Experimental exposures of native plants of the Goro region to SO_2

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Structure of this presentation

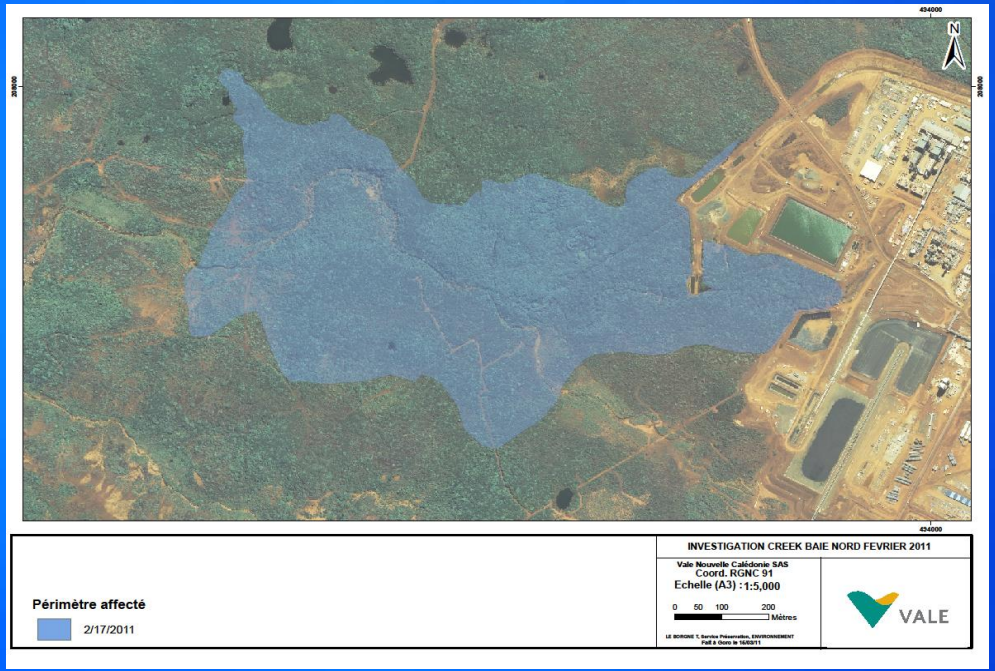
1. **What is the issue?**
2. **Why?**
3. **How?**
4. **What was found so far?**
5. **What it means**

What is the issue?

Vale Nouvelle-Calédonie observed a decline in the condition of several native species, especially *Arillastrum gummiferum*, le chêne gomme, in December 2010.

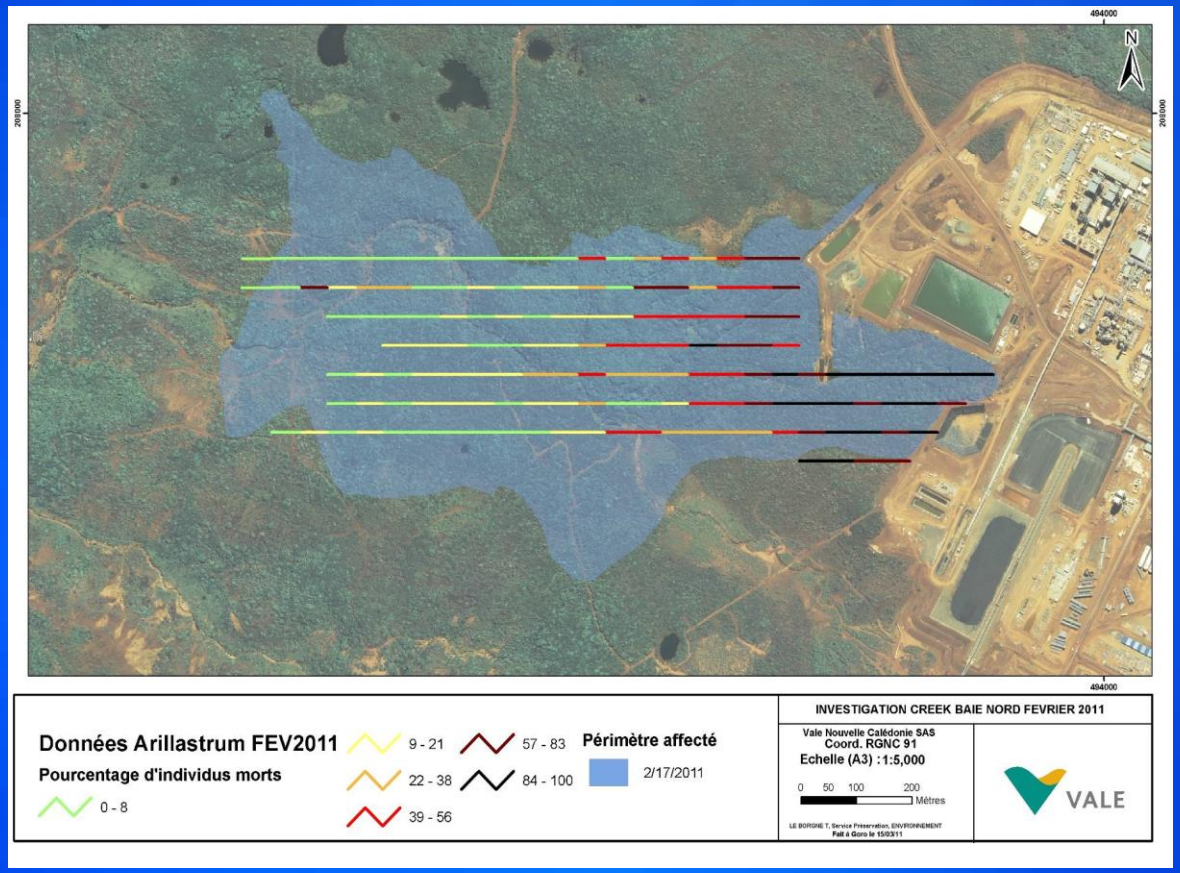
What is the issue?

Forest decline especially in *Arillastrum gummiferum*, le chêne gomme, in an area to the west of the Goro industrial facility in December 2010 led to Vale to begin several investigations to identify the likely cause or causes.



What is the issue?

Numerous possible causes were investigated.



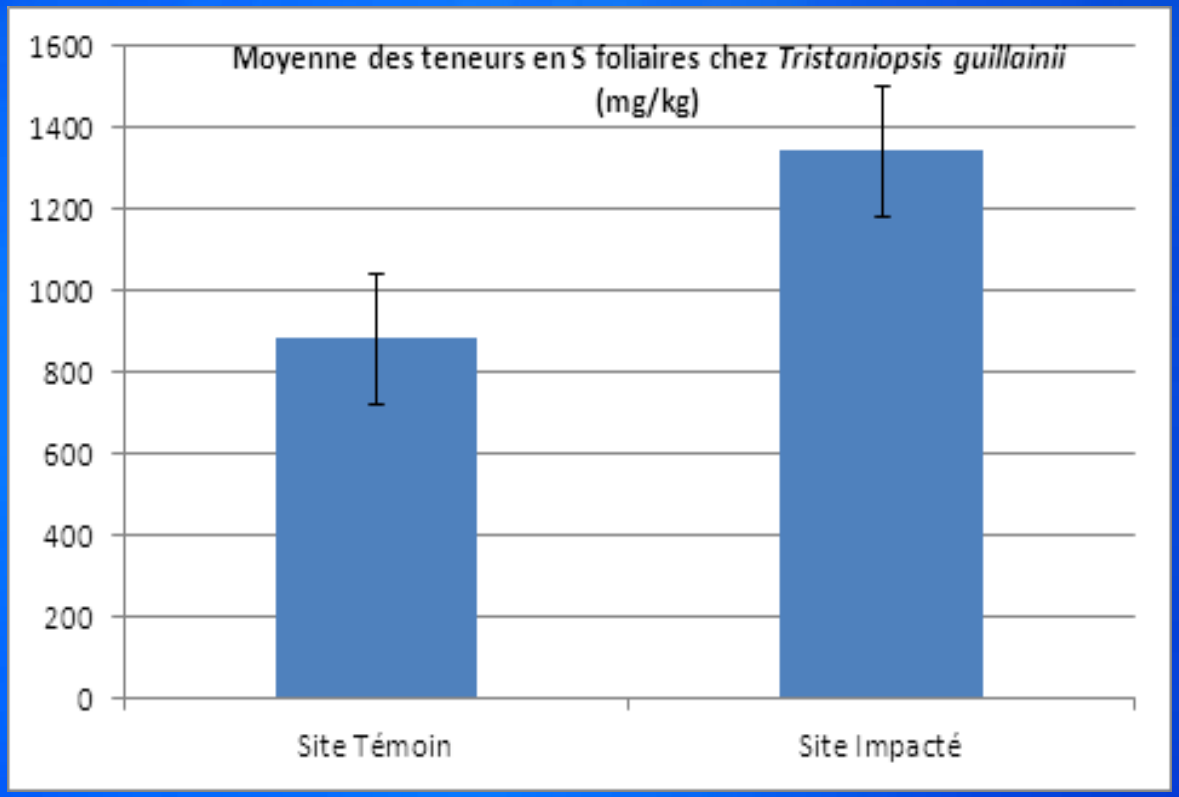
The percentage of dead trees along selected transects within the affected area

Evidence linking the forest decline to SO_2

The symptoms on vegetation were consistent with SO_2 symptoms

Some evidence linking the forest decline to SO_2

The sulphur concentrations in leaves in the forest decline area were 50% higher than normal



Some evidence linking the forest decline to acute exposure to SO_2

Concentrations of SO_2 at the mobile air quality monitoring station to the West of the sulphur stockpile on 18 November 2011 during a sulphur stockpile fire. The maximum recorded hourly average concentration was 7687 µg/m³.

Time	SO_2 (µg/m³)
13:30	53
13:45	6 181
14:00	20 524
14:15	3 912
14:30	132
14:45	62
15:00	36

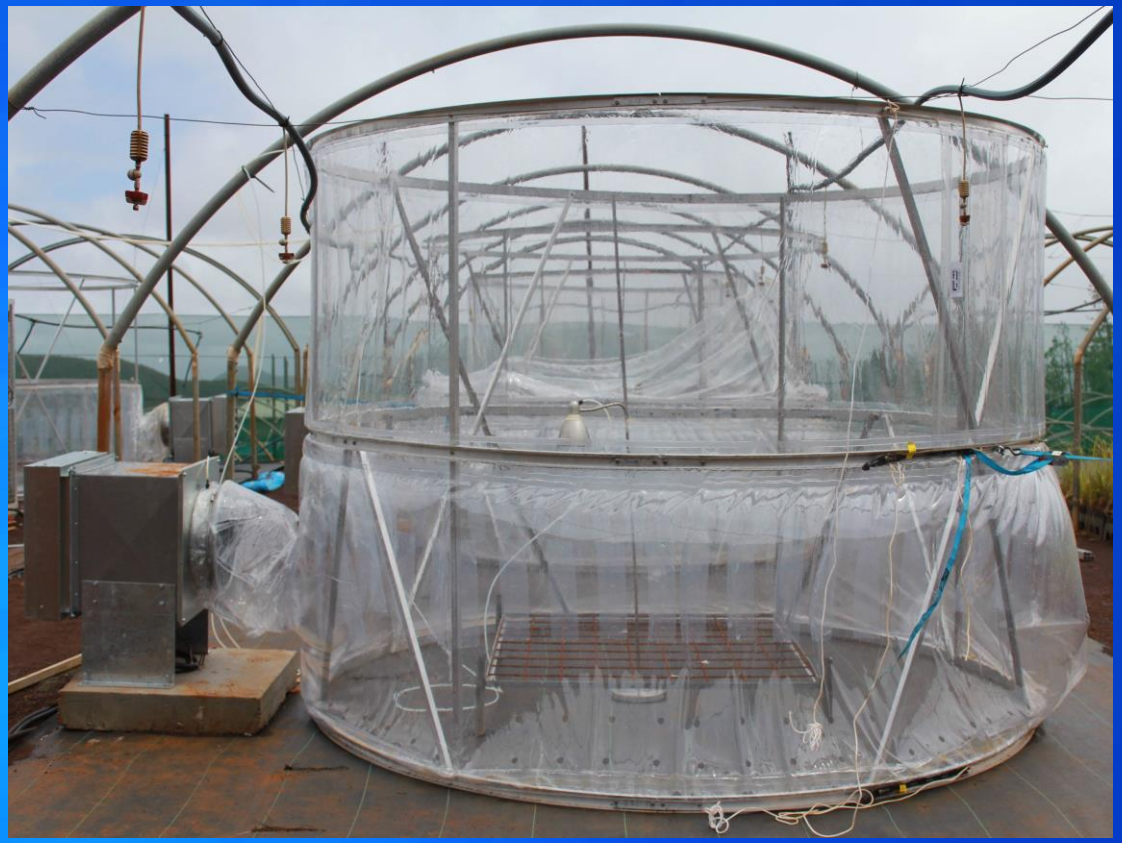
Objective

The purpose of this study is to assess the dose-response relationships for native species and characterise the symptoms of injury caused by acute exposure to sulphur dioxide (SO_2).

How?

This study screened selected species from an area impacted by SO_2.

It used open-top fumigation chambers to provide realistic, near-ambient field conditions.



SO_2 measurement

SO_2 from a gas cylinder was released in in accurately known concentrations into the chambers.

SO_2 was measured in 10 chambers in sequence.

Species selected for fumigation

Species	Exposure
Alphitonia neo-caledonica	1, 2, 3 & 4
Agathus lonceolata	4
Araucaria nemarosa	3 & 4
Arillastrum gummiferum	1, 2, 3 & 4
Deplanchea speciosa	1&2
Flindersia fournierii	1, 2 & 3
Grevillea exul rubiginosa	1, 2, 3 & 4
Gymnostoma deplancheanum	1, 2, 3 & 4
Planchonella wakere	1, 2 & 3
Syzygium macranthum	4

Regulatory limits

- The thresholds in New Caledonia are from studies in other countries.
- The SO_2 regulatory threshold limits in NC for the health of vegetation are a maximum of 1 hour at 570 µg/m^3 (218 ppb). For 24 hours the limit is 230 µg/m^3 (88 ppb).

Exposure conditions

Plants were exposed to SO_2 in 10 open-top chambers, using five concentrations each duplicated.

Exposure	Duration hours/day	Days/week	Number of fumigation days	Dates
1	2	4	10	10 Dec 13 – 6 Jan 14
2	2	4	11	30 Sept 14 – 17 Oct 14
3	2	4	23	13 Nov 14 – 24 Dec 14
4	2	4	80	2 Jul 15 – 4 Dec 15

Mean concentrations of SO_2 in chambers during the 2 hour fumigation period

Chamber number	Exposure 1	Exposure 2	Exposure 3	Exposure 4
	Mean SO_2 concentration (ppb) during fumigations			
4 & 7	46	33	54	37
1 & 2	150	267	488	389
3 & 5	233	604	833	622
6 & 8	422	1036	1215	1092
9 & 10	714	1376	1466	1381

A NC Regulatory Limit for SO2 is 218 ppb for 1 hour

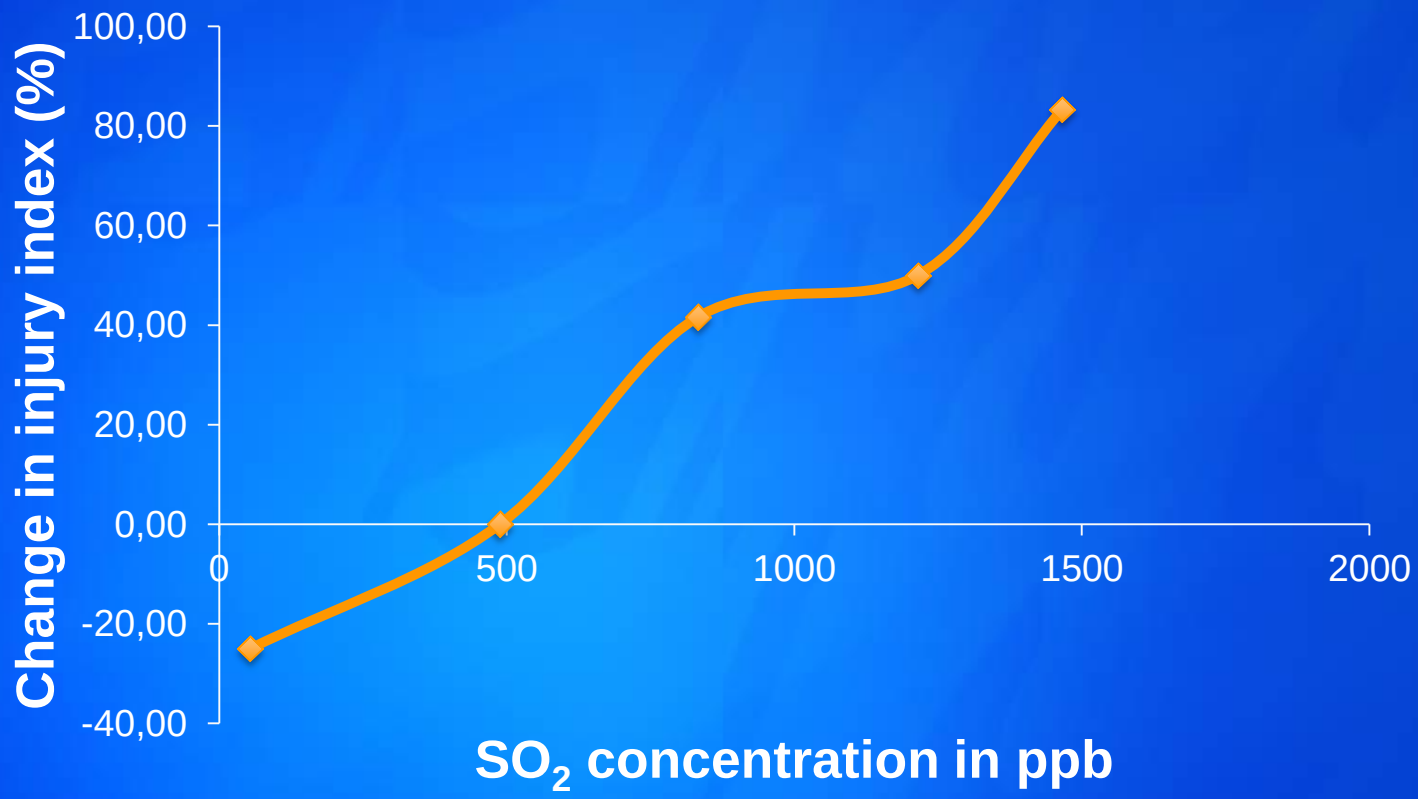
What was found so far

Arillastrum gummiferum

Exposure to SO_2 increased visible acute injury to leaves

Arillastrum gummiferum

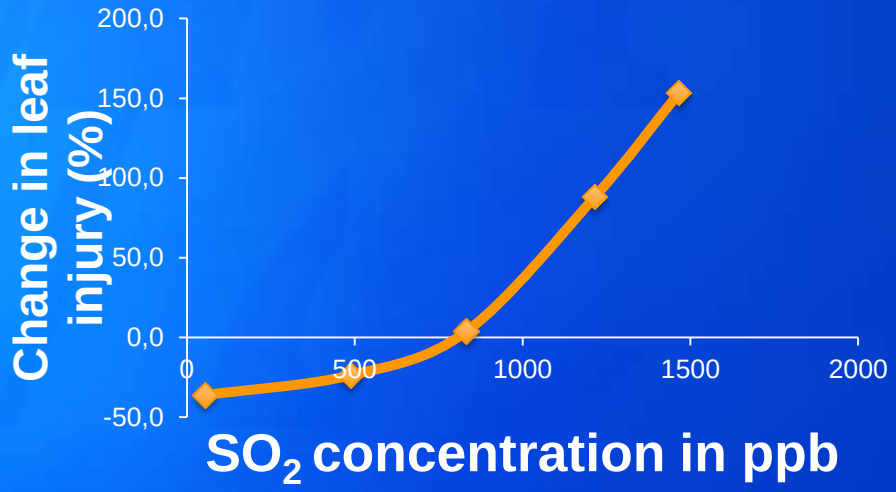
Exposure to SO_2 increased visible acute injury.



Alphitonia neocaledonica

- There were acute leaf injury symptoms of intercostal necrosis and chlorosis.

- Exposure to SO_2 increased leaf injury and decreasing plant fresh weight mainly by decreasing root weight.

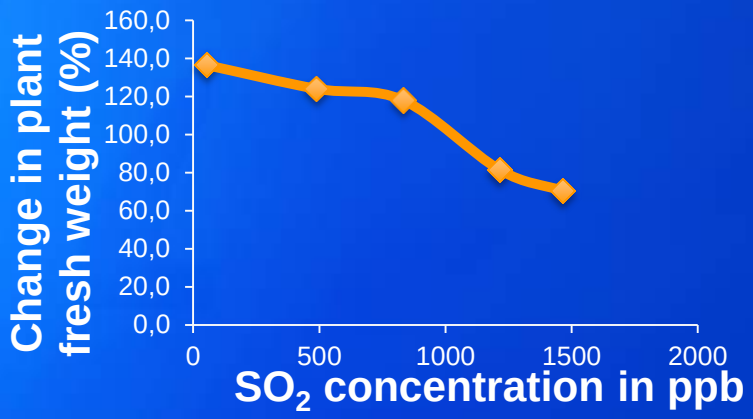


Araucaria nemarosa

Plants showed some bronzing and yellowing of needles in all treatments when exposed to 833 ppb or higher concentrations.

Exposure to SO_2 increased leaf injury, decrease growth in plant fresh weight, shoot and root weight and stem diameter.

Control High SO_2



Deplanchea speciosa

Plants showed some bronzing and yellowing of leaves in all treatments. This injury was not associated with SO_2.

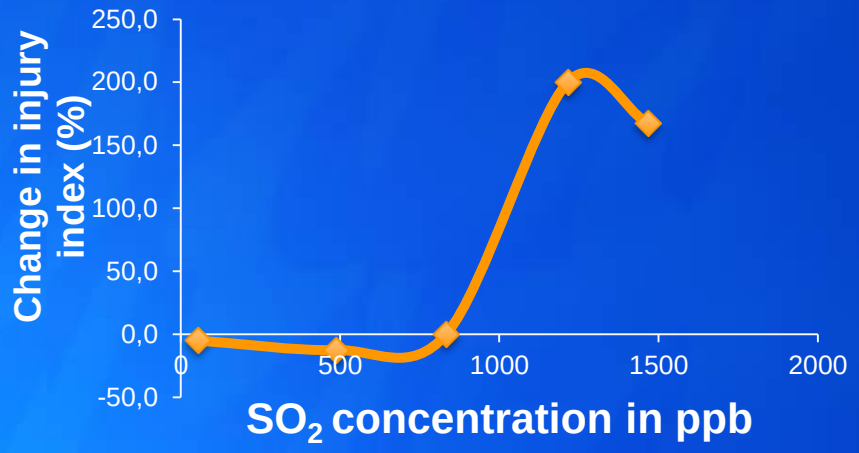
Increasing SO_2 concentration was not associated with the changes to the dry weight of the roots and leaves

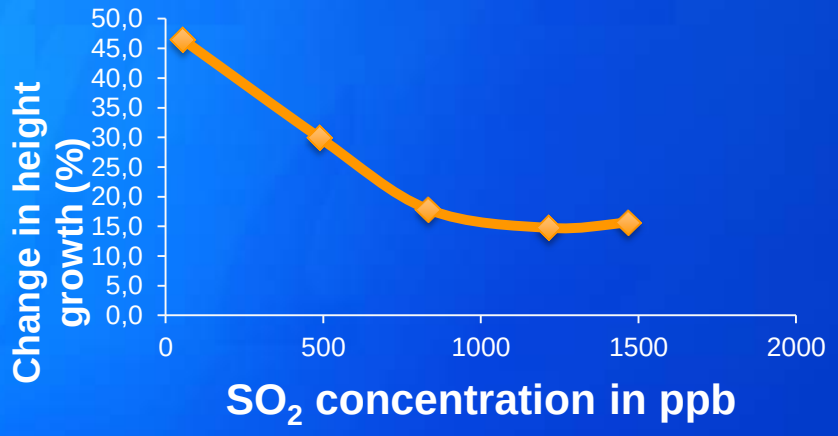
Flindersia fournierii

- Plants exposed to high concentrations of SO_2 showed severe symptoms of acute injury.
- Plants exposed to lower concentrations of SO_2 (1036 and 604 ppb) showed less severe symptoms of necrosis and chlorosis with about 50% the plants injured.

Flindersia fournierii

The highest concentrations of SO_2 were associated with substantially increased leaf injury, decreased height growth, decreased growth in stem diameter, plant shoot and root weight.





Grevillea exul

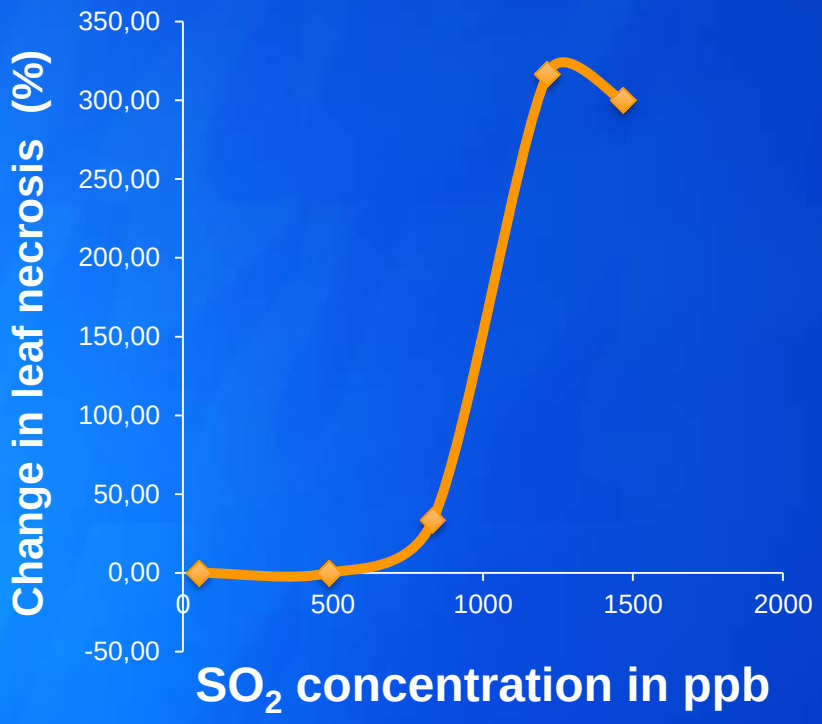
Plants showed symptoms of acute injury when exposed to high concentrations of SO_2. Exposure to the two highest concentrations of SO_2 increased leaf injury.

Control

High SO_2

Gymnostoma deplancheanum

- Plants showed acute injury symptoms near the growth tips of about half of all individuals exposed to the highest concentration of SO_2 (1466 ppb).
- The amount of injury was generally slight and the frequency among plants exposed to high concentrations was variable.

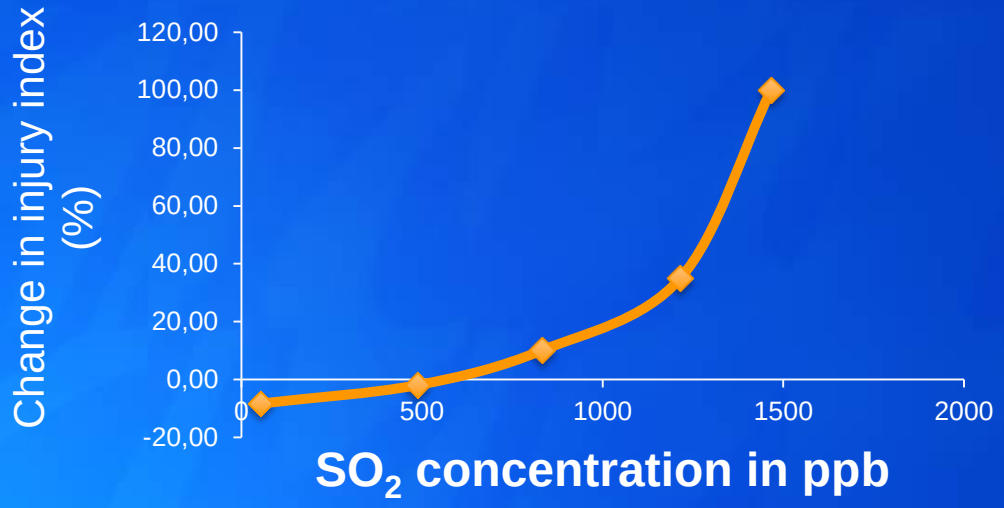


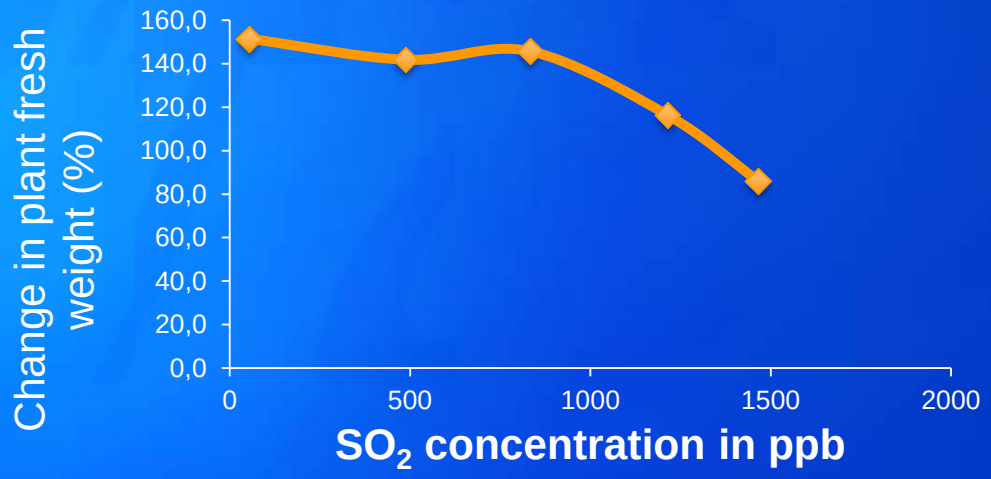
Planchonella wakere

Leaves exposed to 1466 ppb showed symptoms of acute injury by SO_2 with necrotic spots on many leaves.

Planchonella wakere

High concentrations of SO_2 were also associated with reductions in growth of plant height, stem diameter, plant, shoot and root fresh weight.





Summary

- This is the first study of this type ever in the South Pacific.
- Almost all of these species showed visible injury when exposed to 1466 ppb of SO_2 for 2 hours, 4 days per week for 23 fumigation days.
- These species showed no visible injury at concentrations of 488 ppb or less of SO_2.
- At concentrations between these two the severity of injury varied among species.
- The NC Regulatory Limit of 218 ppb for 1 hour will protect these species

Summary

The visible impacts varied among species

More sensitive to SO_2	Less sensitive to SO_2
Arillastrum gummiferum	*Alphitonia neo-caledonica*
Araucaria nemarosa	*Grevillea exul*
Flindersia fournierii	*Gymnostoma deplancheanum*
Planchonella wakerii	*Syzygium macranthum*

Experiment 2: Summary of visible effects of SO_2 on selected native plant species

Species	SO_2 concentration in ppb				
	Control	267	604	1036	1376
Arillastrum gummiferum	-	-	+	+	+
Alphitonia neo-caledonica	-	-	-	+	+
Deplancha speciosa	-	-	-	-	-
Flindersia fournierii	-	-	+	+	+++
Grevillea exul	-	-	-	-	-
Gymnostoma deplanchum	-	-	+	+	+
Planchonella wakerii	-	-	+	++	+++

- No injury; + minor injury; ++ moderate injury; +++ severe injury

Experiment 3: Summary of visible effects of SO_2 on selected native plant species

Species	SO_2 concentration in ppb				
	Control	488	833	1215	1466
Arillastrum gummiferum	-	-	+	+	+
Alphitonia neo-caledonica	-	-	-	-	+
Araucaria nemarosa	-	-	+	+	++
Flindersia fournierii	-	-	+	++	+++
Grevillea exul	-	-	-	+	++
Gymnostoma deplanchum	-	-	-	+	+
Planchonella wakerii	-	-	+	++	+++

- No injury; + minor injury; ++ moderate injury; +++ severe injury

Experiment 4: Summary of visible effects of SO_2 on selected native plant species

Species	SO_2 concentration in ppb				
	Control	389	622	1092	1381
Arillastrum gummiferum	-	-	+	+	++
Alphitonia neo-caledonica	-	-	-	+	++
Araucaria nemarosa	-	-	+	+	++
Agathis lonceolata	-	-	+	++	++
Grevillea exul	-	-	-	+	++
Gymnostoma deplanchum	-	-	-	+	+
Syzygium macranthum	-	-	-	-	-

- No injury; + minor injury; ++ moderate injury; +++ severe injury

Implications

- For the most sensitive species studied, the visible injury threshold is 400-600 ppb for 2 hours for more than 20 days of exposure.
- The NC Regulatory Limit of 218 ppb for 1 hour only will protect these species by a wide margin

Thank You

Any questions?