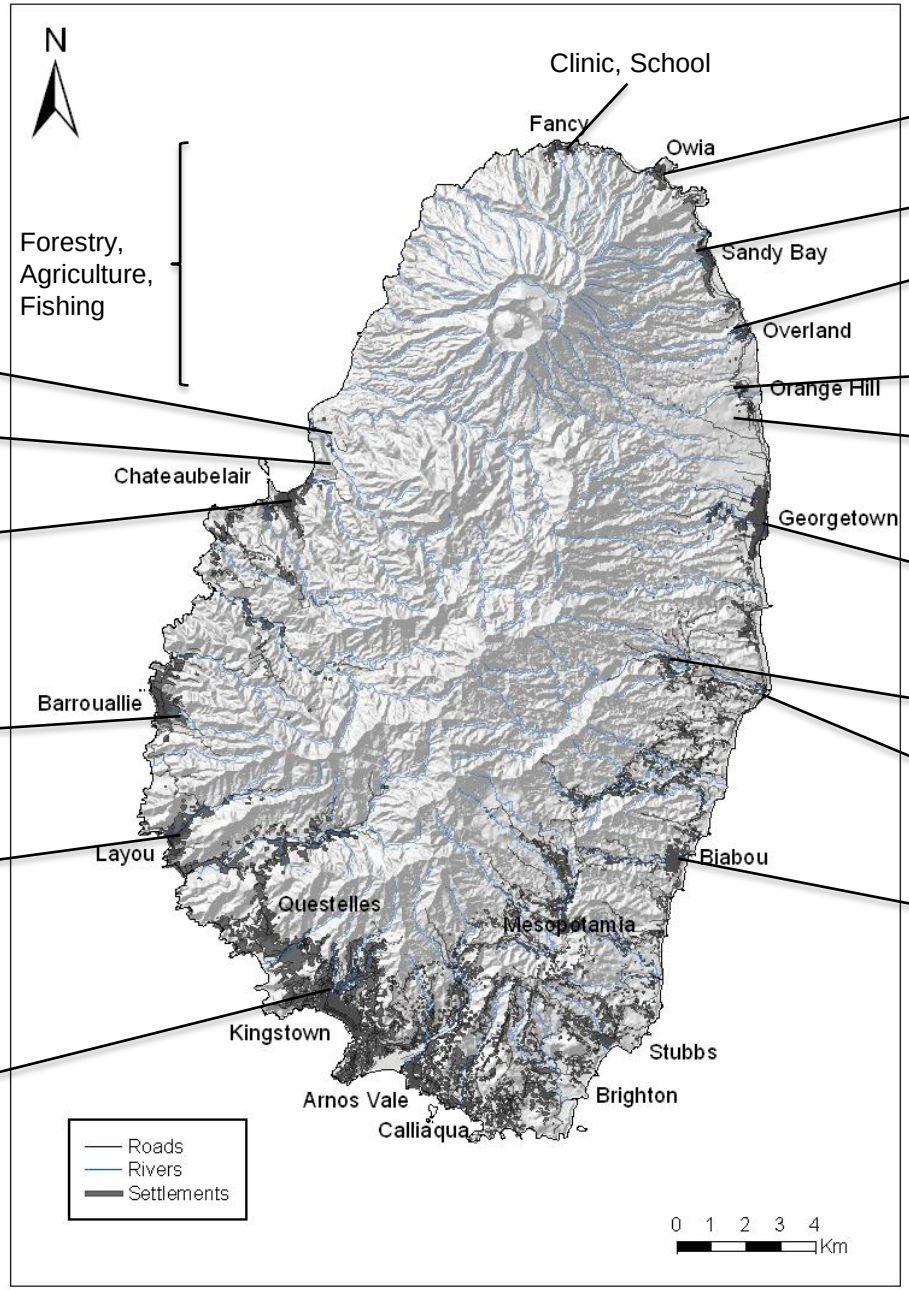


Oct. 1902



Mar. 1903

Infrastructure in St Vincent today



Fishing Complex, Clinic, Primary School, Salt Pond Development

Clinic, Primary & Secondary School
Primary School

Banana Boxing Plant

Copra Factory, domestic water supply, Horticulture R&D Complex
Banana Boxing Plant

Hydroelectric Power Station, School

Hospital, Clinic, Methodist School

Hospital, St Benedict's Children's Home, Factory, Secondary School, special needs school, water pipelines, Georgetown Technical Institute

Hydroelectric Power Station, Clinic, School

Clinic, School

Arrowroot Factory, Coconut packing plant, Clinic, School

Petrol Station, School

New Airport (planned)

Airport, Hospital, Port, Schools, Botanic Gardens, Factory
Power Station (Lowman's Bay, Arnos Vale)

SRC Map, 2015

Ash impacts during an eruption

Eyjafjallajokull 17th April 2010

>1mm ash

1979	South Rivers, Colonaire Vale and areas south (Barrouallie, Layou)	Hydroelectric power station, factories, clinics, schools
1902	The South (incl. Kingstown, Biabou)	Airport, port, hospital, power station, botanic gardens

- Minor traffic hazards due to covering road markings, loss of traction and reduced visibility
  - Affected by wind and remobilisation – e.g. driving
  - Disruptions to traffic networks restricts emergency services
  - After an eruption – visibility remains an issue until the next rainfall or until ash is cleaned-up from roads, roofs, trees…
- Communications networks overloaded due to high demand (mobile and landline)
- Ash clean-up operations create high demand for water
- Eye, nose, throat, acute respiratory symptoms, mental health
  - People with pre-existing conditions are more likely to be affected
  - Effects can continue until rainfall or until organised clean-up of ash
  - May be greater demand for nebulisers and counselling

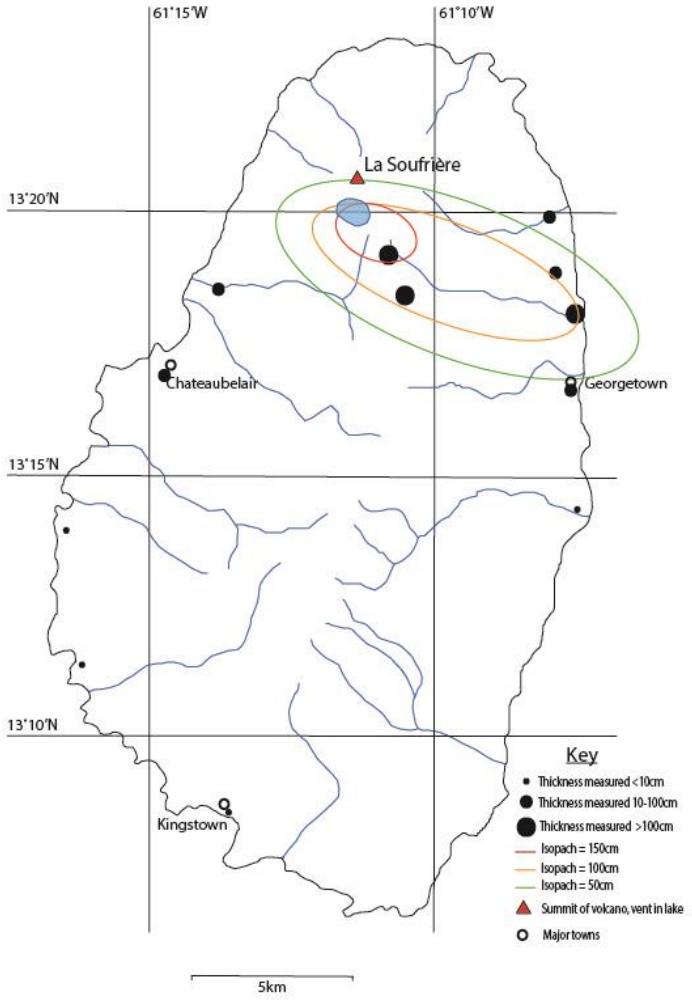
Ashfalls in 1902

1902	The South (incl. Kingstown, Biabou)	Airport, port, hospital, power station, botanic gardens

- 1902 - light ash fall during evening 6th May and morning (pre-climatic phase)
- From noon until 4pm 7th May high intensity ash fall – in Kingstown lamps needed to be lit at 4pm

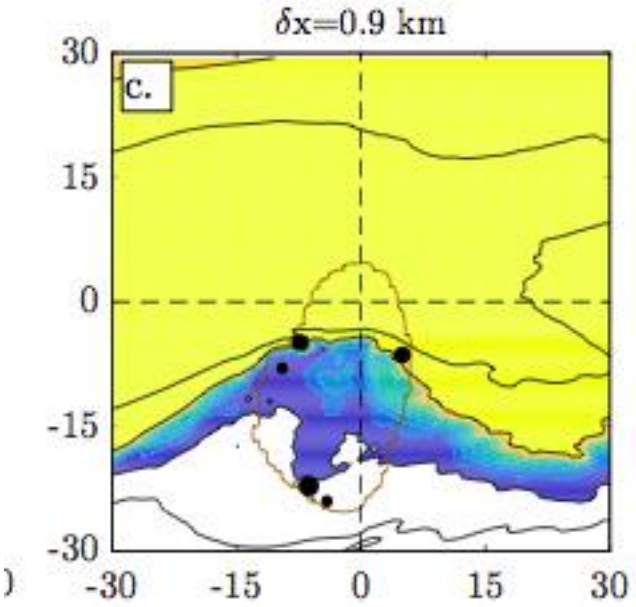
- In Barbados, if sounds taken as height of eruption
  + 2 hours becoming gloomy
  +2.75 hours first fall
  +4.5 hours ‘quite heavy’
- 170 km away but still received cms of ash!

More anomalies: 1902 Ash Fall on Barbados



Note that template map sourced from: http://www.sogival.com/en/destination/58

May 7, 1902 : Patrick Sugden MSci Thesis : actual data



Modelled ash output – shows some fall expected in Kingstown, as observed

Impacts of ashfall after an eruption

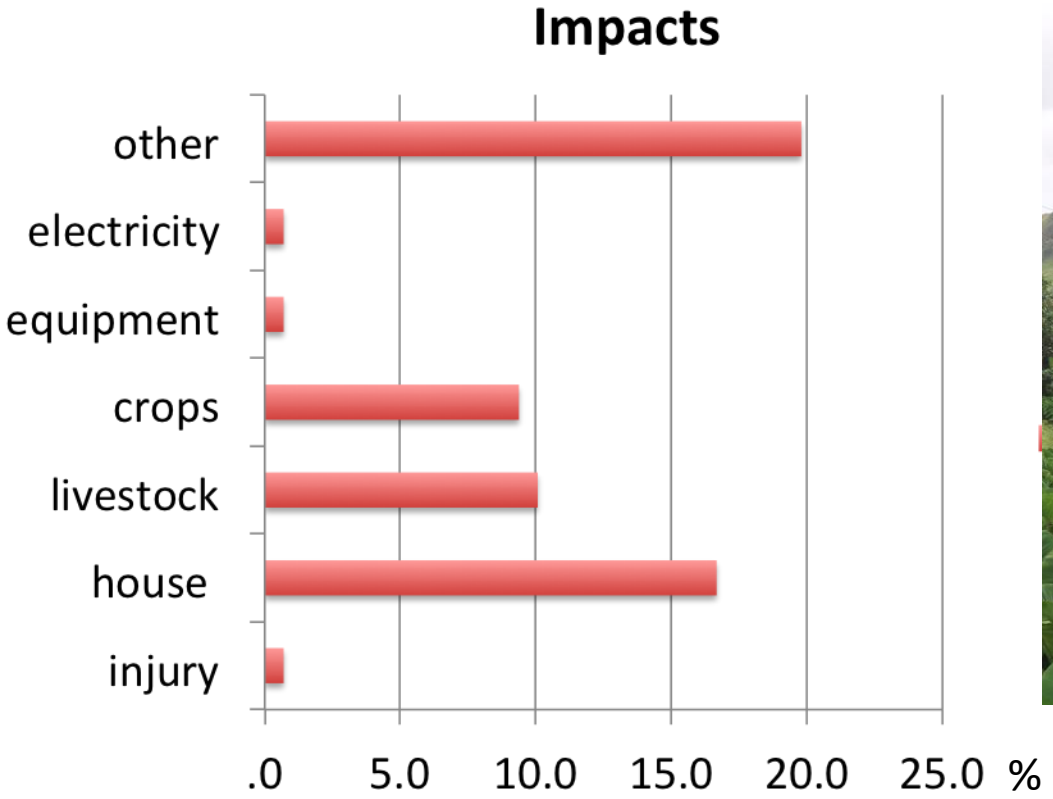
Montserrat

>10mm ash

1979	**Owia, Old Sandy Bay, Georgetown, Chateaubelair, Richmond Vale, Richmond**	**Hospitals, hydroelectric power station, Owia Fishing complex, factories, clinics, schools, Forestry, agriculture, livestock**
1902	Kingstown, Biabou	Airport, port, hospital, power station, botanic gardens

- A few mm ash can reduce photosynthesis (covering leaves)
- Acid rain can burn vegetation, leave brown spots on leave and in extreme cases can strip leaves from plants
  - During an eruption, and effects last until ash is washed off, or turned into soil
- Ingestion by livestock abrades teeth and can cause diarrhoea and fatigue (Mt Hudson, Chile 1991)
- Impacts depend on growing season, type of crop and amount of uncontaminated feed for animals
  - In 1979 released animals caused damage to agriculture and posed dangers to people. Coconut trees were killed, arrowroot and banana crops were affected

1979 – Impacts – Ash was important

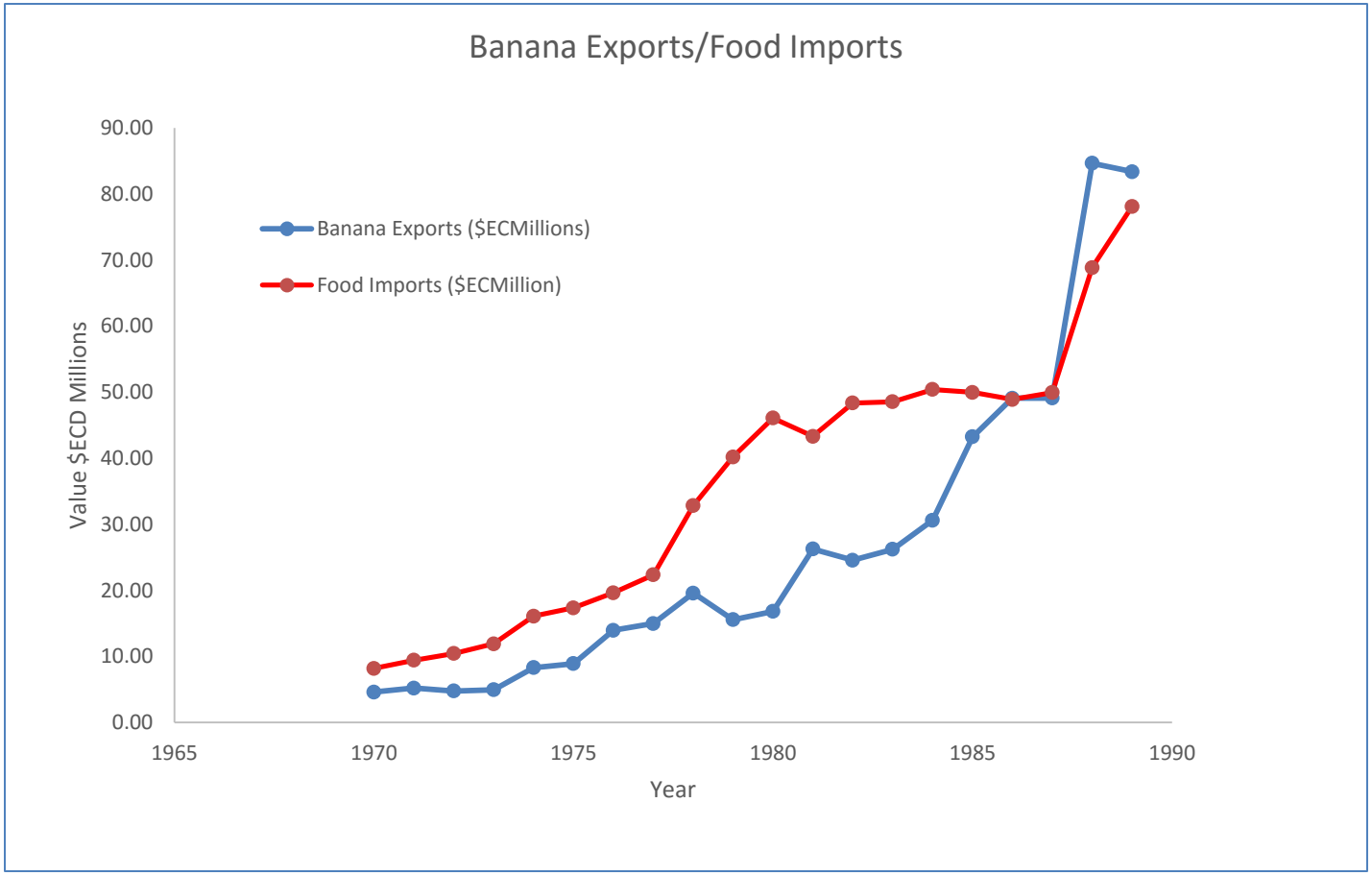


Teresa Armijos

Compare: self-reported house impacts of 20% in 2013 floods and 39% Hurricane Tomas

Larger scale infrastructure damage esp. shelters

Banana Exports/Imports



Grossman, 1993

>10mm ash

1979	**Owia, Old Sandy Bay, Georgetown, Chateaubelair, Richmond Vale, Richmond**	**Hospitals, hydroelectric power station, Owia Fishing complex, factories, clinics, schools, Forestry, agriculture, livestock**
1902	Kingstown, Biabou	Airport, port, hospital, power station, botanic gardens

- Ash reduces water infiltration & increases surface albedo
  - Longer term effect, depending how much ash has fallen
- Increase in turbidity in water supplies from suspended ash
  - May interfere with disinfection treatment (inhibiting the detection of bacteria)
  - Ash can remain in suspension for days to weeks
- May increase water acidity and alter soluble mineral chemistry
  - Water is likely to become unpalatable due to discolouration or metallic taste before becoming a health hazard
- Ash may cause clogging of water and irrigation networks
  - Effects continue until ash is washed from catchment and/or manually cleared from water reservoirs and systems

>10mm ash

1979	**Owia, Old Sandy Bay, Georgetown, Chateaubelair, Richmond Vale, Richmond**	**Hospitals, hydroelectric power station, Owia Fishing complex, factories, clinics, schools, Forestry, agriculture, livestock**
1902	Kingstown, Biabou	Airport, port, hospital, power station, botanic gardens

- Ash ingress in open water systems and through sewer pipes
  - Risk of damage to wastewater treatment plants if ash enters sewers
- Ash is abrasive - wear and tear on moving parts (e.g. pump components) and damage to equipment
  - During an eruption and risk of damage may prevail for days/weeks as ash is washed into the system from the catchment
- Blockages in pre-treatment equipment and intakes at water processing plants, and overflows in sewerage networks
  - Effects can last until systems are unblocked manually
- May increase the volume of sludge for disposal

>10mm ash

1979	**Owia, Old Sandy Bay, Georgetown, Chateaubelair, Richmond Vale, Richmond**	**Hospitals, hydroelectric power station, Owia Fishing complex, factories, clinics, schools, Forestry, agriculture, livestock**
1902	Kingstown, Biabou	Airport, port, hospital, power station, botanic gardens

- Overhead power line breakages (weight of ash)
- Possible electrical flashover (if ash is wet) – power cuts
  - During eruption or afterwards if there is rainfall after eruption (increases conductivity)
- Hydroelectric power stations – ash suspended in intake water can cause wear of turbines
- Fine ash can block filters and air intakes in air conditioning systems
  - Continues to be problematic until ash is washed/cleared from atmosphere and surroundings

>10mm ash

1979	**Owia, Old Sandy Bay, Georgetown, Chateaubelair, Richmond Vale, Richmond**	**Hospitals, hydroelectric power station, Owia Fishing complex, factories, clinics, schools, Forestry, agriculture, livestock**
1902	Kingstown, Biabou	Airport, port, hospital, power station, botanic gardens

- Corrosion of air conditioning systems
- Corrosion of roofing materials (e.g. galvanised steel)
  - In 1979 those who washed ash from roofs suffered reduced damage due to corrosion
- Clinic closures due to ashfall contamination
- Hospitals/Clinics - challenges in performing sterile dressings
- Hospital supplies affected by disrupted transportation (air, road)
- Increased demand at Hospitals/Clinics from clients for nebulisers and counselling services

>30mm ash

1979	Orange Hill, Waterloo. Rabacca, New Sandy Bay Village, Wallibou	Horticulture Research and Development Complex, factories, clinics, schools, forestry, agriculture, livestock
1902	Central/south	

- Severe traffic hazards likely
- Gutter and storm drain blockages – erosion and gulley's form
- Severe damage to wastewater treatment plants if ash enters sewers
- Collapse and crushing of plants & crops
- Household gutters can become blocked and cause them to break under loading

>100mm ash

1979	Possible very close to vent?	Forestry, agriculture, livestock
1902	Wallibou, Richmond, Richmond Vale, Chateaubelair, Fancy, Owia, Sandy Bay, Overland, Georgetown, South Rivers, Colonaire Vale	Hospitals, hydroelectric power stations, Owia Fishing complex, Horticulture Research and Development Complex, factories, clinics, schools, forestry, agriculture, livestock

- >100mm ash may create heavy loading on structures
  - Long span, low pitched roofs are most vulnerable
  - Collapse during eruption or shortly afterwards if ash is not cleared up quickly, increased loading if it rains before roofs are cleared of ash
- If ash is wet, static loads increase by up to 100%
- Building styles, materials, age and condition are important factors in live load bearing capacity
  - St Vincent structures: 71% Concrete, 19% wooden (2001 Census); mainly pitched roofs (Lowe, 2010)
  - Concrete roofs withstand greater loads, but may increase risk to earthquake ground shaking if building codes are not enforced/adhered to

>100mm ash

1979	Possible very close to vent?	Forestry, agriculture, livestock
1902	Wallibou, Richmond, Richmond Vale. Chateaubelair, Fancy, Owia, Sandy Bay, Overland, Georgetown, South Rivers, Colonaire Vale	Hospitals, hydroelectric power stations, Owia Fishing complex, Horticulture Research and Development Complex, factories, clinics, schools, forestry, agriculture, livestock

- Roads impassable when wet (>50mm)
- Severe damage to waste water treatment plants if ash enters sewers
- Collapse and crushing of plants & crops
- Severe damage to agriculture, livestock losses possible

>1000mm ash

1979	N/A	N/A
1902	Orange Hill, Waterloo	Horticulture Research and Development Complex, factories, forestry, agriculture, livestock

- Roads impassable and driving conditions very dangerous
- Very severe damage to waste water treatment plants if ash enters sewers
- Long-term damage to agriculture
  - >150mm crop survival is likely to be extremely limited
- Collapse of many structures
  - Variable observed thicknesses of ash induce collapse: 75-300mm
  - In Georgetown the May 7^{th} > 150mm ash
- Collapse of may overhead power lines
  - Long-term power outages

Other critical issues

- Balancing work and home life and responsibilities
  - E.g. In Montserrat, collecting children and ensuring family safety
- Interdependence between impacts and affected infrastructure sectors
  - For example, power cuts affect critical infrastructure function, communications networks, air conditioning units (that cool computer systems and reduce ash ingress), and can damage equipment in power surges when power is restored
- Collaboration and defining responsibilities can reduce impacts or duration of impacts
- Need to plan ahead for hazards – emergency management and clean-up of ashfalls

Summary of impacts based on 1979 eruption

	Impacts	Locations affected
>1mm	Visibility and traction affect roads, public health effects, ash blockages in water and waste water	South Rivers, and the south (Biabou, Kingstown)
>10mm	Significant traffic hazards; gutter and storm drain blockages; damage to wastewater treatment plants if ash enters sewers; overhead power line breakages; possible electrical flashover	Windward: Owia, Old Sand Bay, Georgetown Leeward: Richmond, Richmond Vale, Chateaubelair
>30mm	Severe traffic hazards; gutter and storm drain blockages; severe damage to wastewater treatment plants if ash enters sewers	Windward: Orange Hill, Waterloo, Rabacca, New Sandy Bay Village Leeward: Wallibou
>50mm	Roads impassable if wet, agriculture severely affected; moderate to heavy loading of roofs; electrical flashover	Windward: Overland

Summary of impacts based on 1902 eruption

	Impacts	**Locations affected**
>10mm	Significant traffic hazards; gutter and storm drain blockages; damage to wastewater treatment plants if ash enters sewers; overhead power line breakages; electrical flashover	Biabou, Kingstown
>100mm	Severe agricultural damage; severe damage to wastewater treatment plants if ash enters sewers; heavy loading of roofs and some structural collapse	Leeward: Wallibou, Richmond, Richmond Vale, Chateaubelair Windward: Fancy, Owia, Sandy Bay, Overland, Georgetown, South Rivers, Colonaire Vale
>1000mm	Long terms effects on agriculture; collapse of many structures	Windward: Orange Hill, Waterloo

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