NOV 11-13, 2019

SUSTAINABLE AG EXPO
&
INTERNATIONAL SUSTAINABLE WINEGROWING SUMMIT

SAN LUIS OBISPO, CALIFORNIA

Grapevine leafroll disease in South Africa; its properties, epidemiology and control

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Winetech
Wine Industry Network of Expertise and Technology
Netwerk vir Kundigheid en Tegnologie vir die Wynbedryf

UNIVERSITEIT STELLENBOSCH UNIVERSITY

Grapevine leafroll disease: Most important viral disease of wine grapevines in South Africa.

Causes an impairment of vascular tissue:

Reduced yields.
Uneven ripening of bunches, reduced sugars, reduced colour.

Leafroll infected

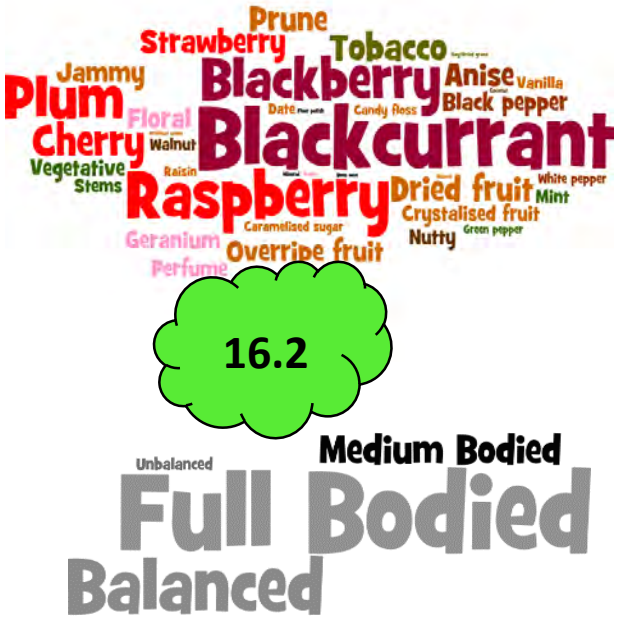
Healthy

Image: R.A. Naidu

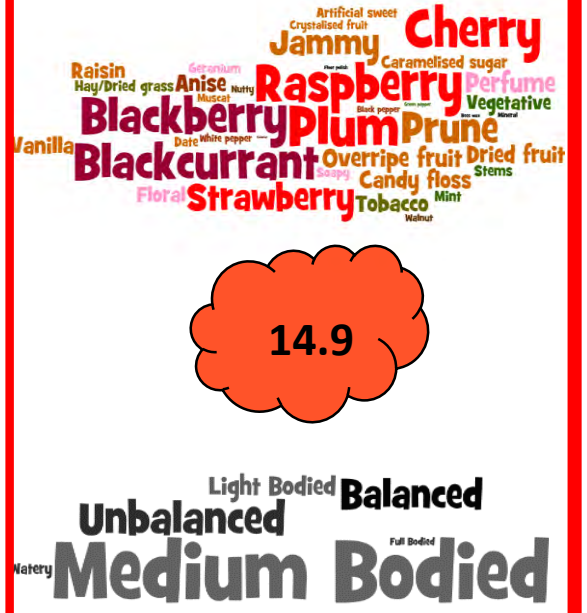
Image: http://wine.wsu.edu/research-extension/plant-health/virology/symptoms/

Blind sensory evaluation (30 of South Africa's top wine makers). Cabernet Sauvignon wine from leafroll infected and healthy vines

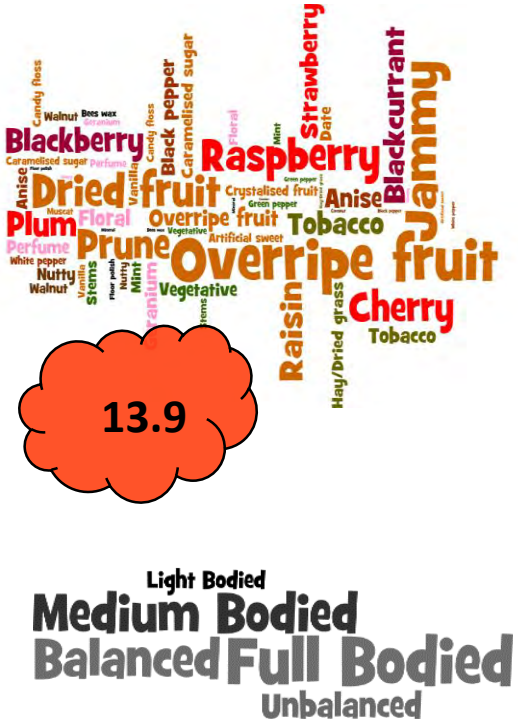
Healthy vines
Brix @ Harvest: 25.3



Infected vines
Brix @ Harvest: 23.1



Infected & later harvest
Brix @ Harvest: 25.3




Block 37 (Total 11939):
2001: 487 (4.08%)
2002: 855 (7.17%)
2003: 1847 (15.55%)
2004: 3735 (31.44%)
2005: 5115 (43.09%)
Number of infected plants c. doubles annually
2001: All LR infected vines
2002: All LR infected vines
2003: All LR infected vines
2004: Newly LR infected vines
2005: Newly LR infected vines

Replacement of vineyards every 20-25 years because of reduced yields and quality

Most important Virus:

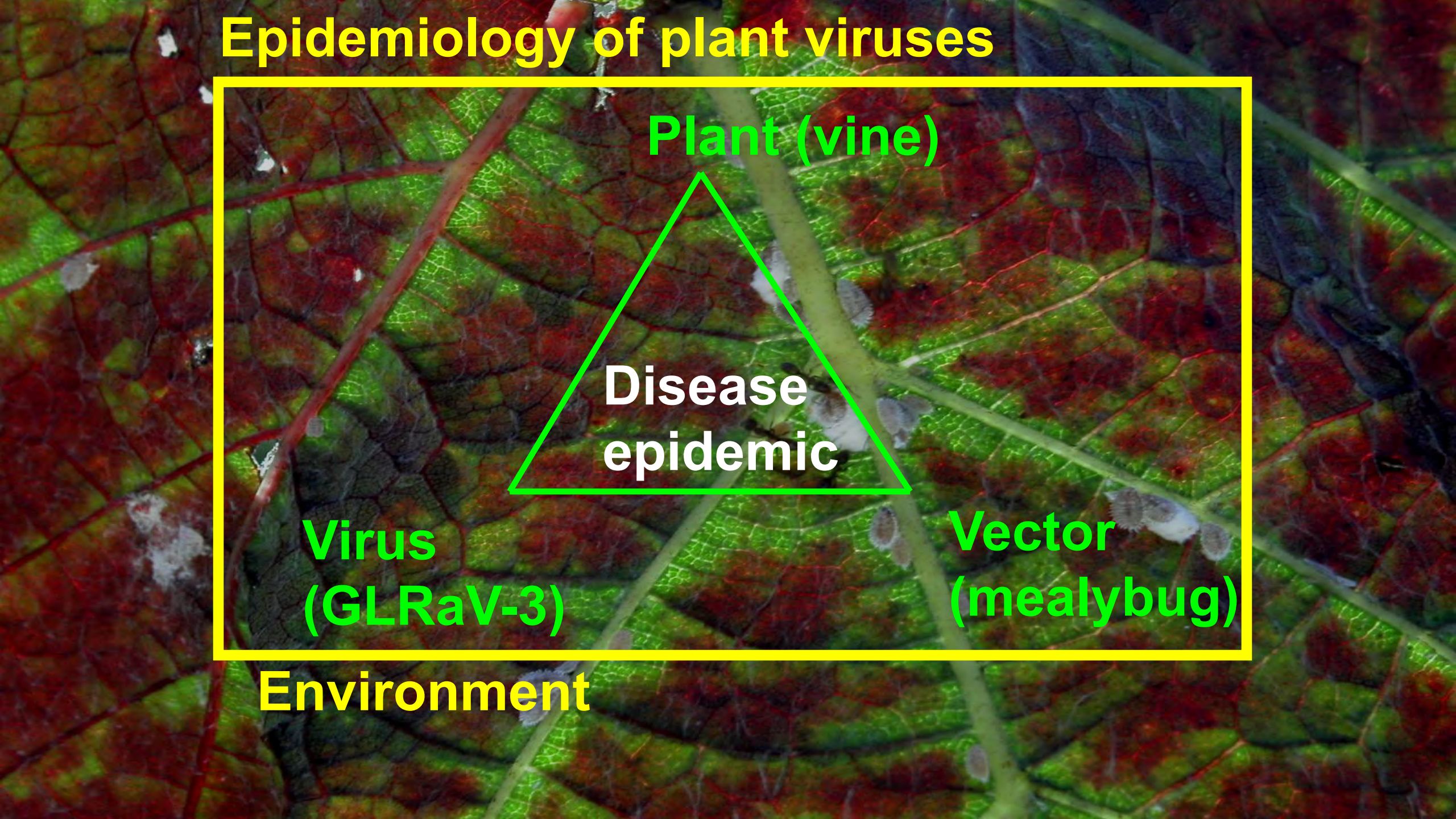
Grapevine leafroll associated virus type 3 (GLRaV-3)

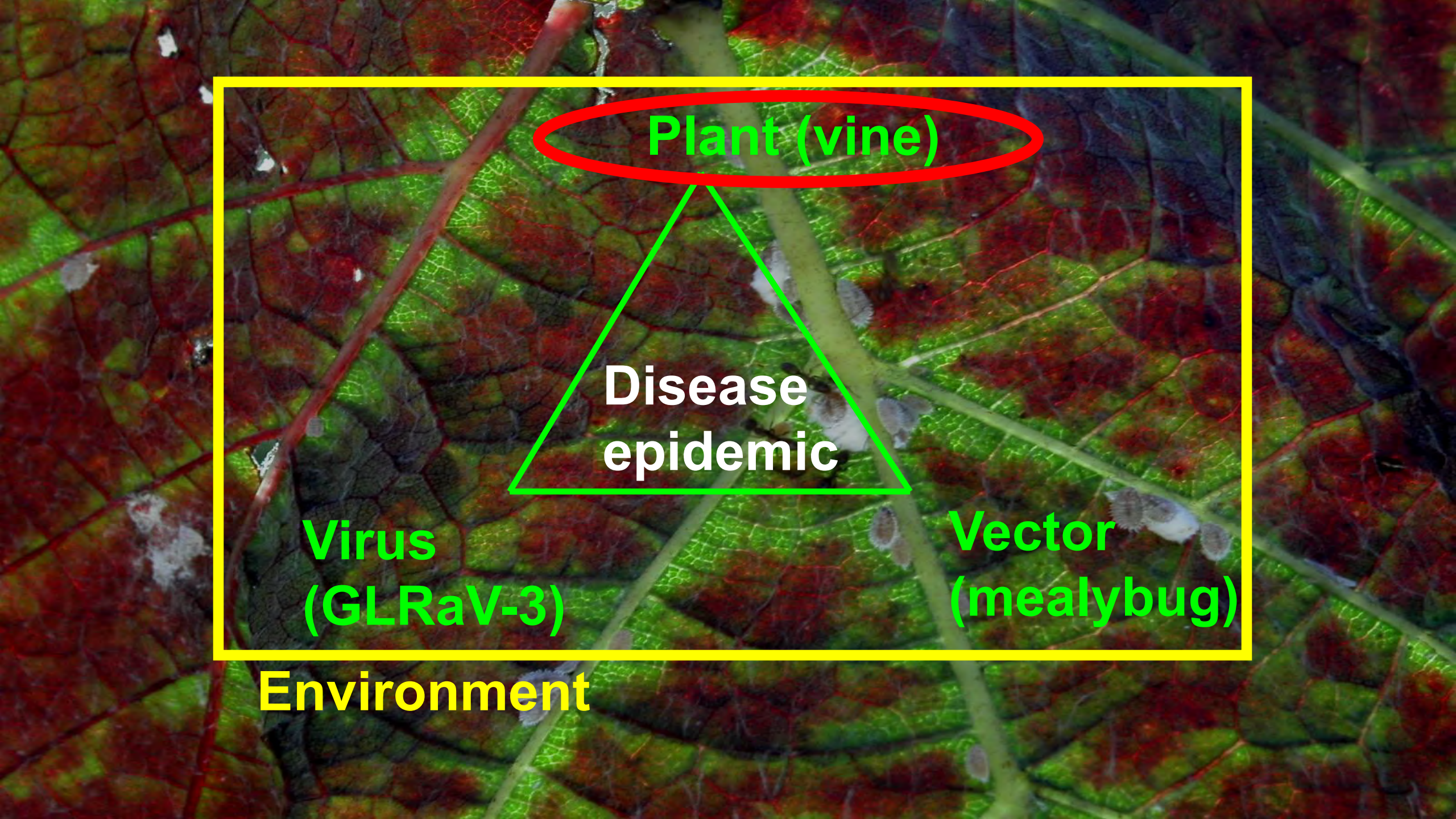
(Type member of ampeloviruses)

Background Photo: K. Kasdorf

Control of plant viruses

No compounds which can be applied on large scales in agriculture to kill viruses (equivalent to fungicides for fungi or antibiotics for bacteria).


Epidemiology of plant viruses
Plant (vine)
Disease
epidemic
Virus
(GLRaV-3)
Vector
(mealybug)
Environment

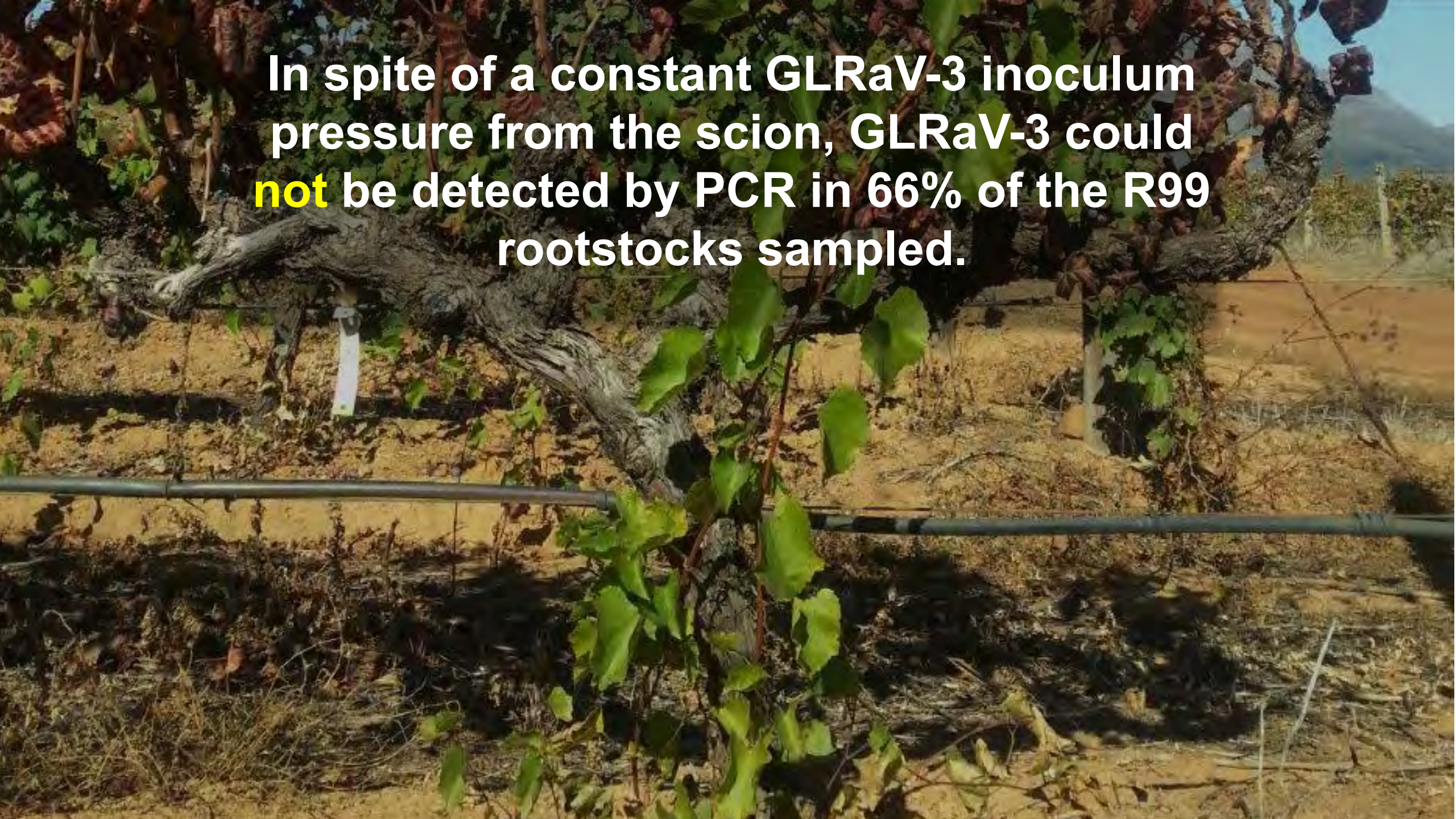

Plant (vine)
Disease
epidemic
Virus
(GLRaV-3)
Vector
(mealybug)
Environment

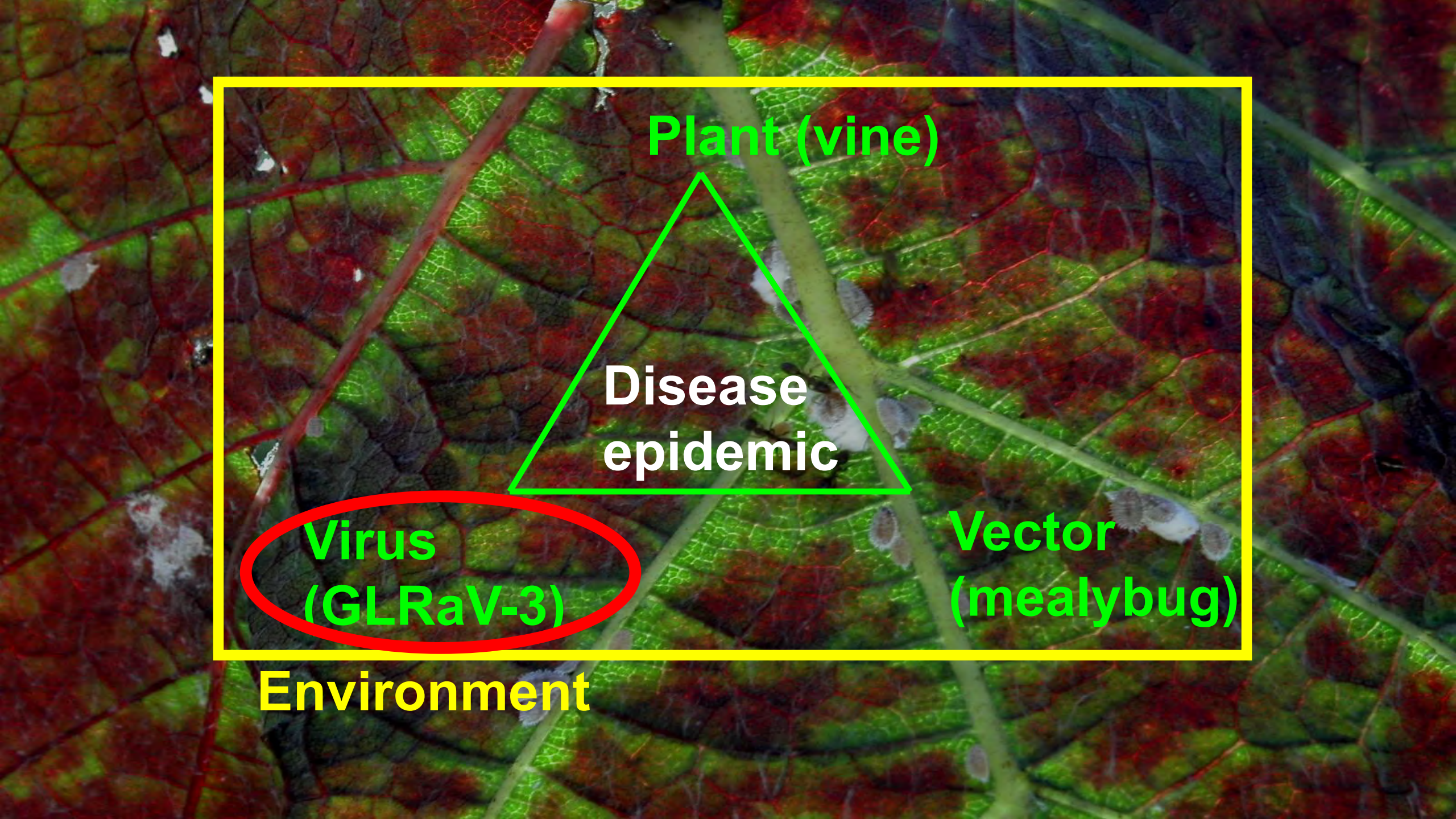
All tested *Vitis vinifera cv.'s* are susceptible to GLRaV-3.


Disease also affects green-berried cultivars. Generally symptoms are not obvious (exceptions eg. Chardonnay)
Background photo:R. Carstens

Virus also affects rootstocks
(*Vitis berlanderie, V. riparia, V. rupestris*).


Rootstocks also do not show any LR symptoms


In spite of a constant GLRaV-3 inoculum pressure from the scion, GLRaV-3 could not be detected by PCR in 66% of the R99 rootstocks sampled.


Plant (vine)
Disease
epidemic
Virus
(GLRaV-3)
Vector
(mealybug)
Environment


NOT mechanically transmissible


GLRaV-3: Natural host range is restricted to *Vitis species.*

Transmitted by vegetative propagation of infected planting material.

Transmitted by grafting infected material

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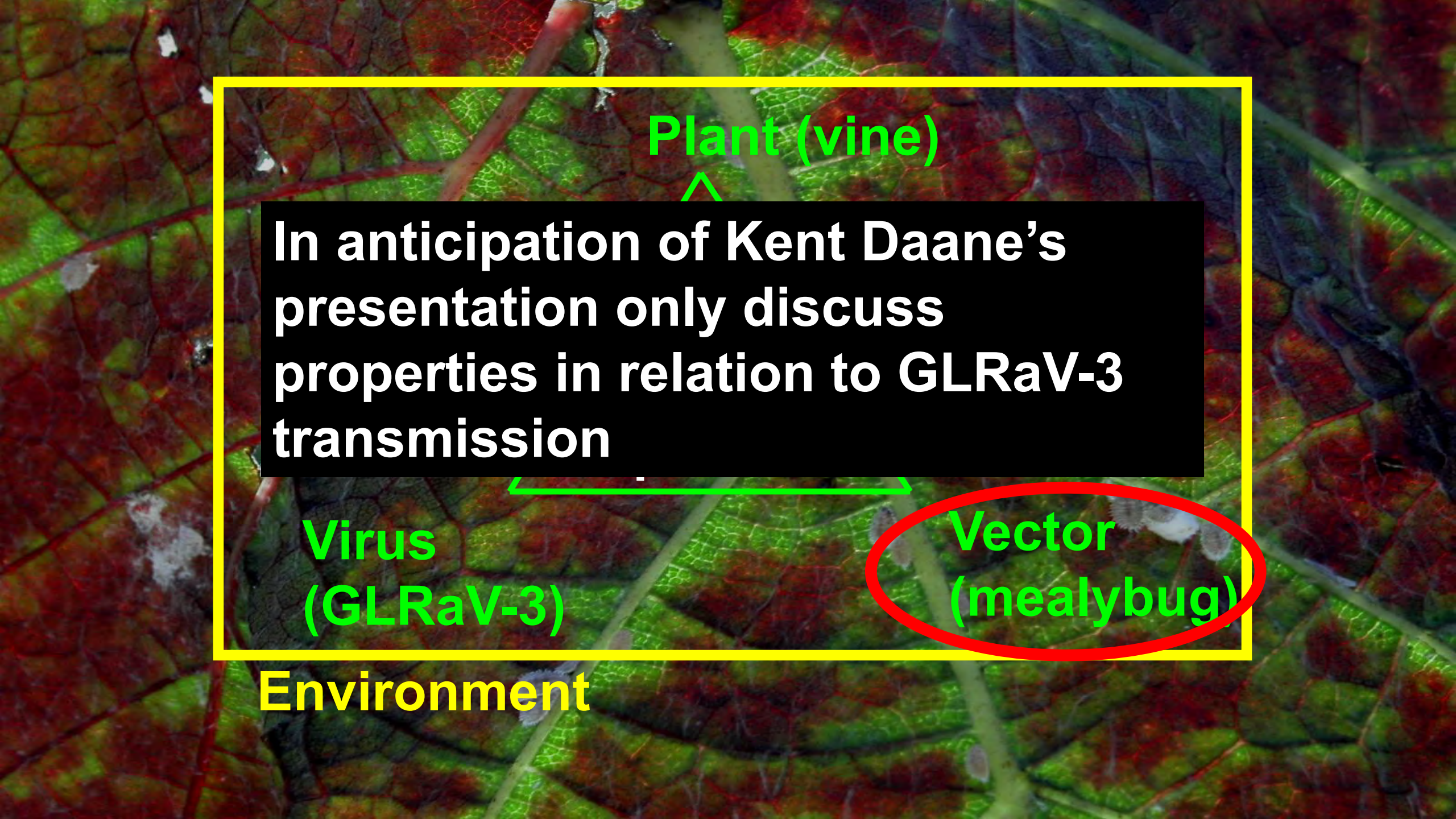
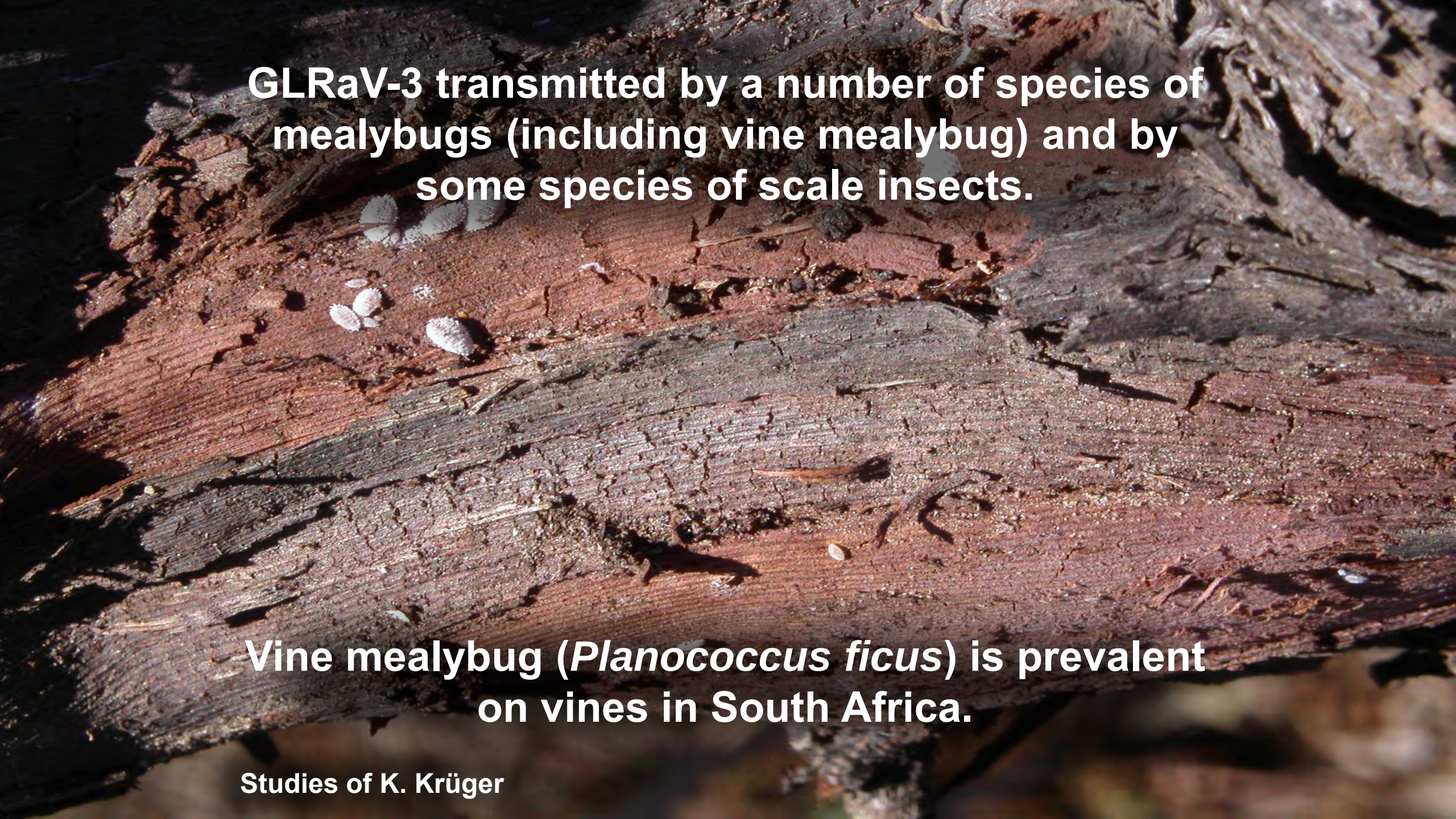

Plant (vine)
In anticipation of Kent Daane's presentation only discuss properties in relation to GLRaV-3 transmission
Virus (GLRaV-3)
Vector (mealybug)
Environment



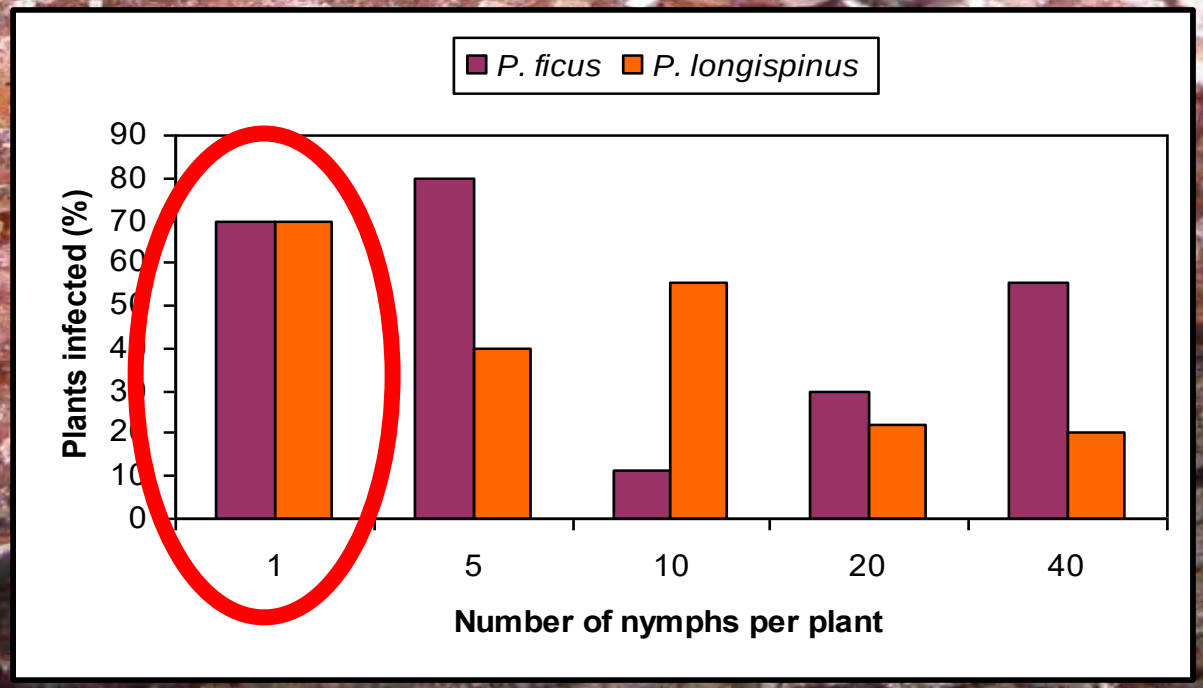
GLRaV-3 transmitted by a number of species of mealybugs (including vine mealybug) and by some species of scale insects.

Vine mealybug (*Planococcus ficus*) is prevalent on vines in South Africa.

Studies of K. Krüger

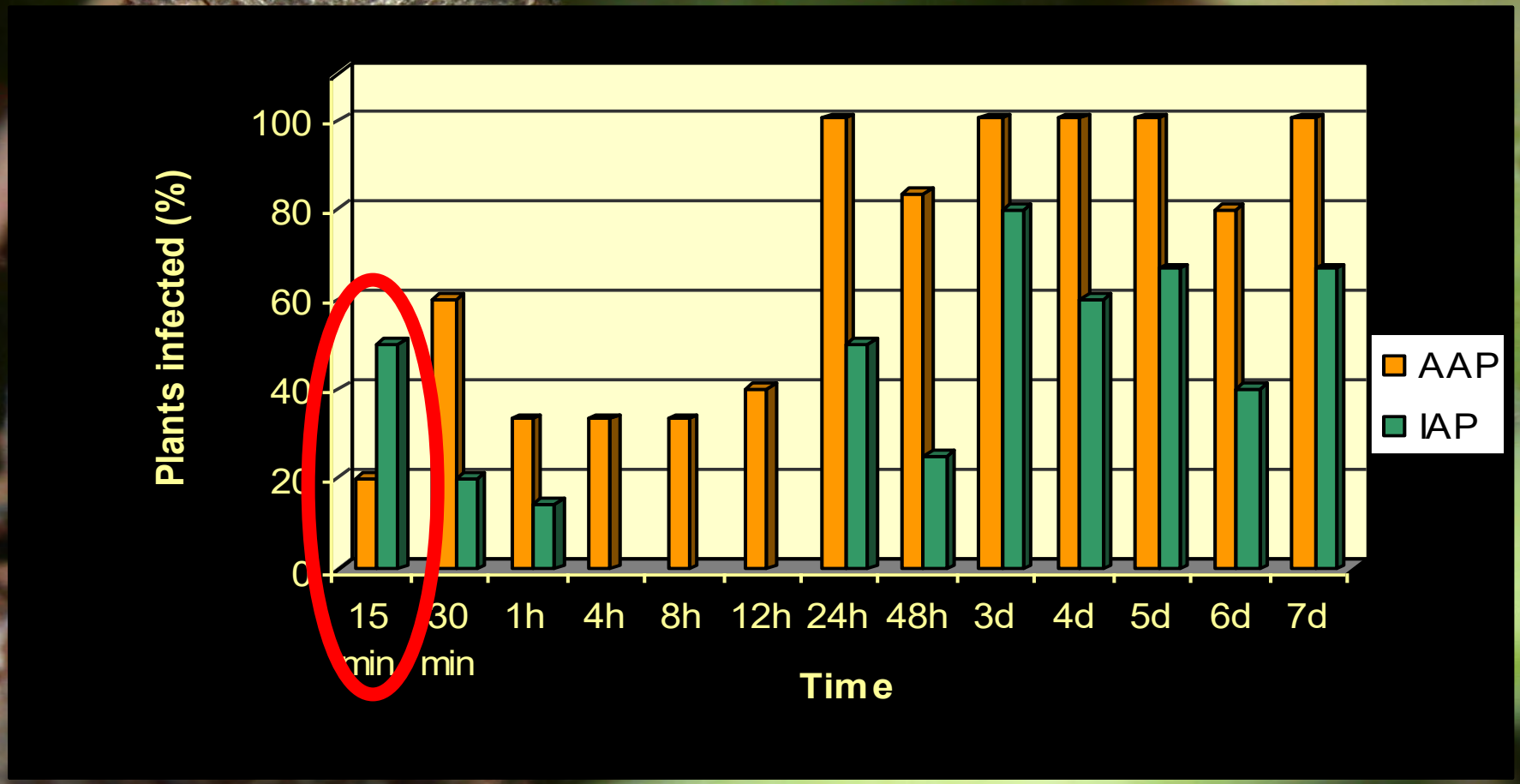
GLRaV-3 transmission efficiency

Kerstin Krüger



Studies of K. Krüger

Semi-persistent transmission of GLRaV-3 transmission by *Planococcus ficus*:



Studies of K. Krüger

Semi persistent transmission of GLRaV-3 implies:

Virus only associated with mouth parts of the insect.

Virus is lost on moulting.

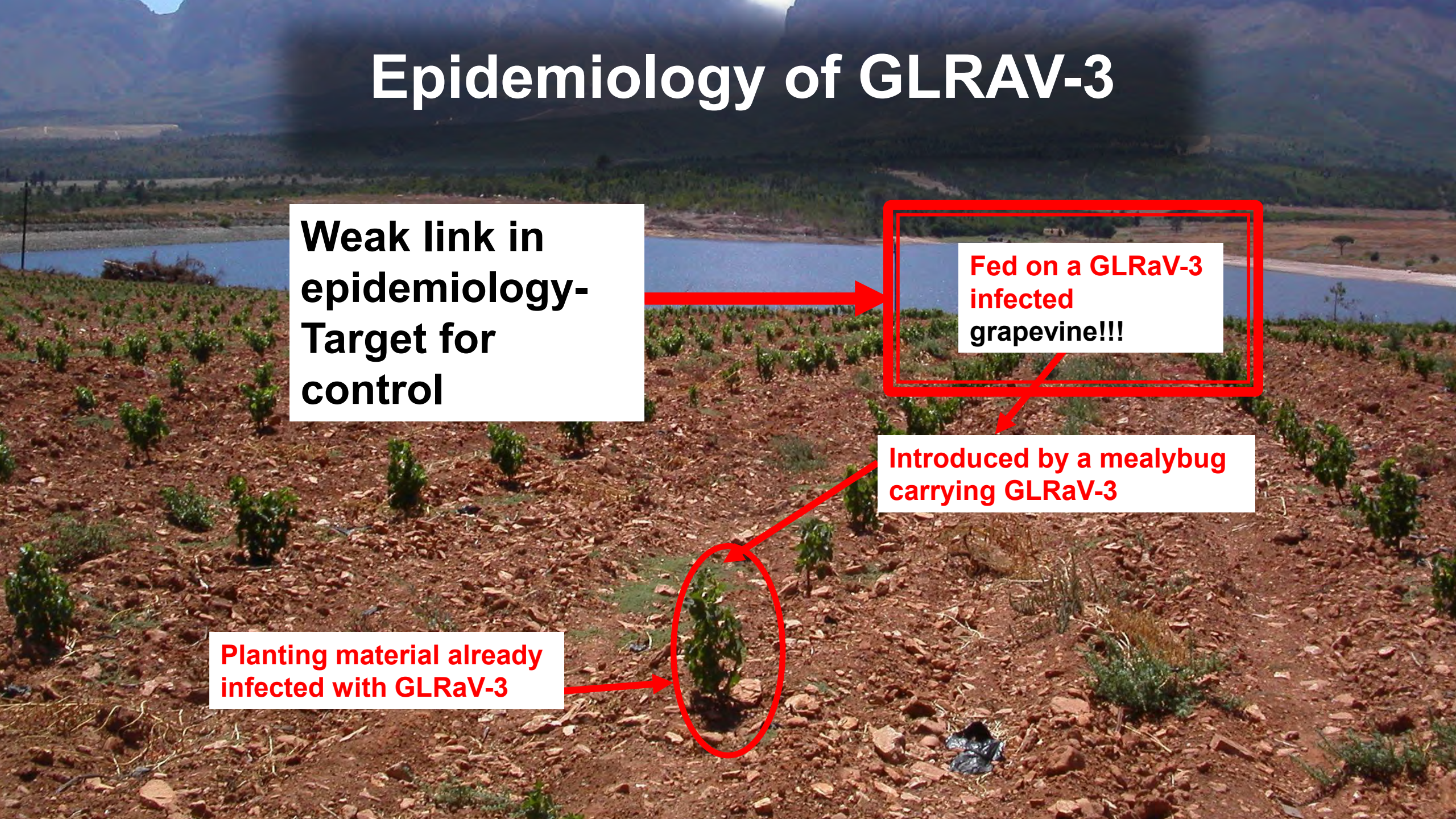
Virus does not replicate in the insect.

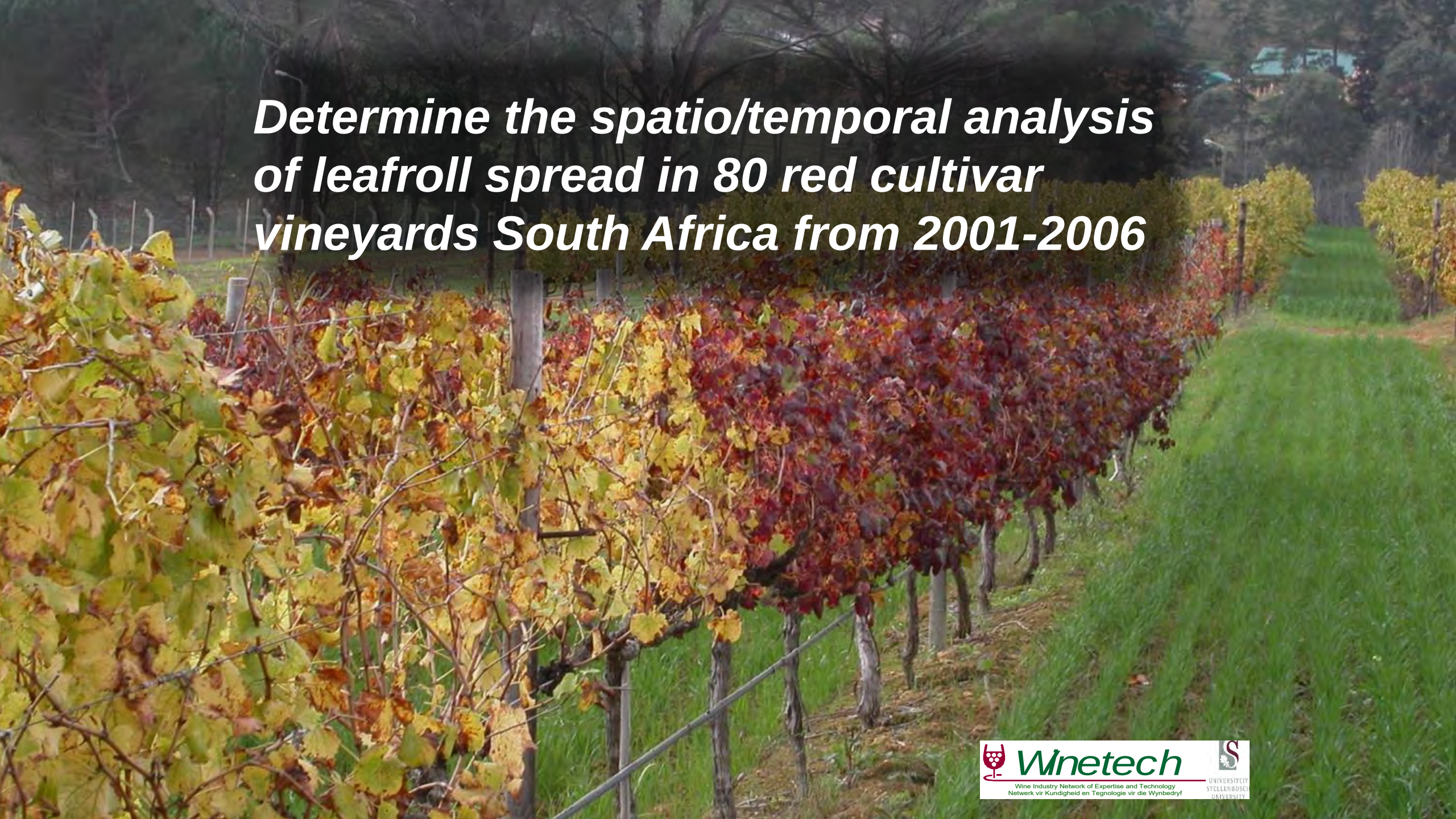
Virus is not transmitted to insect offspring.

Mealybug not very motile, but small and in large numbers, dispersal is potentially by:

- Own movement
  - Crawling short distances
- Possibly by wind
  - Long distances
  - Short distances
- Possibly by birds/ants
- Man
  - Agronomic activities (e.g. pruning, harvesting)
  - Implements

Epidemiology of GLRAV-3




Determine the spatio/temporal analysis of leafroll spread in 80 red cultivar vineyards South Africa from 2001-2006
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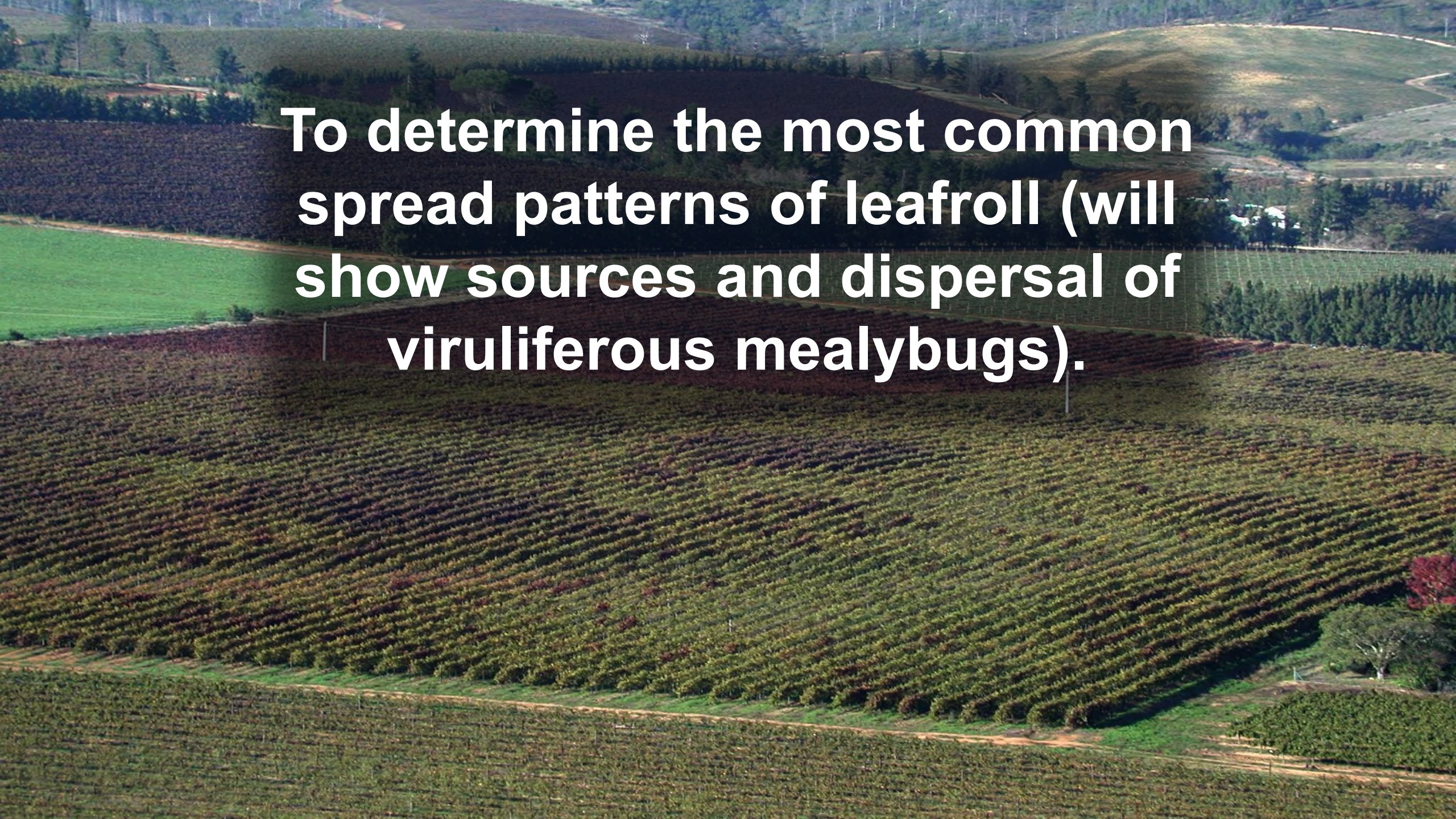
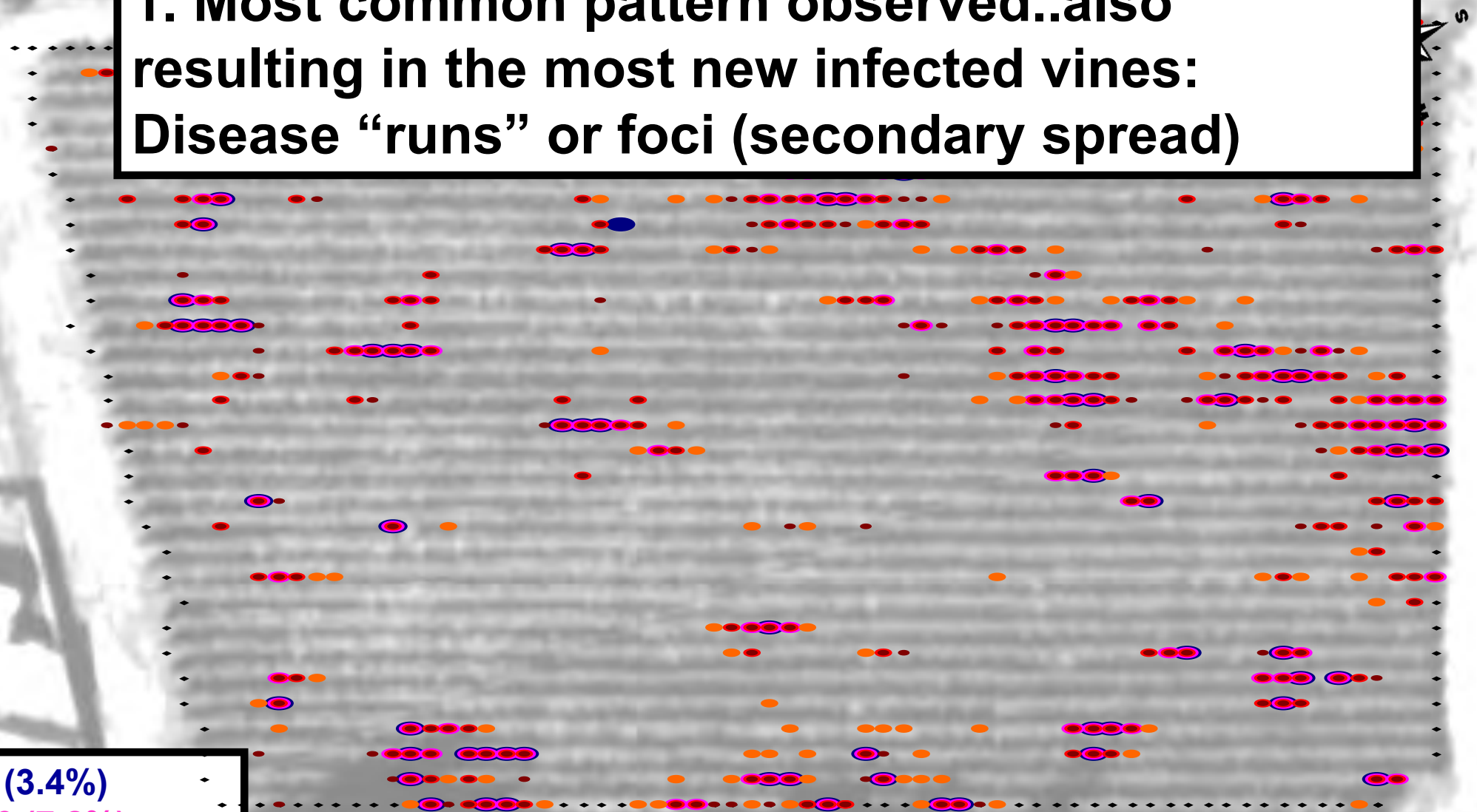
Wine Industry Network of Expertise and Technology
Netwerk vir Kundigheid en Tegnologie vir die Wynbedryf
UNIVERSITEIT STELLENBOSCH UNIVERSITY


To determine the most common spread patterns of leafroll (will show sources and dispersal of viruliferous mealybugs).

1. Most common pattern observed..also resulting in the most new infected vines: Disease “runs” or foci (secondary spread)



2001, 73 (3.4%)
2002, 156 (7.2%)
2003, 282 (13.1%)
2004, 358 (16.7%)
2005, 468 (21.8%)

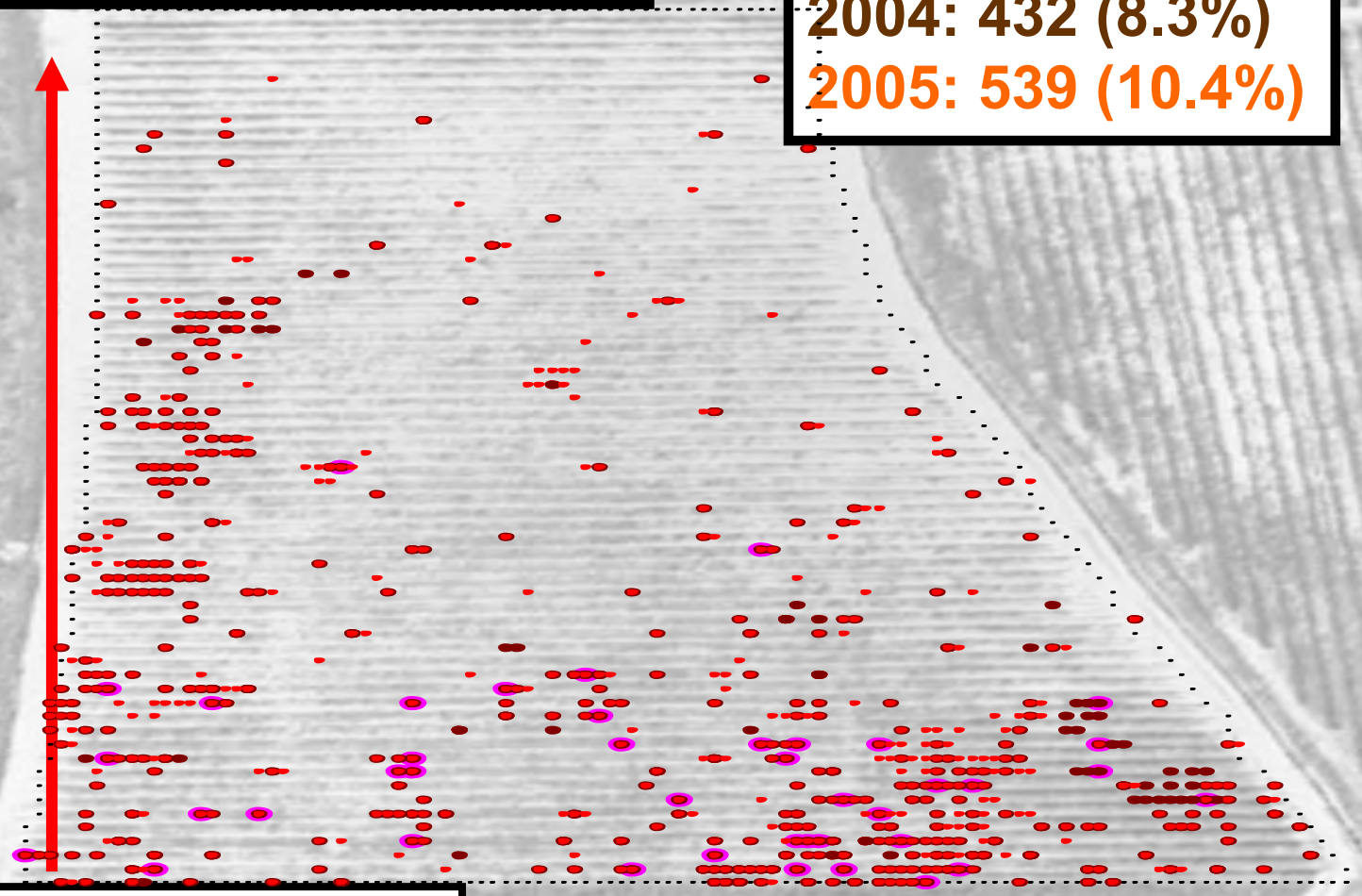
Spread from an infected plant to neighbours first along the row, then across the row (known as secondary spread), probably by short distance dispersal of viruliferous mealybugs; 1) by their own motility.

2) Carried on implements to adjoining healthy vines

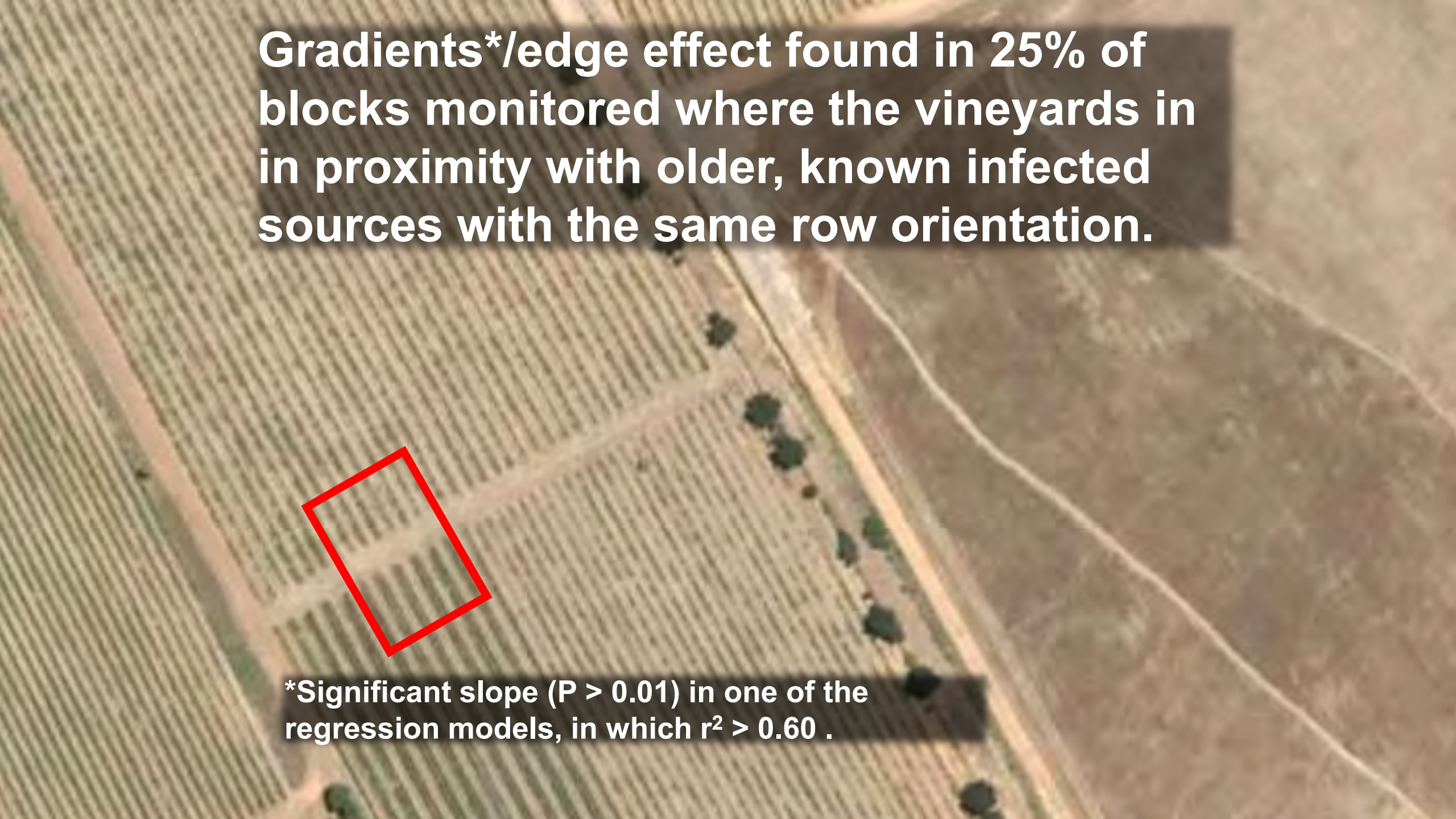
3) Picked up from infected vines and carried on workers clothing to adjacent healthy vines

2. Gradients or edge effects (primary spread)

2002: 40 (0.8%)
2003: 148 (2.8%)
2004: 432 (8.3%)
2005: 539 (10.4%)

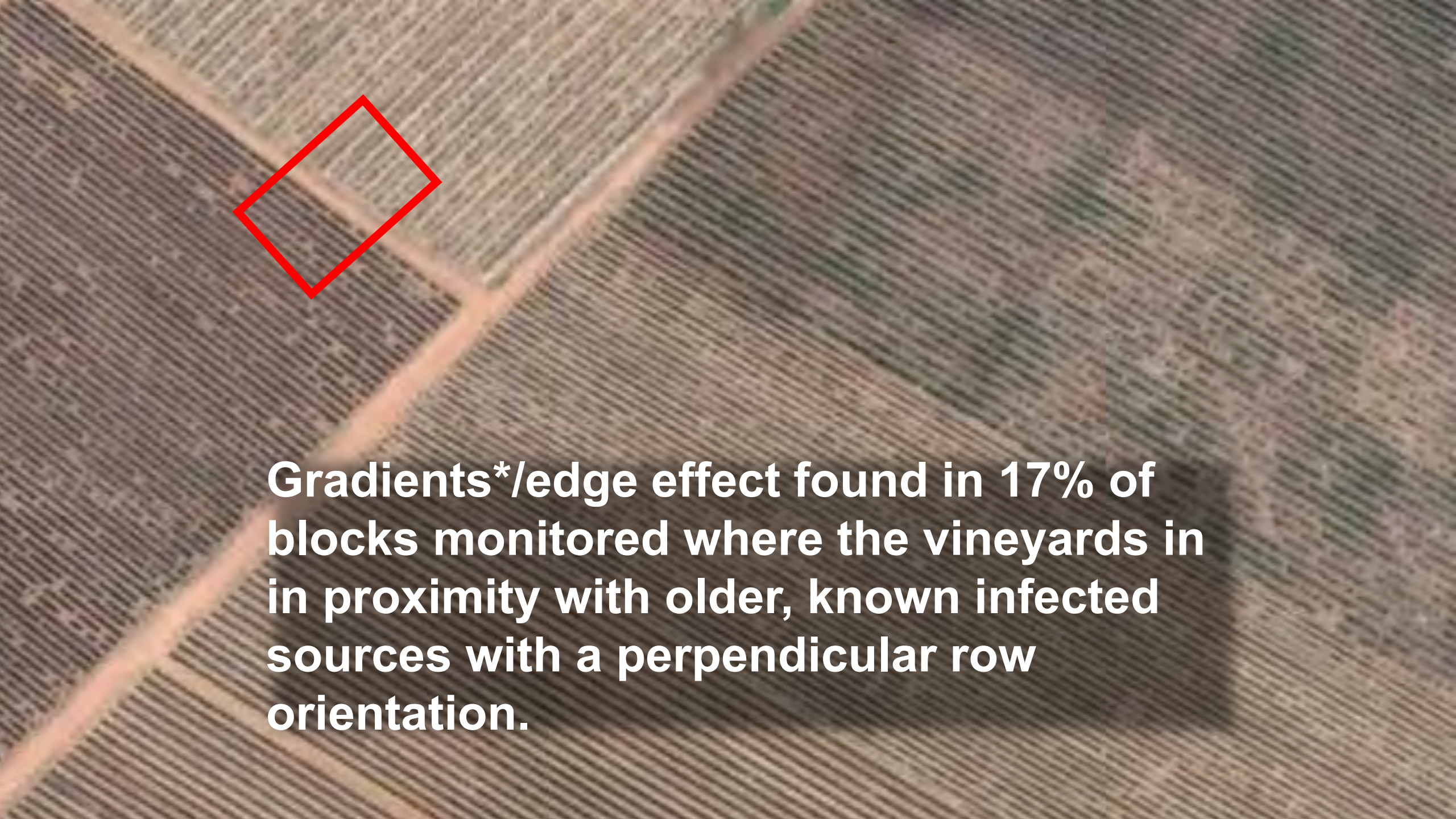


2004
Y = -9.458x + 0.429
Significant slope (P > 0.001); r^2= 0.63

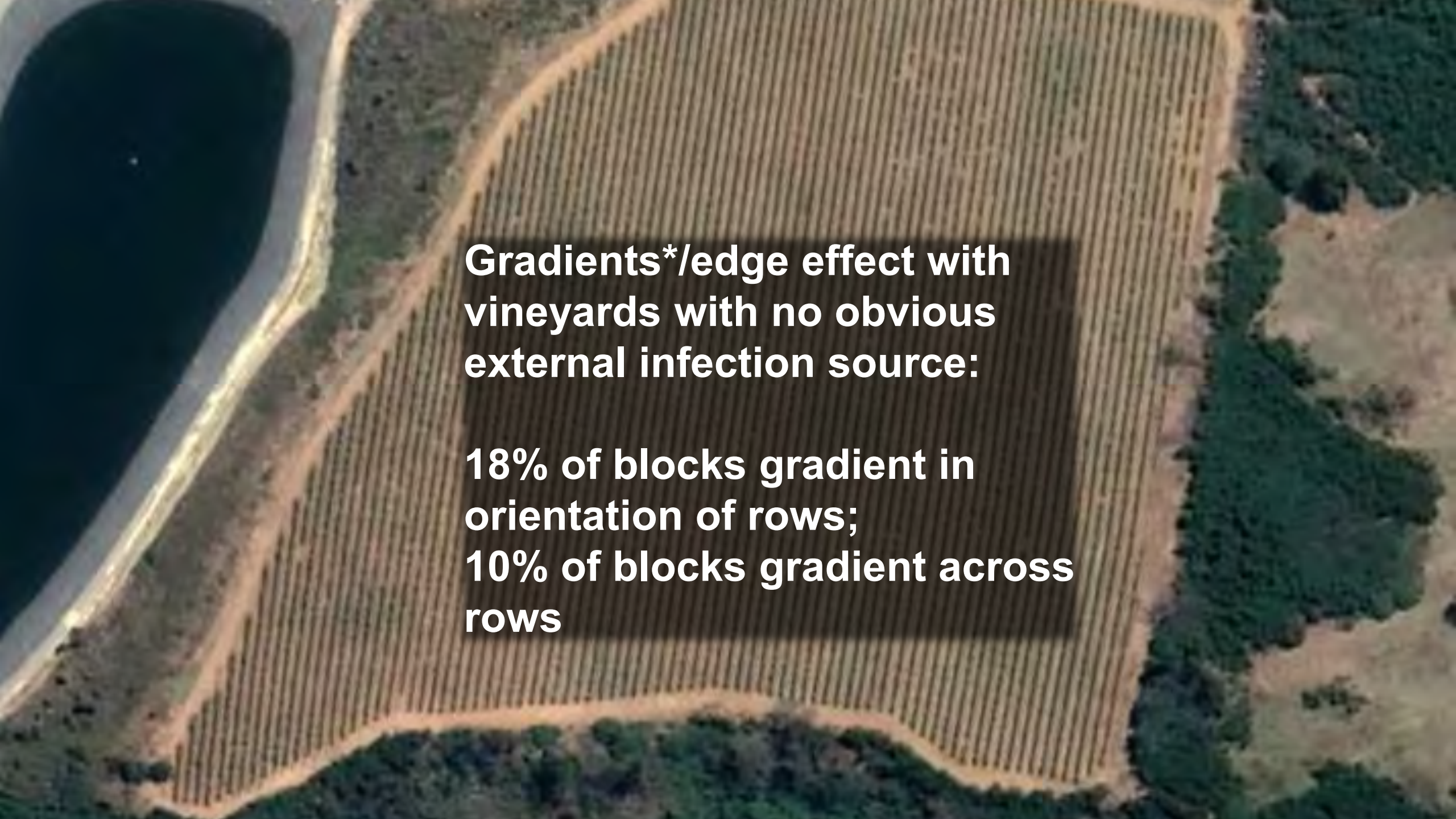


Gradients*/edge effect found in 25% of blocks monitored where the vineyards in in proximity with older, known infected sources with the same row orientation.

*Significant slope (P > 0.01) in one of the regression models, in which $r^2 > 0.60$.



Gradients*/edge effect found in 17% of blocks monitored where the vineyards in in proximity with older, known infected sources with a perpendicular row orientation.


Gradients*/edge effect with vineyards with no obvious external infection source:
18% of blocks gradient in orientation of rows;
10% of blocks gradient across rows

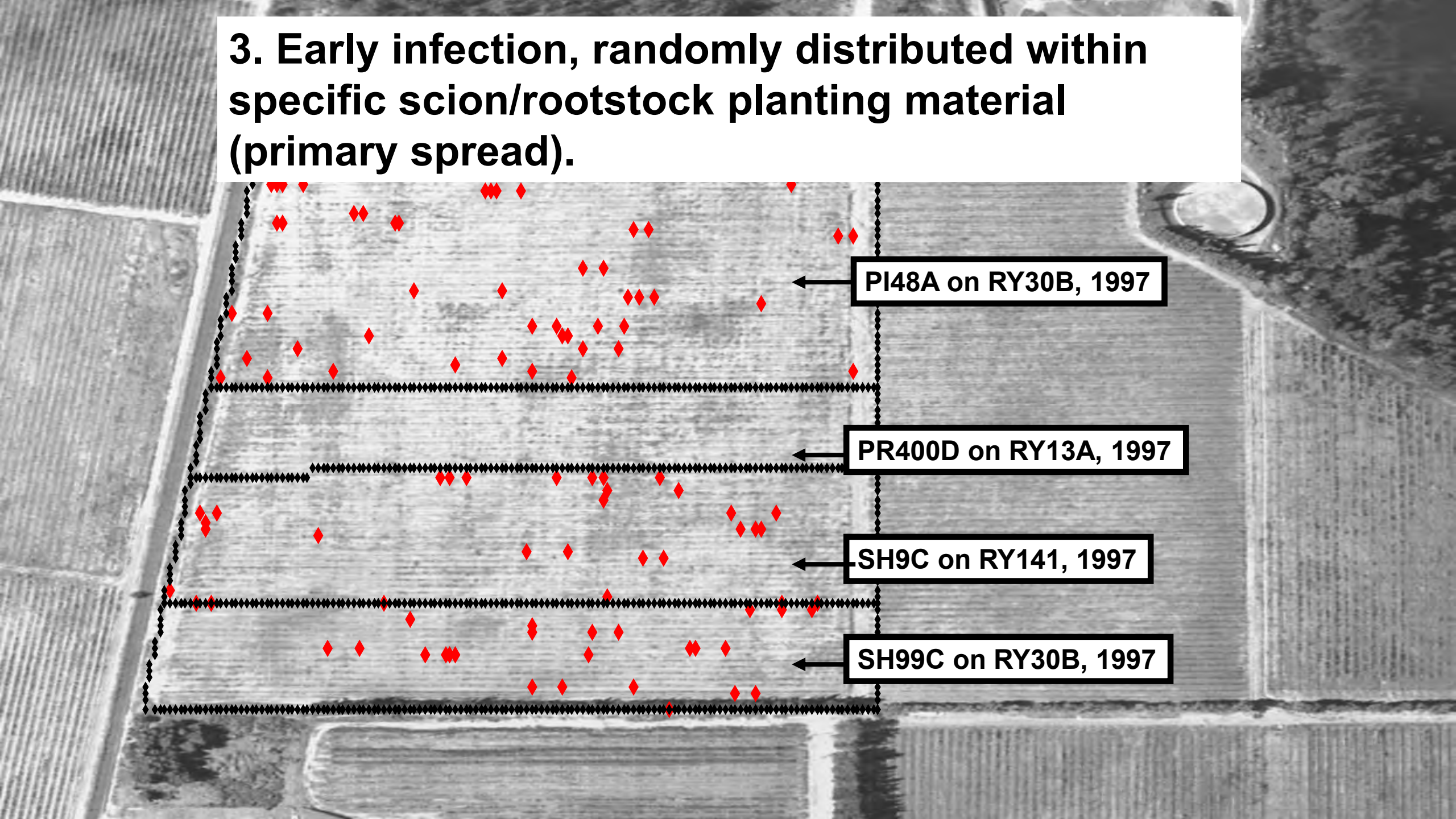
Gradients possibly due to GLRaV-3 viruliferous mealybugs carried on implements from external sources

GLRaV-3 viruliferous mealybugs picked up and carried on workers clothing from external sources

Slide modified from Vititec slide

Viruliferous mealybugs from external sources dispersed by wind (egg sacks or crawlers) or on leaves

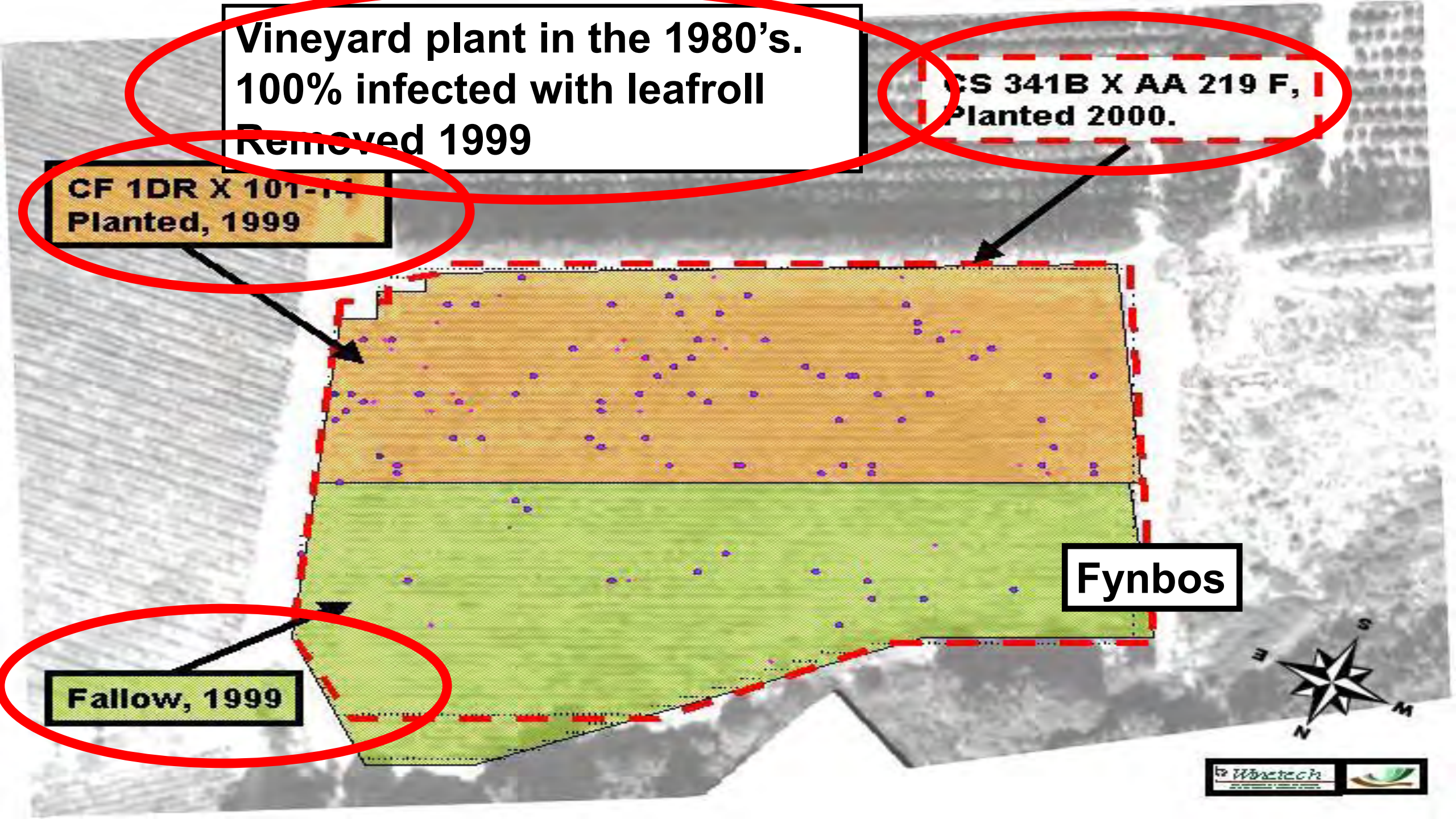
3. Early infection, randomly distributed within specific scion/rootstock planting material (primary spread).

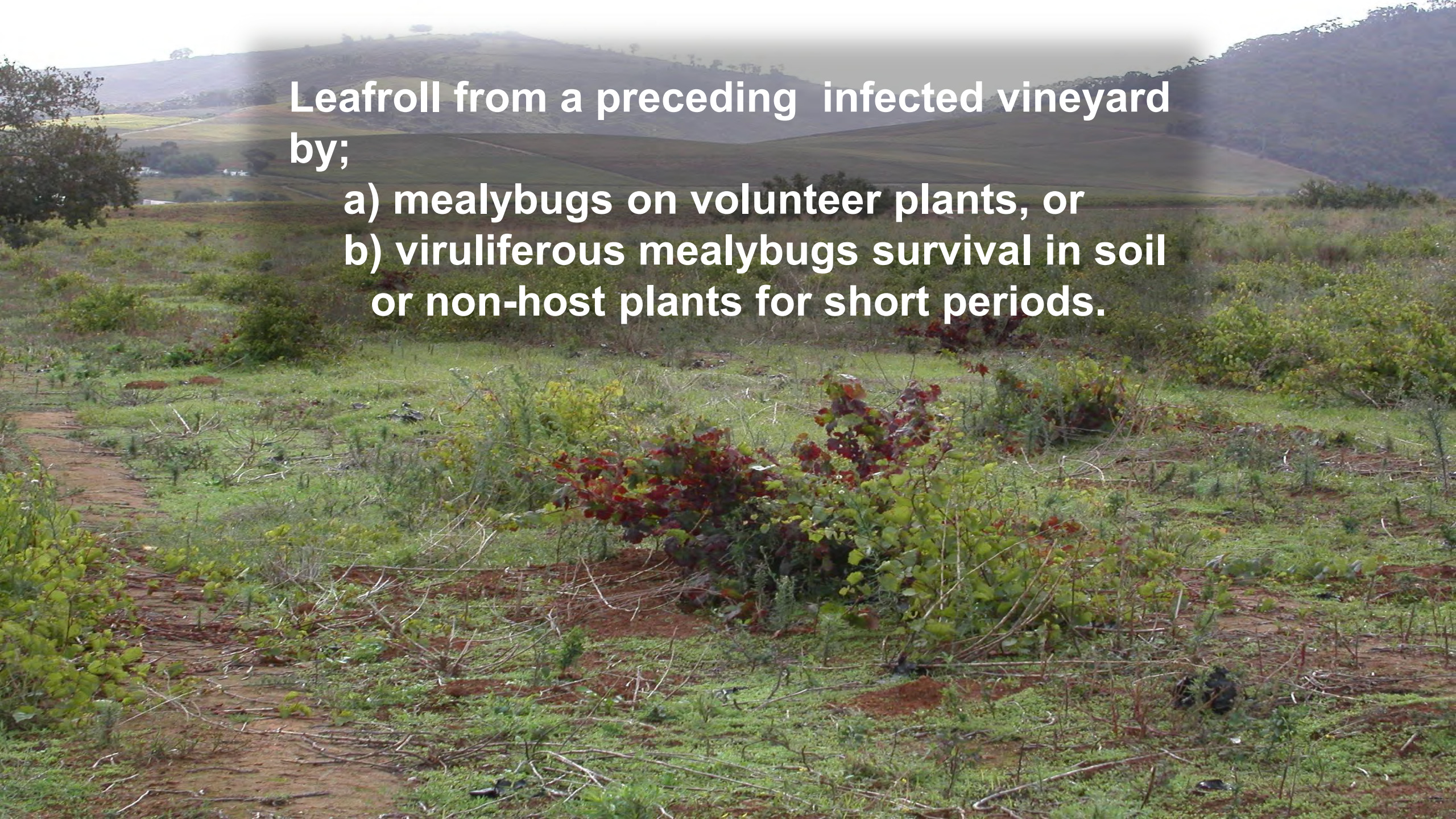


Primary spread of Leafroll by infected planting material.

a)Scion.

b)Rootstock.


Vineyard plant in the 1980's.
100% infected with leafroll
Removed 1999
CS 341B X AA 219 F,
Planted 2000.
CF 1DR X 101-14
Planted, 1999
Fynbos
Fallow, 1999
S
W
N
E

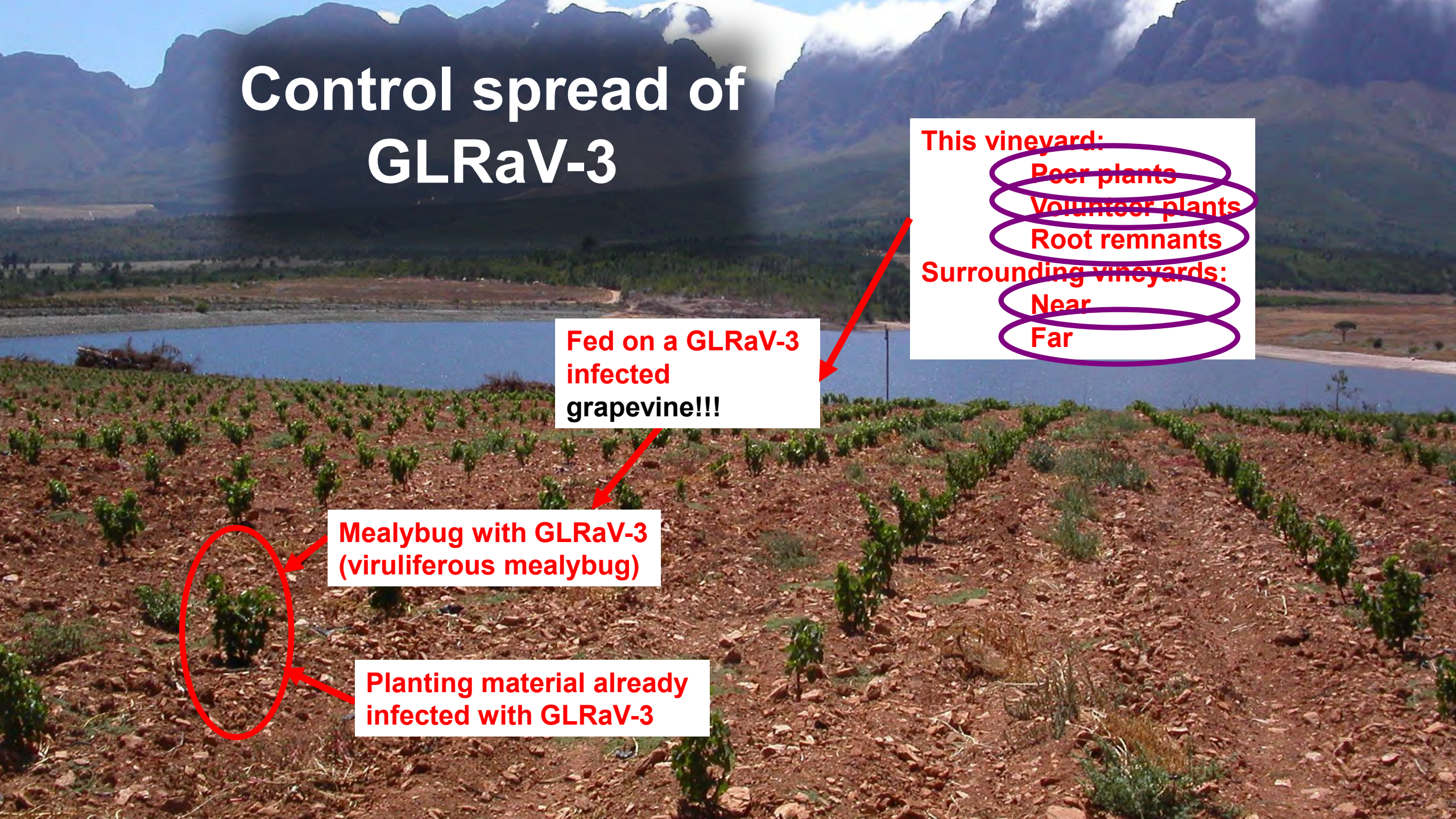


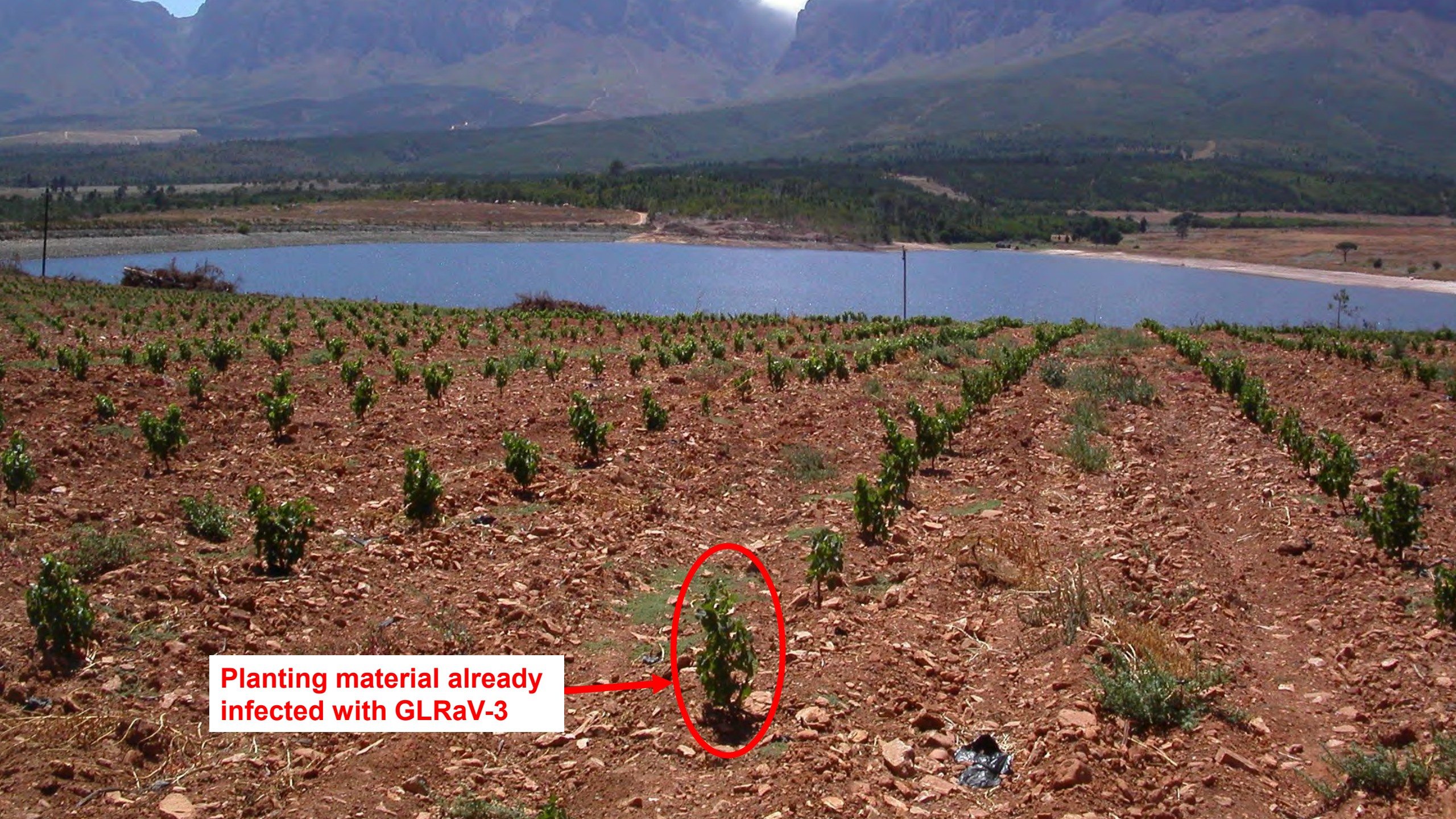
Leafroll from a preceding infected vineyard by;

a) mealybugs on volunteer plants, or

b) viruliferous mealybugs survival in soil or non-host plants for short periods.


To control of grapevine leafroll spread: Must prevent the various means of disease spread


Control spread of GLRaV-3
This vineyard:
Peer plants
Volunteer plants
Root remnants
Surrounding vineyards:
Near
Far
Fed on a GLRaV-3 infected grapevine!!!
Mealybug with GLRaV-3 (viruliferous mealybug)
Planting material already infected with GLRaV-3


Planting material already infected with GLRaV-3

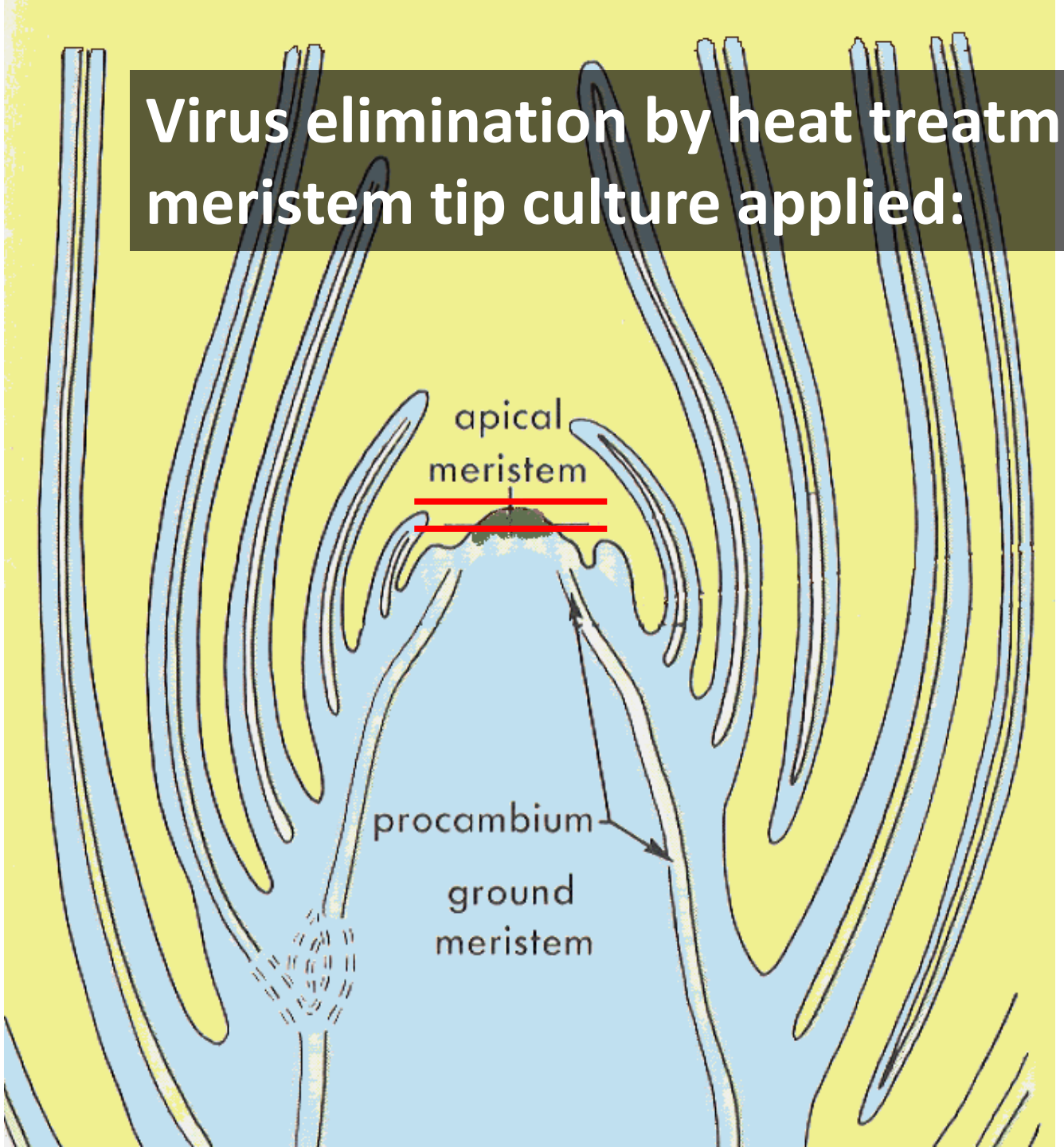
Prevent presence of infected planting material: Certification

1. Virus elimination

2. Propagation

- Nuclear block
- Foundation block
- Mother block
- Nurseries

Virus elimination by heat treatment and meristem tip culture applied:



0.24mm slice (virus-free)

Virus infected

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Elimination of GLRaV-3 in nuclear plants in SA excellent.

No leafroll infection of nuclear material

In nuclear block over many years.

Photo: Vititec


Material after virus elimination still
susceptible to virus, must protect!!

Do propagation in foundation and mother-blocks in field.

Nuclear block

↓

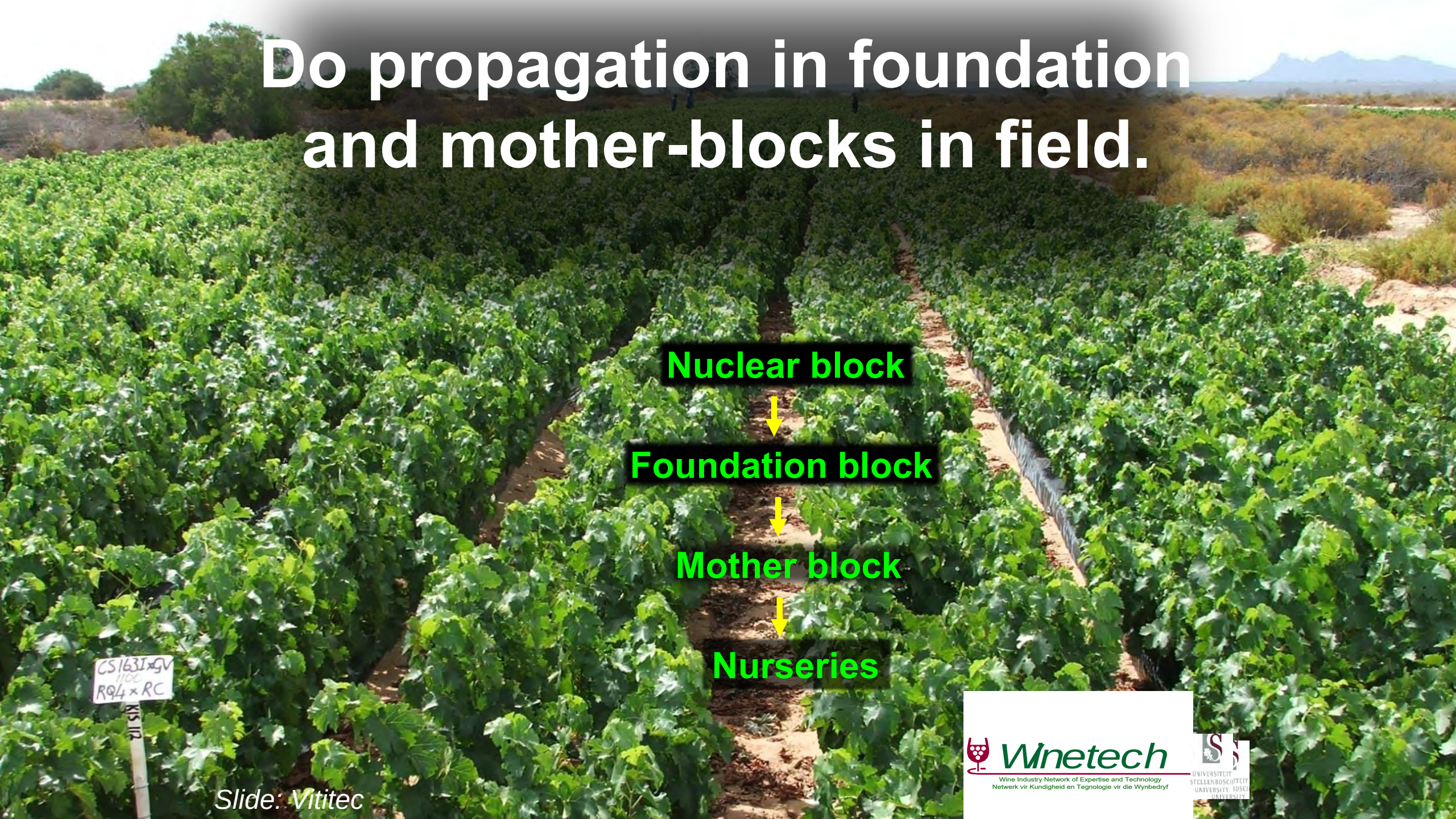
Foundation block

↓

Mother block

↓

Nurseries



Slide: Vititec

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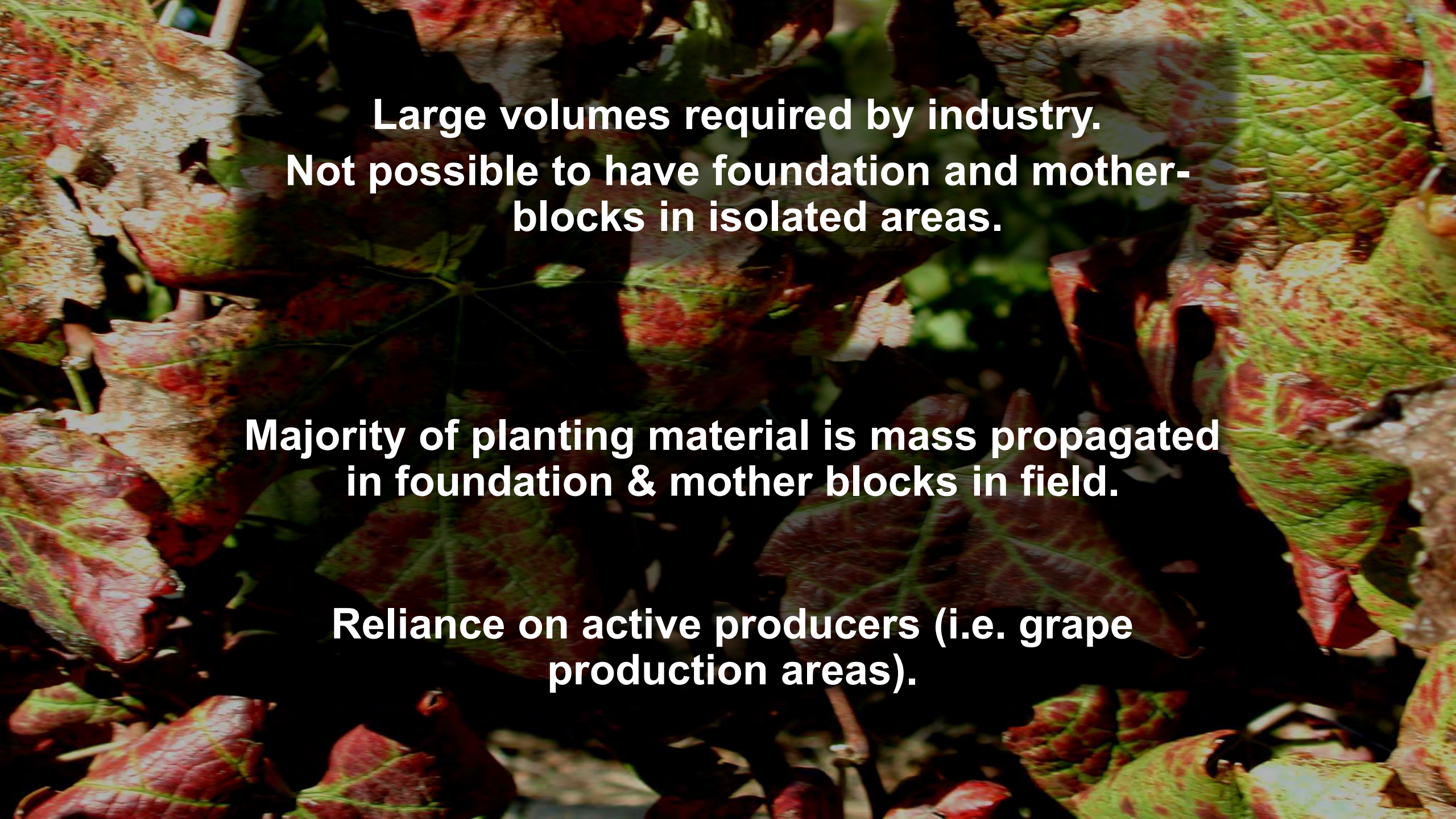
A small percentage of foundation block material in areas isolated from other vineyards. Is rated as 3-star material.

Slide: Vititec



Large volumes required by industry.

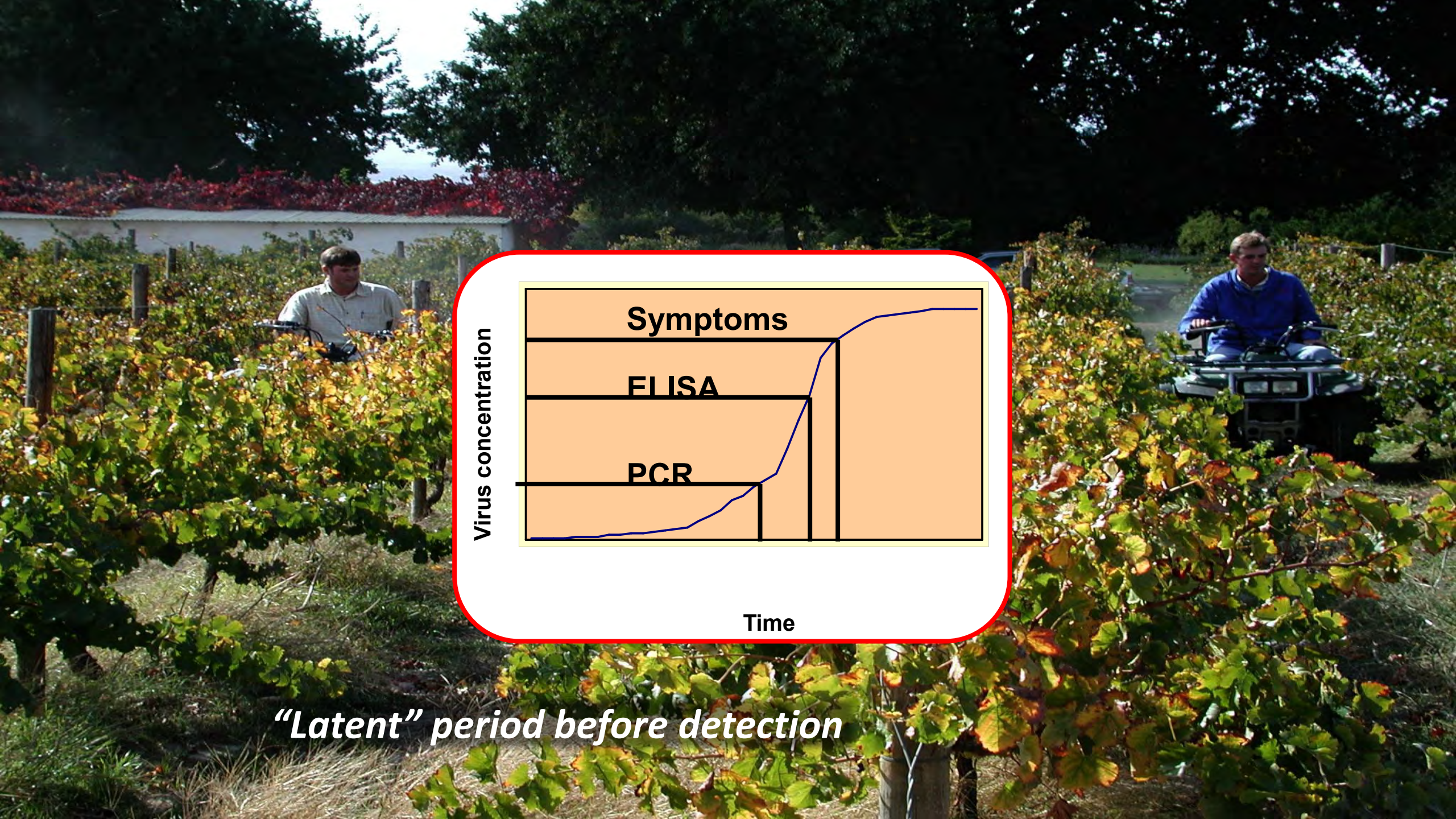
Not possible to have foundation and mother-blocks in isolated areas.

Majority of planting material is mass propagated in foundation & mother blocks in field.

Reliance on active producers (i.e. grape production areas).


Presence of mealybug vectors/virus reservoir.
“Re”-infection of healthy planting material in mother-blocks by GLRaV-3.


Monitor by Visual inspection in red cultivars, ELISA in white cultivars.

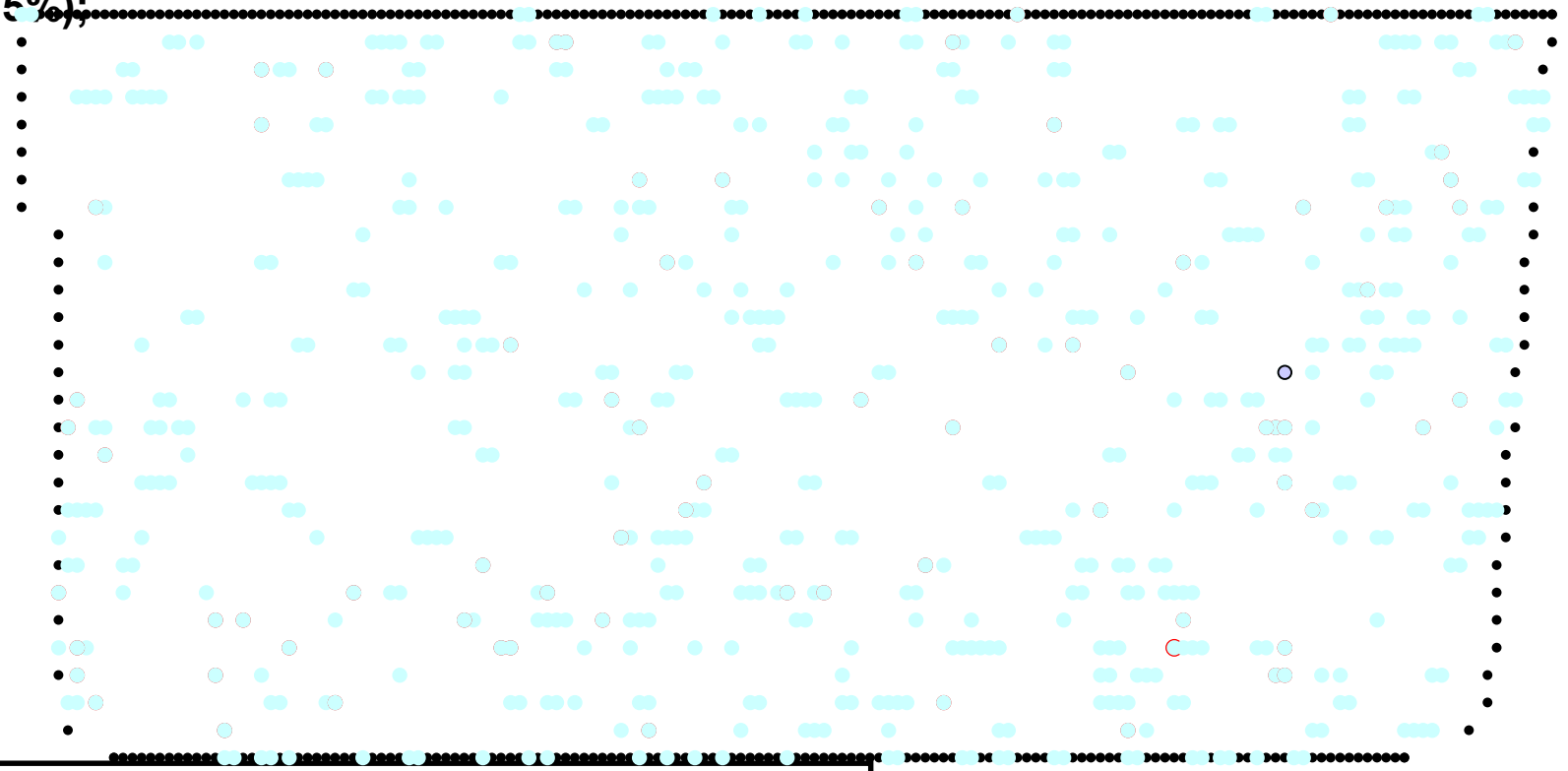


“Latent” period before detection

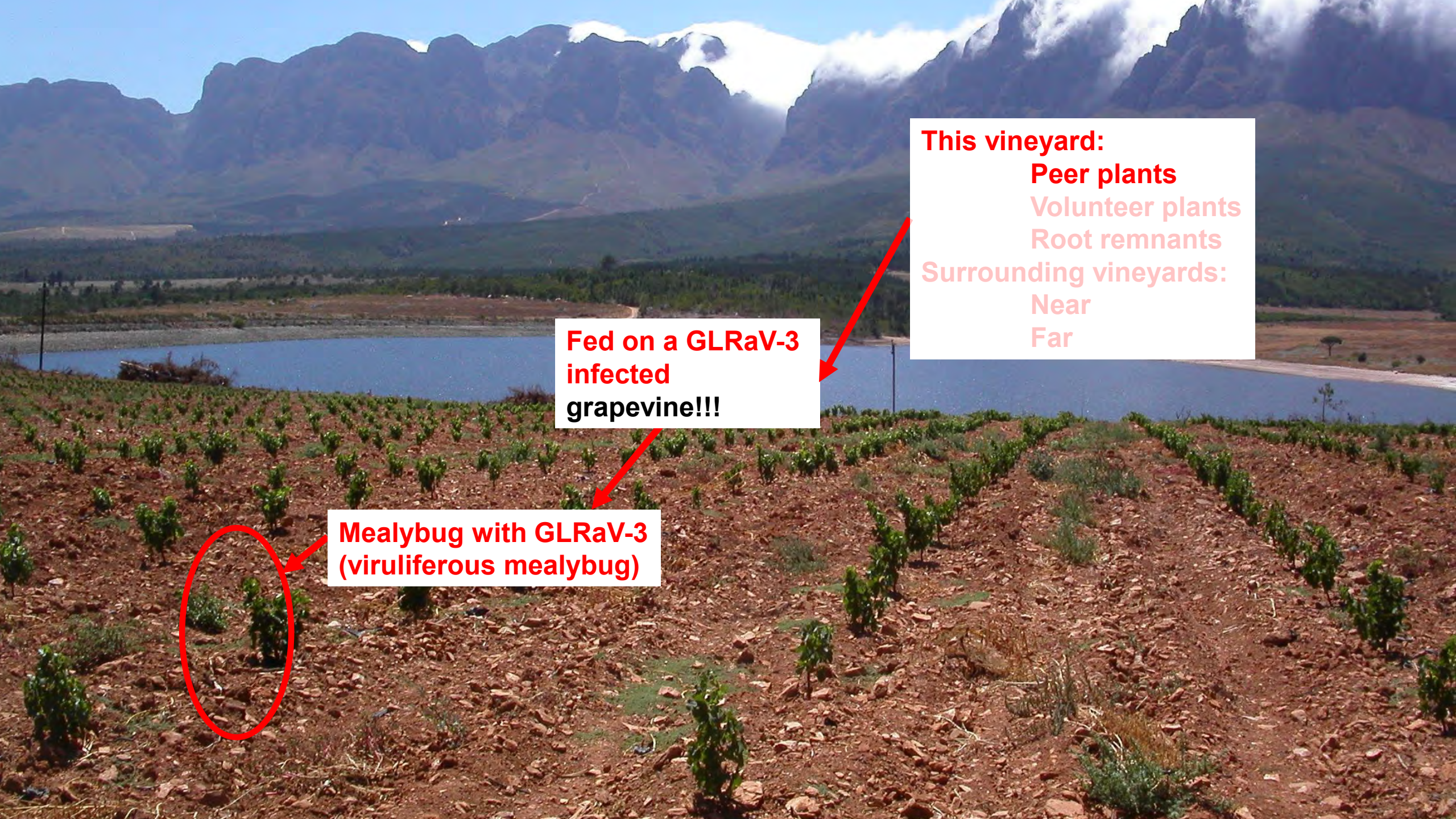
Where possible, plant only 3-star material otherwise if normal plant certified material, treat vines with systemic insecticide.
Monitor symptoms, remove infected vines (red cultivars).

Rooiland 7 (CS46 on 101-14, 1.67ha, 4475 vines)

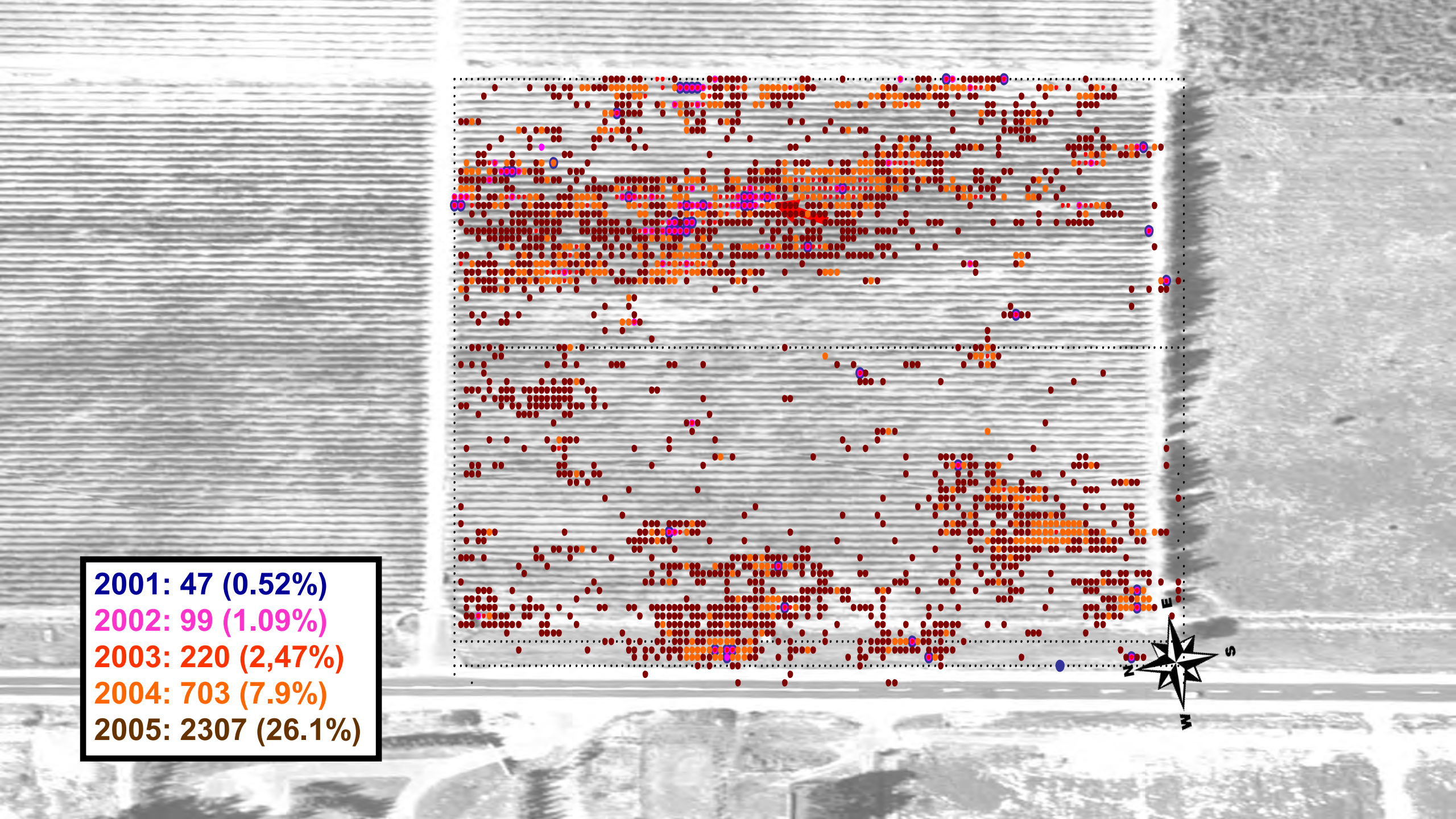
2003: 548 (12.2%): (imidacloprid), removed winter 2003
2004: 27 (0.6%) removed winter 2004
2005: 9 (0.2%) removed winter 2005
2006: 14 (0.32%) removed winter 2006
2007: 17 (0.4%) removed winter 2007
2008: 4 (0.1%),
2009: 3 (0.075%);
2010: 1
2011: 0
2012: 1



Cumulative 13.6% of vines removed


This vineyard:
Peer plants
Volunteer plants
Root remnants
Surrounding vineyards:
Near
Far
Fed on a GLRaV-3 infected grapevine!!!
Mealybug with GLRaV-3 (viruliferous mealybug)

Control of GLRaV-3 spread within a vineyard (secondary spread) is the most critical aspect of control.


2001: 47 (0.52%)
2002: 99 (1.09%)
2003: 220 (2,47%)
2004: 703 (7.9%)
2005: 2307 (26.1%)
N
E
S
W

In a relatively uninfected (<20%) vineyard:

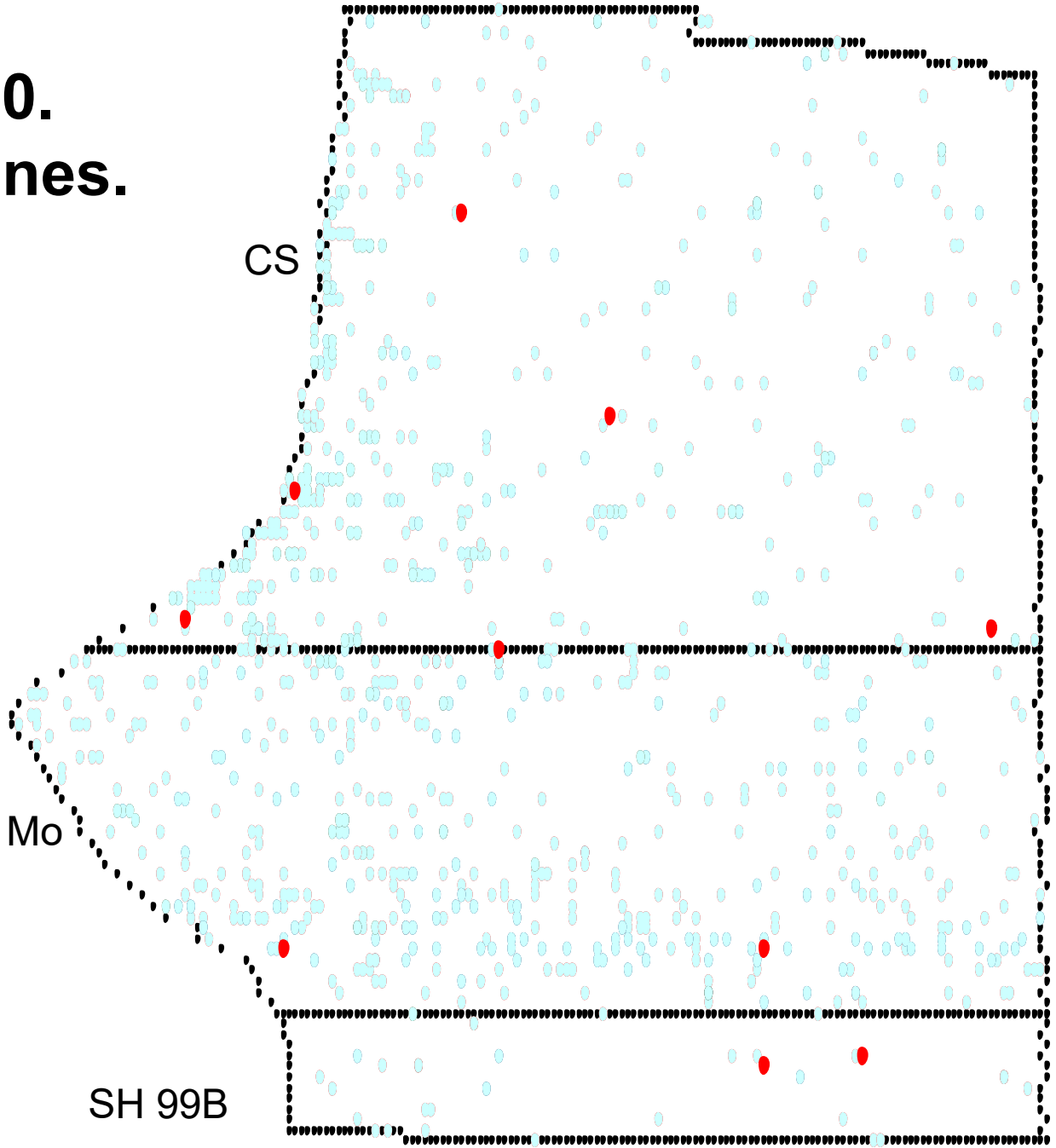
Control mealybugs by treating vines with a systemic insecticide/biological control.

Monitor symptoms (red cultivars), remove infected vines

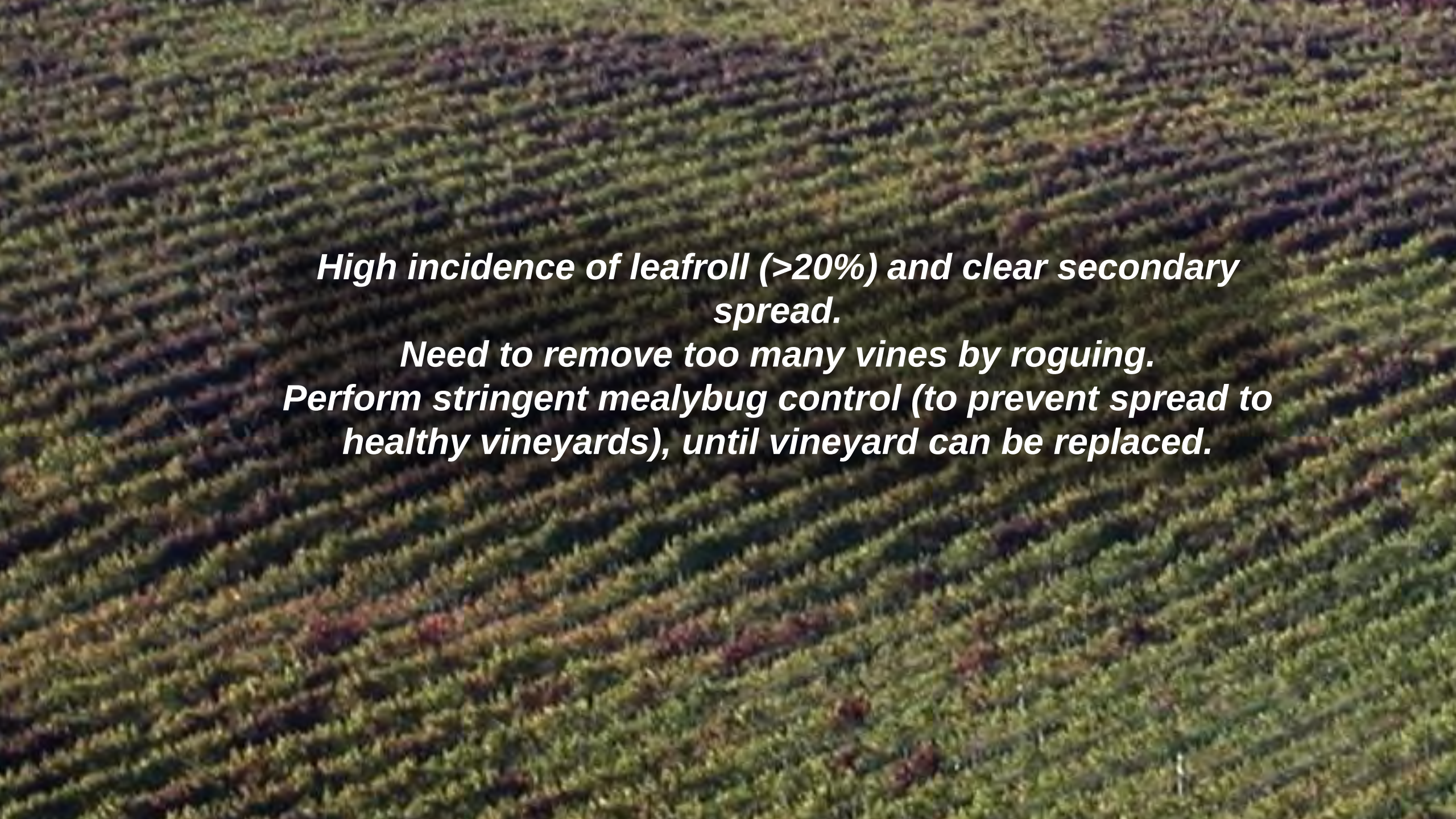
Kopland 5:
Established 2000.
5.16ha, 13830 vines.

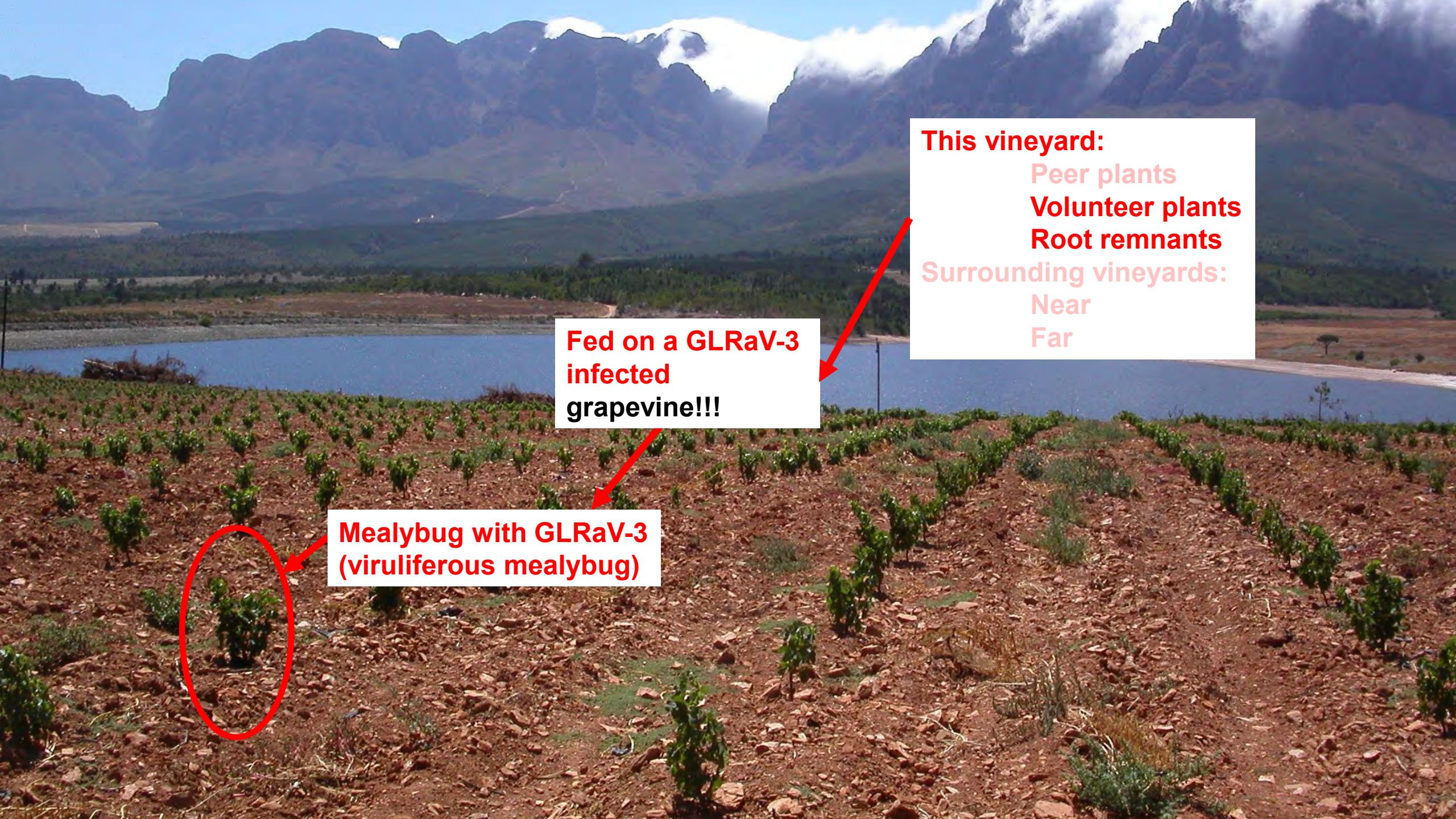
2006: 509 (3.7%)
2007: 211 (1.7%)
2008: 101 (0.8%)
2009: 30 (0.23%)
2010: 22 (0.17%)
2011: 12 (0.09%)
2012: 10 (0.08%)

481 more (almost double) vines removed than initially recorded



Remove totally or kill infected vines, otherwise they continue to serve as inoculum sources.

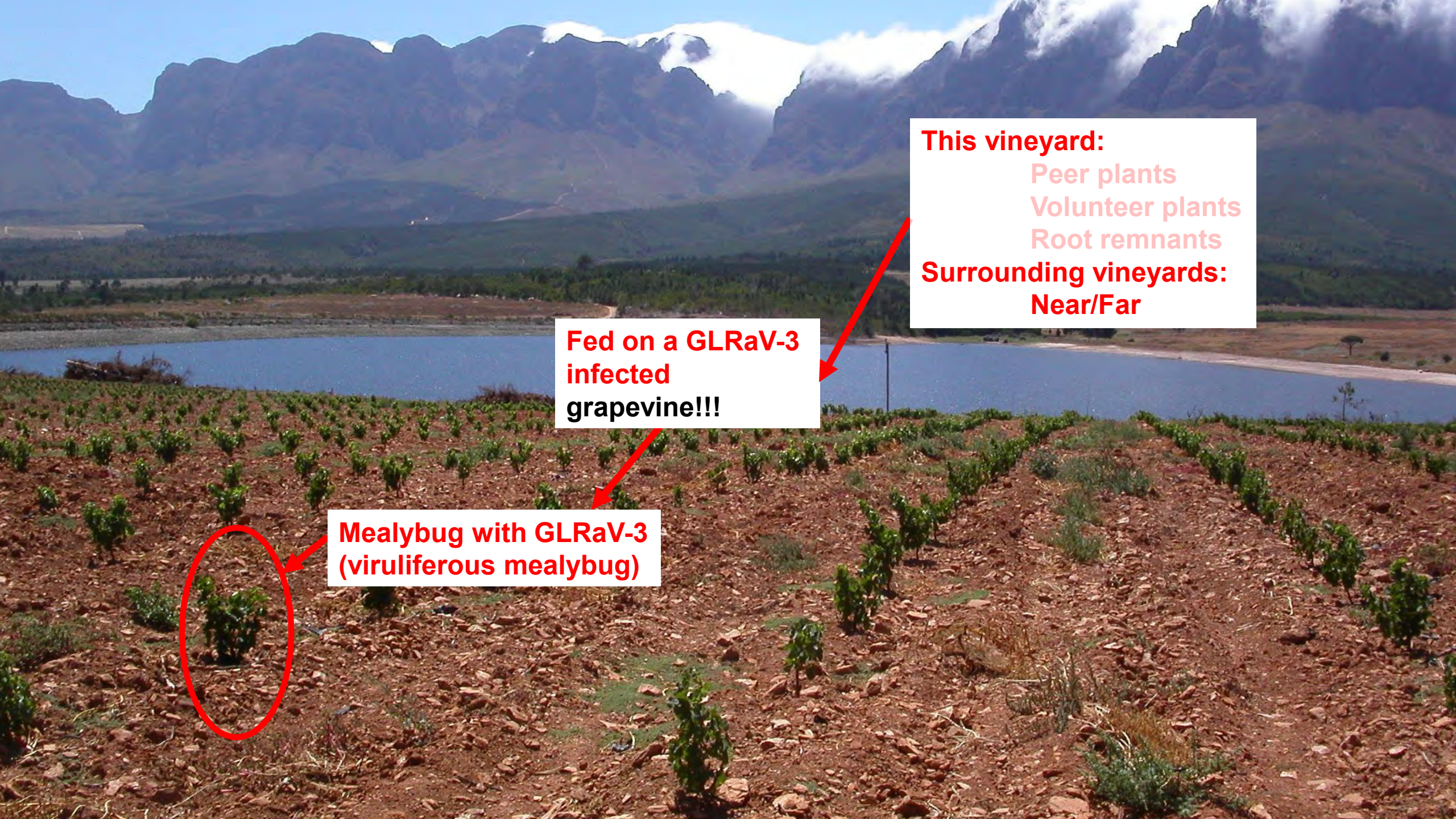

High incidence of leafroll (>20%) and clear secondary spread.
Need to remove too many vines by roguing.
Perform stringent mealybug control (to prevent spread to healthy vineyards), until vineyard can be replaced.


This vineyard:
Peer plants
Volunteer plants
Root remnants
Surrounding vineyards:
Near
Far
Fed on a GLRaV-3 infected grapevine!!!
Mealybug with GLRaV-3 (viruliferous mealybug)

In the preceding, old vineyard treat with systemic insecticide in last season and remove roots thoroughly.

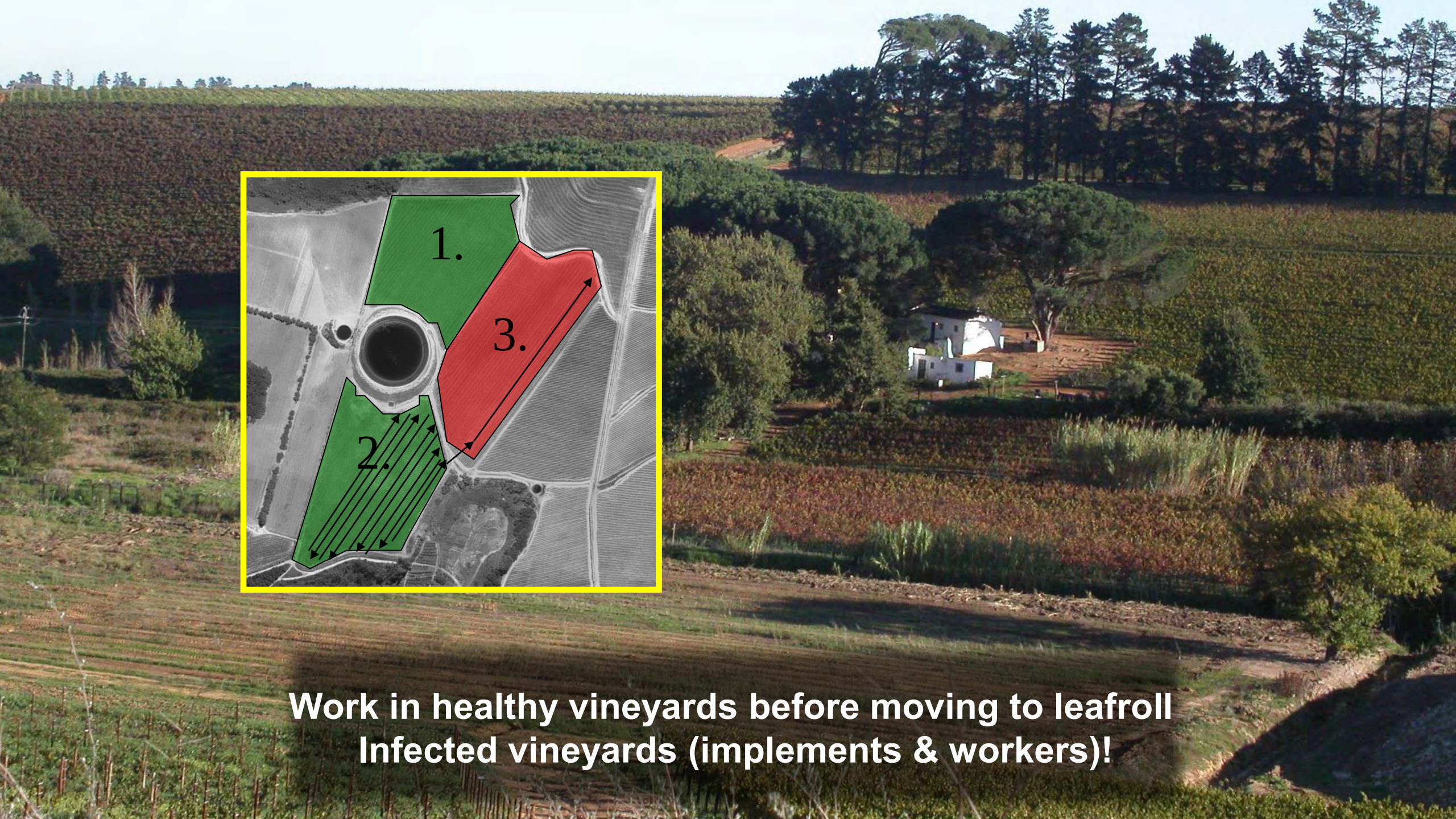
Use fallow period to remove volunteers of old vineyard (LR infected)


Remove volunteers in vineyards


This vineyard:
Peer plants
Volunteer plants
Root remnants
Surrounding vineyards:
Near/Far
Fed on a GLRaV-3 infected grapevine!!!
Mealybug with GLRaV-3 (viruliferous mealybug)

Typical edge effect or “disease gradient” when infection comes from an adjoining vineyard

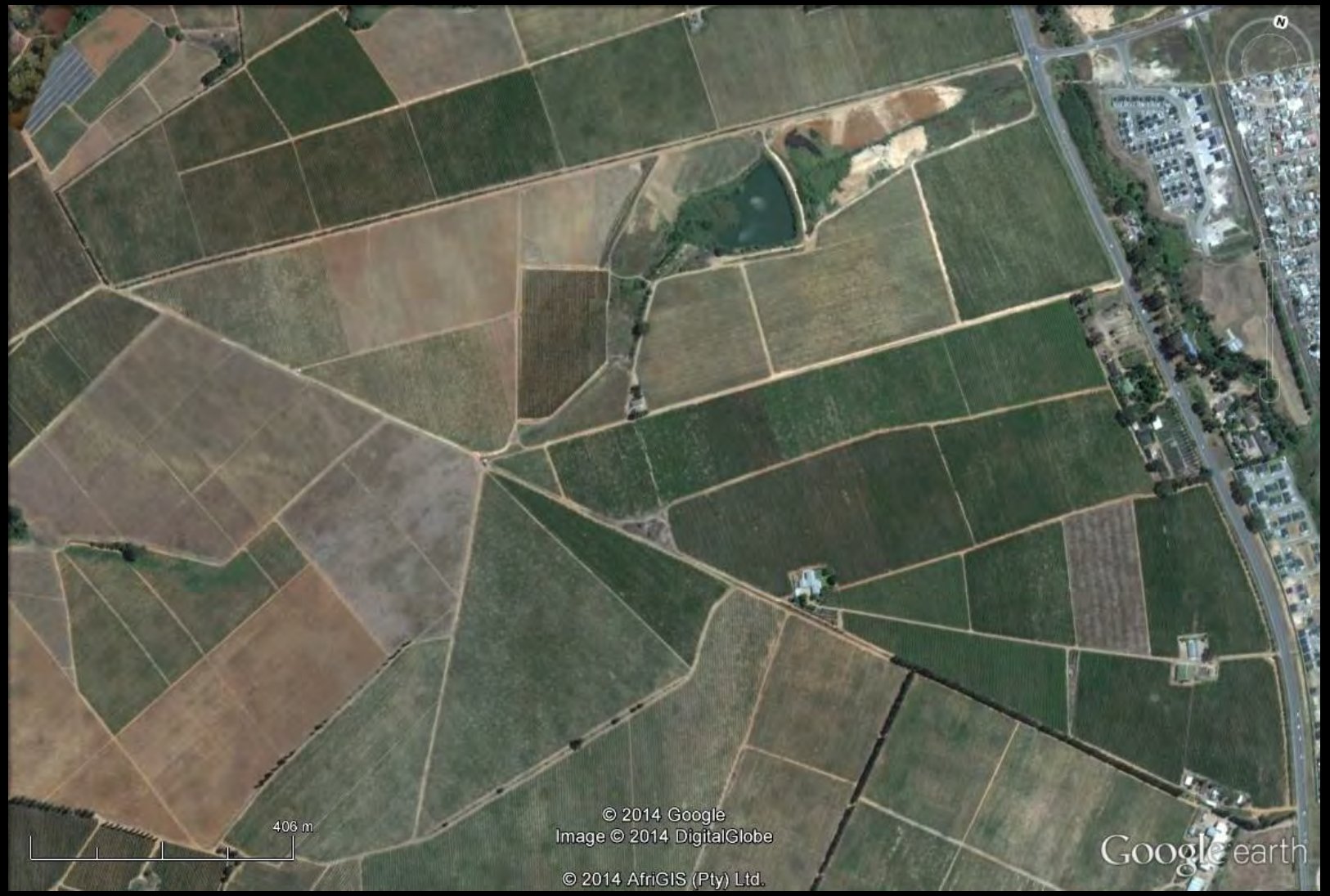
Control mealybugs in adjoining and distant leafroll infected vineyards!



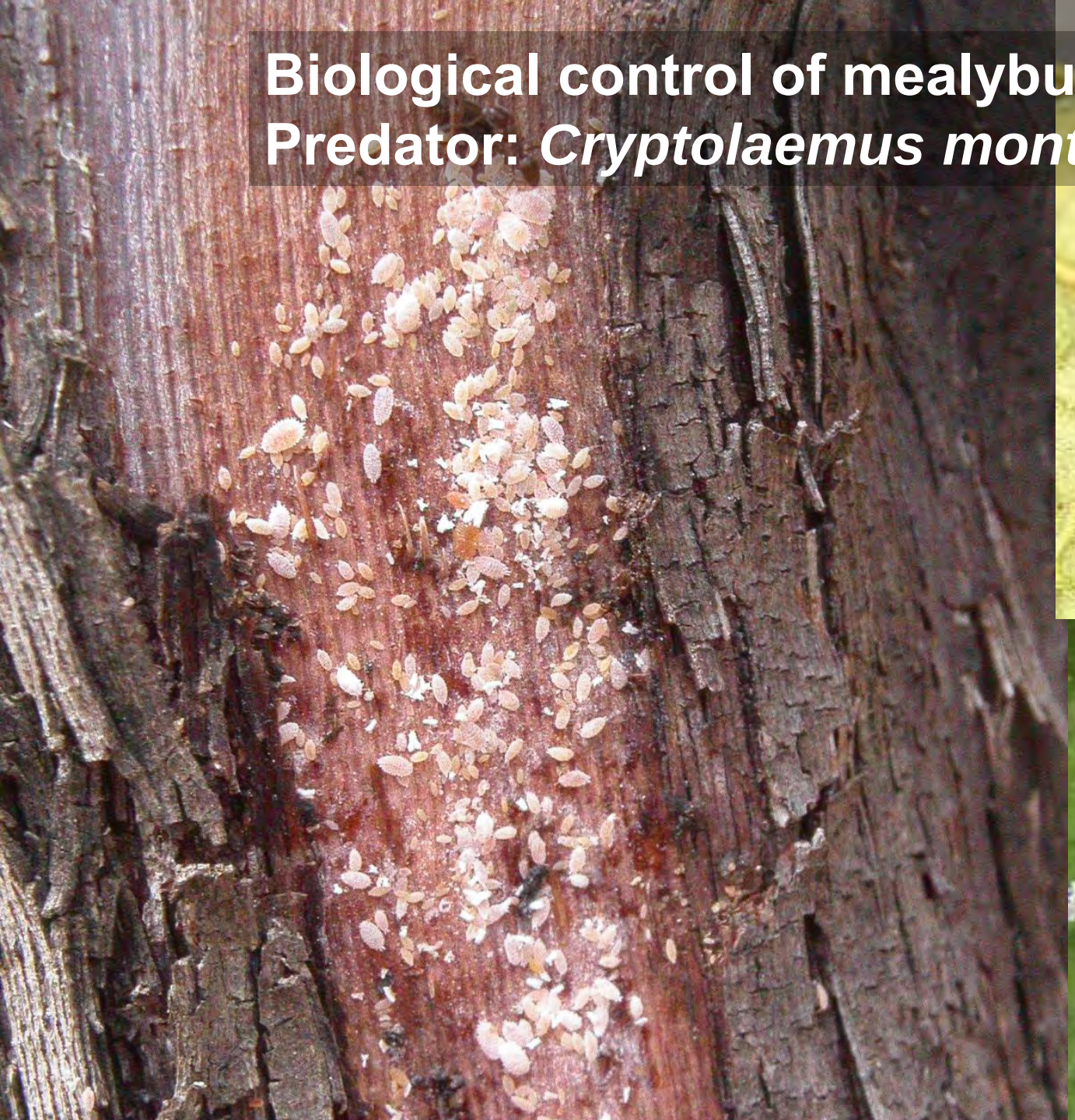
Work in healthy vineyards before moving to leafroll Infected vineyards (implements & workers)!

Wash off mealybugs if implements were used
in leafroll infected vineyards

Neighbour doesn’t control mealybug or leafroll?



Biological control of mealybugs: Predator: *Cryptolaemus montrouzieri*

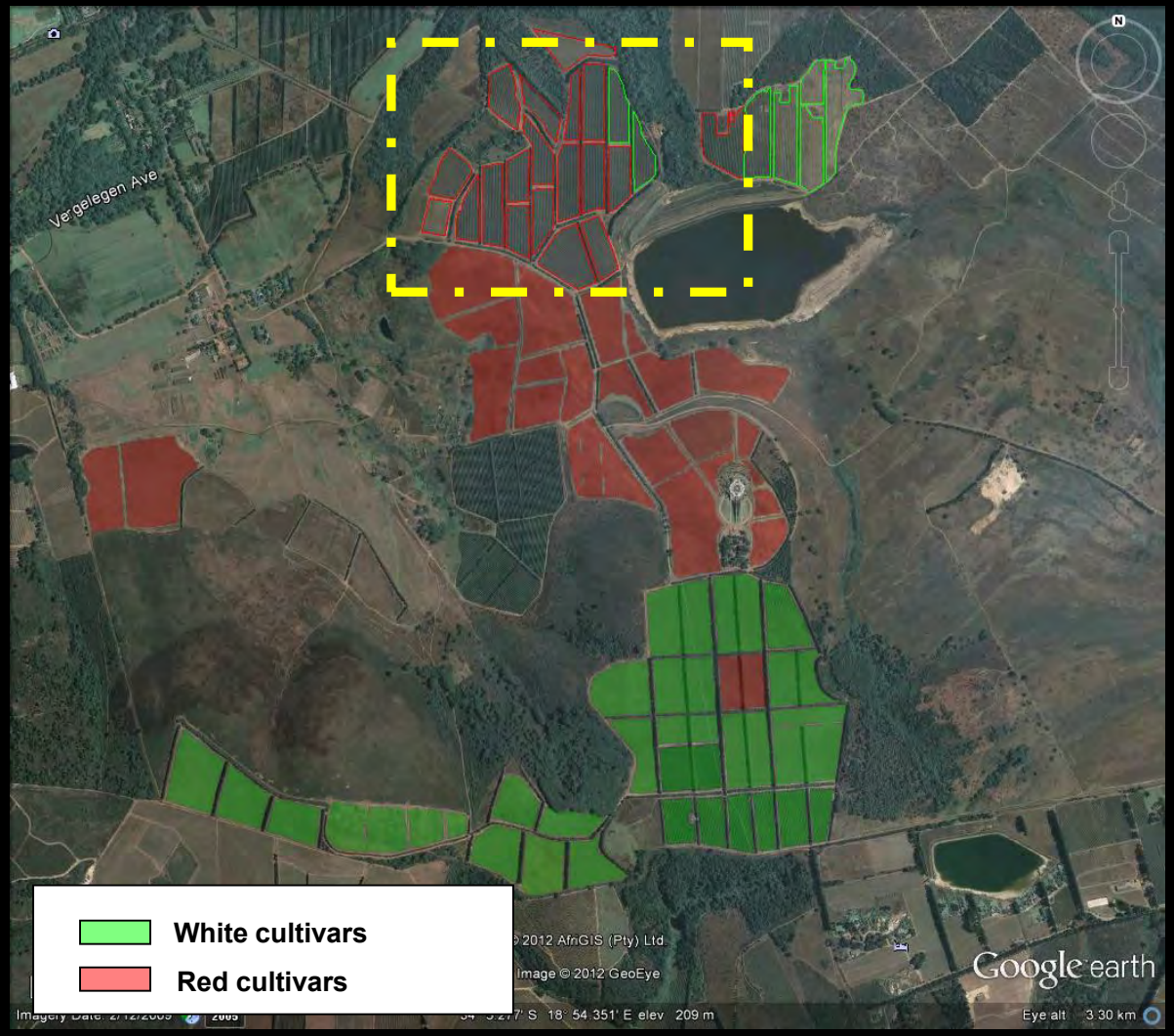


Biological control of mealybugs:
Parasitoid: *Leptomastix dactylopii*
Augmentative biological control


Worcester
R60
Paarl
R312
R304
Sandringham Cl
M15
R27
M7
Old Paarl Rd
Cape Town, South Africa
Cape Town
R102
M5
Stellenbosch
R310
Adam Tas
Baden Powell Dr
M3
Somerset West
R45
R406
R44
VERGELEGEN
Africa
Integrated control strategy
tested on a commercial scale
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Cnes/Spot Image
© 2012 AfriGIS (Pty) Ltd.
27 km
34° 9.098' S 18° 46.484' E elev -13 m
Google earth
Eye alt 116.33 km

Phase 1:

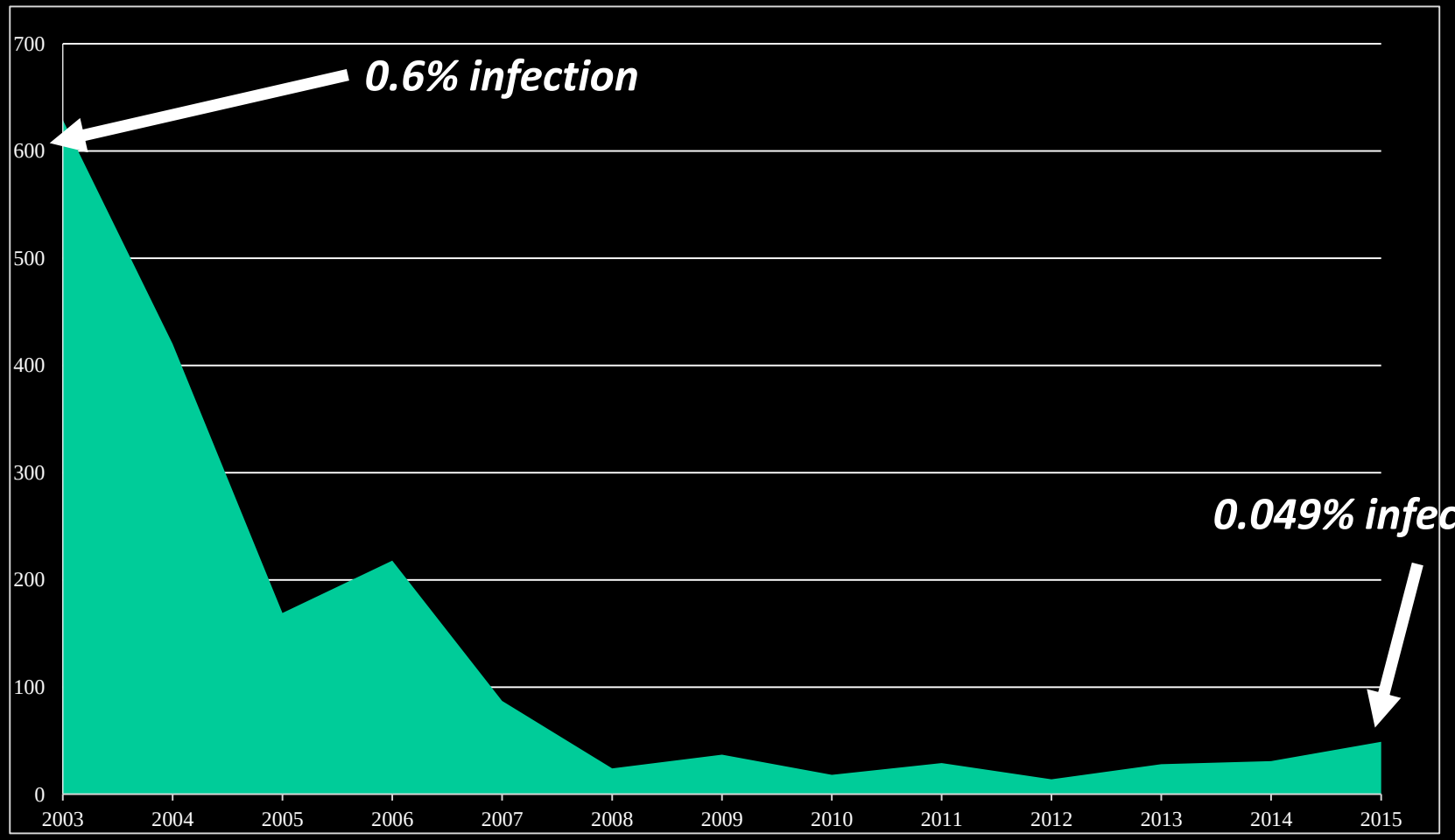
On virgin soils (foundation blocks), mainly red cultivars. Plant from 1999-2003. 36,6ha (904 acres)



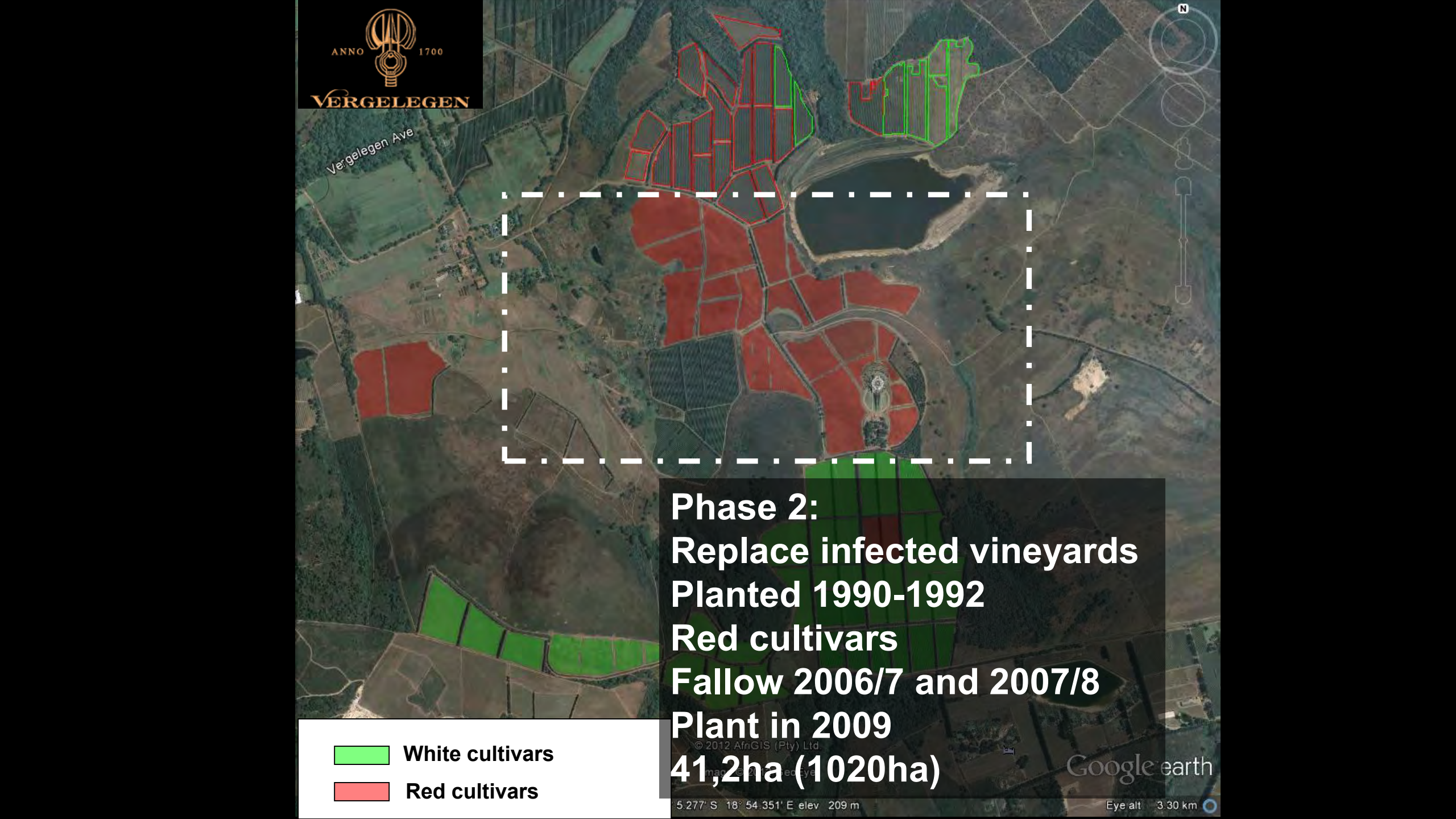
ANNO 1700

VERGELEGEN

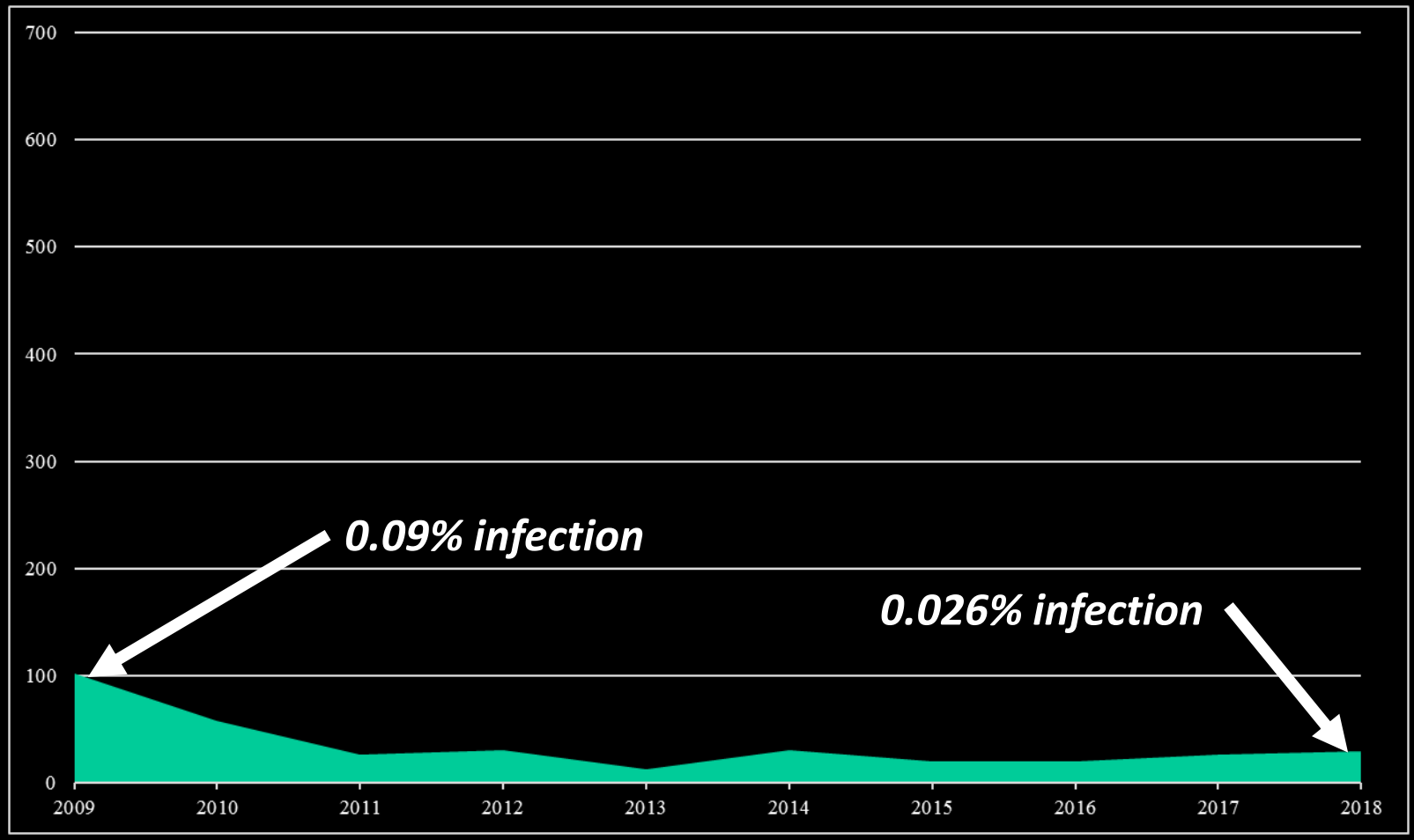
Number of leafroll infected vines in Phase 1 on Vergelegen (Total number of vines = 98195)



1753 vines (1.7% of total) removed in past 13 years

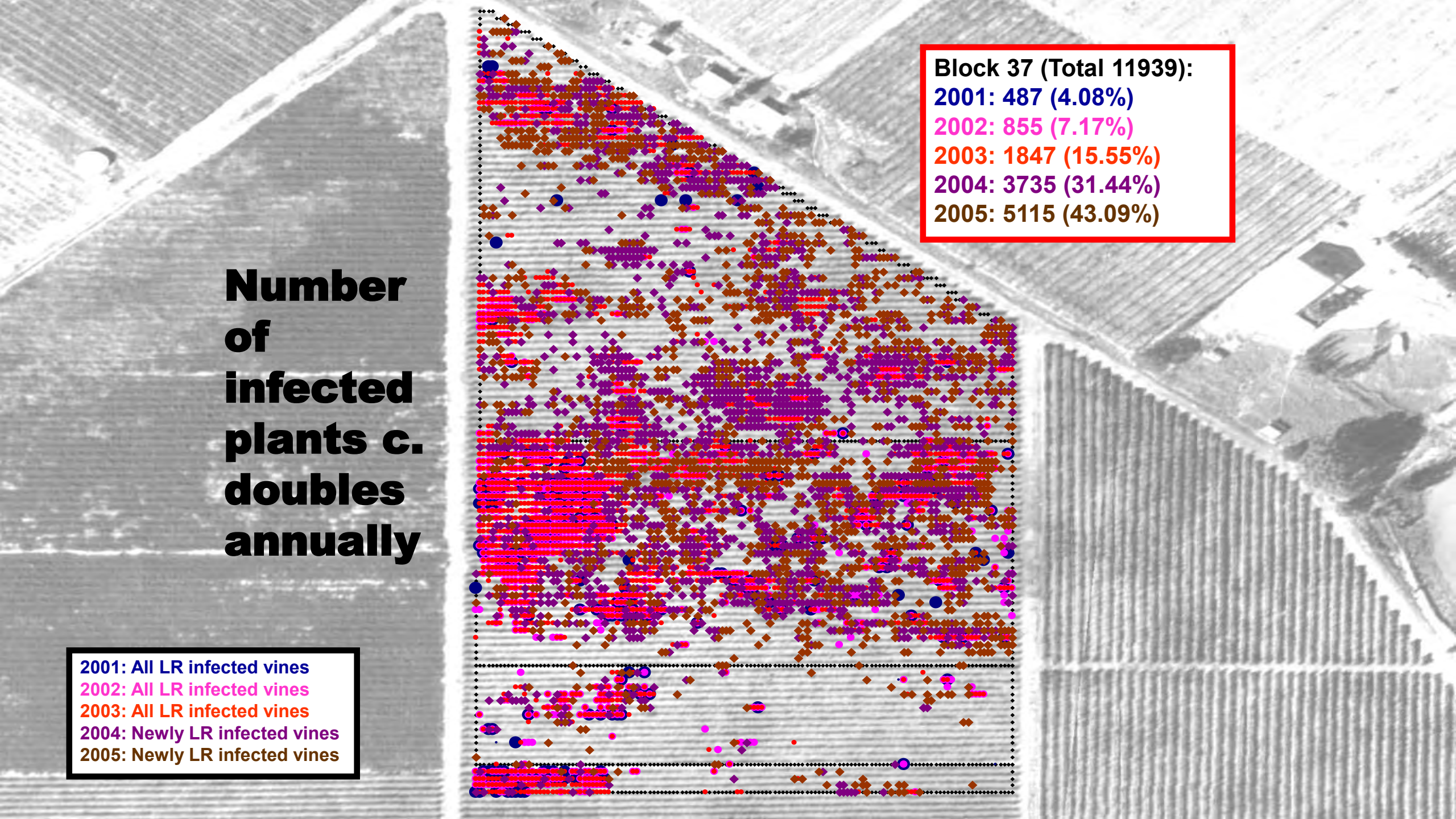

ANNO 1700
VERGELEGEN
Vergelegen Ave
Phase 2:
Replace infected vineyards
Planted 1990-1992
Red cultivars
Fallow 2006/7 and 2007/8
Plant in 2009
41,2ha (1020ha)
White cultivars
Red cultivars
© 2012 AfriGIS (Pty) Ltd
Google earth
5.277' S 18° 54.351' E elev 209 m
Eye alt 3.30 km

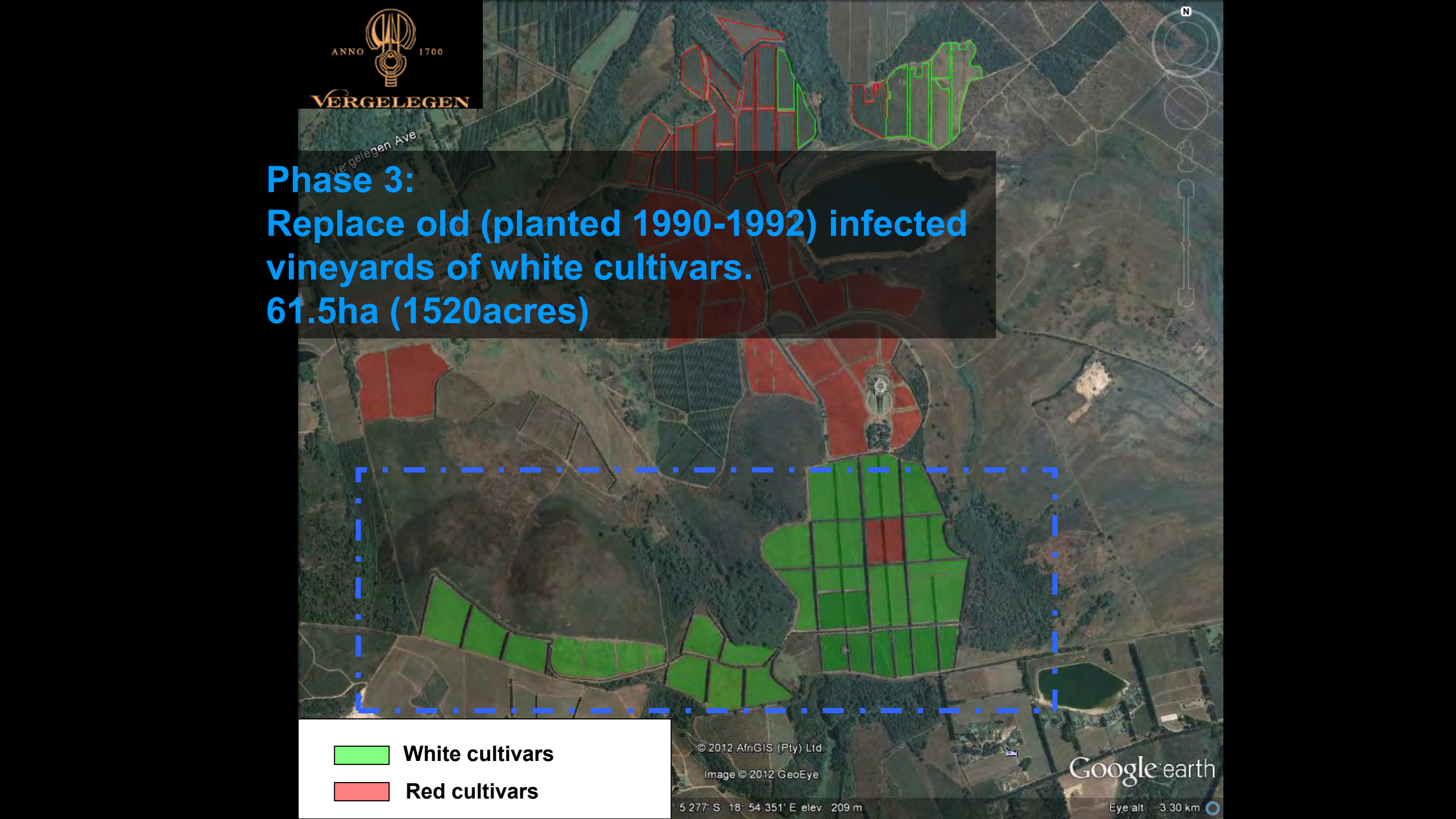
Number of leafroll infected vines in Phase 2 on Vergelegen (Total number of vines = 111431)

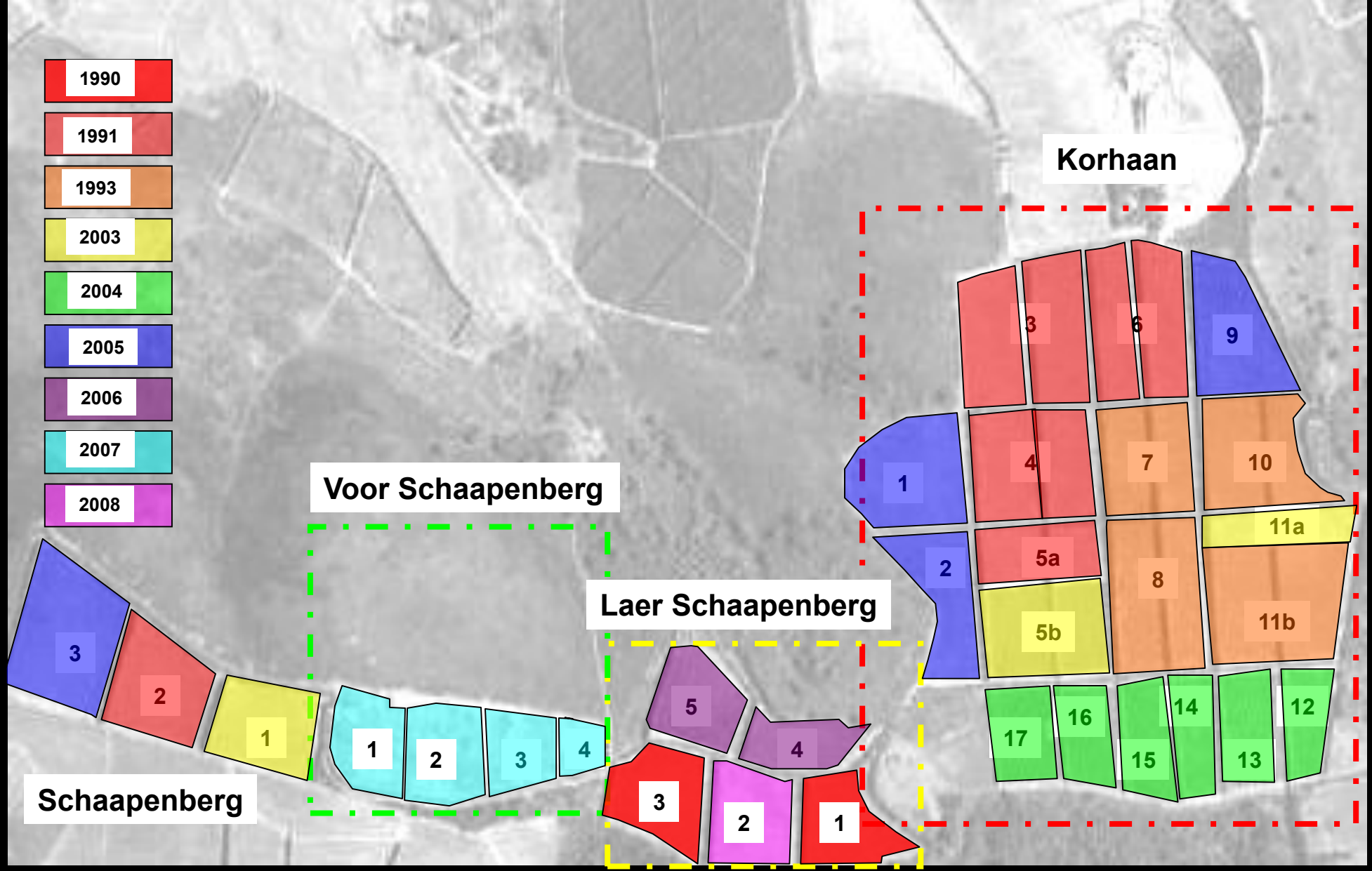


354 vines (0.31% of total) removed in past 10 years


Exception to find leafroll infected vines in 19 year-old red cultivars on Vergelegen, following sustained roguing

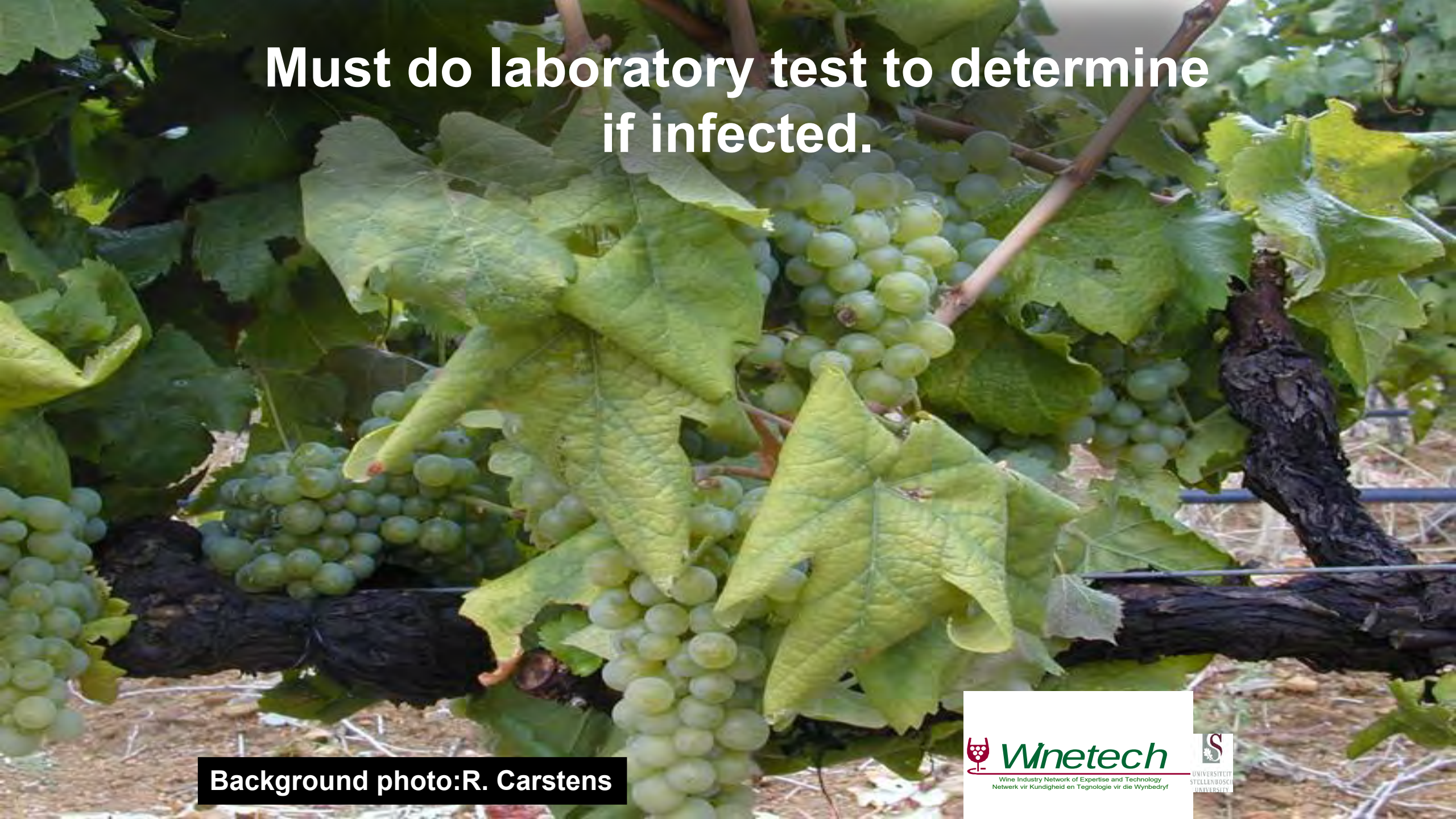

Block 37 (Total 11939):
2001: 487 (4.08%)
2002: 855 (7.17%)
2003: 1847 (15.55%)
2004: 3735 (31.44%)
2005: 5115 (43.09%)
Number of infected plants c. doubles annually
2001: All LR infected vines
2002: All LR infected vines
2003: All LR infected vines
2004: Newly LR infected vines
2005: Newly LR infected vines


ANNO 1700
VERGELEGEN
Vergelegen Ave
Phase 3:
Replace old (planted 1990-1992) infected vineyards of white cultivars.
61.5ha (1520acres)
White cultivars
Red cultivars
© 2012 AfriGIS (Pty) Ltd
Image © 2012 GeoEye
Google earth
Eye alt 3.30 km



Old vine removal period from 2003/4, still continuing
Plant from 2009-

Must do laboratory test to determine if infected.



Background photo:R. Carstens

Winetech
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Annual GLRaV-3 ELISA tests done annually.
Composite sample of 10 vines, if composite positive - test individual vines

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Korhaan 1

- Border plant
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- LR 2016

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Netwerk vir Kundigheid en Tegnologie vir die Wynbedryf

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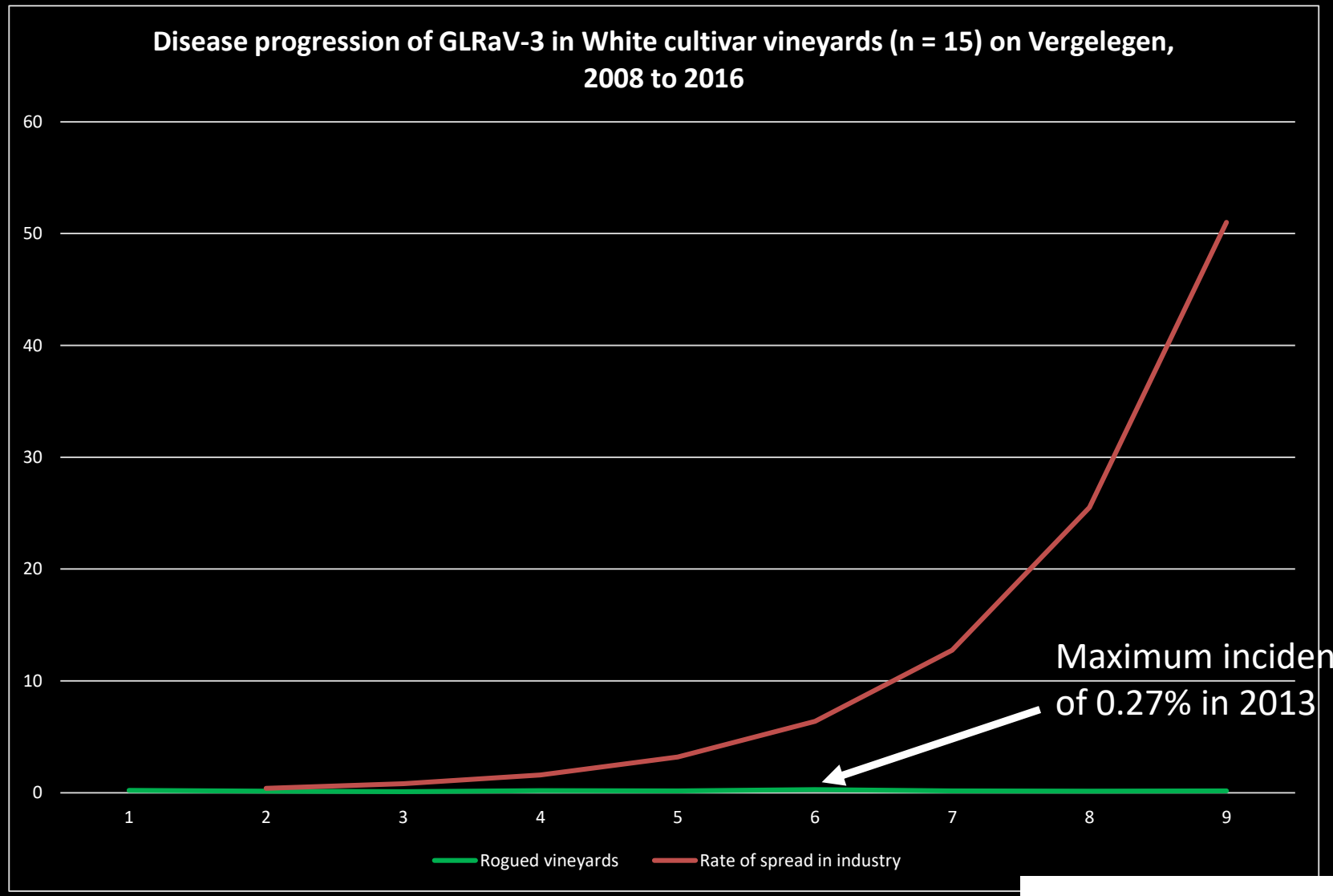

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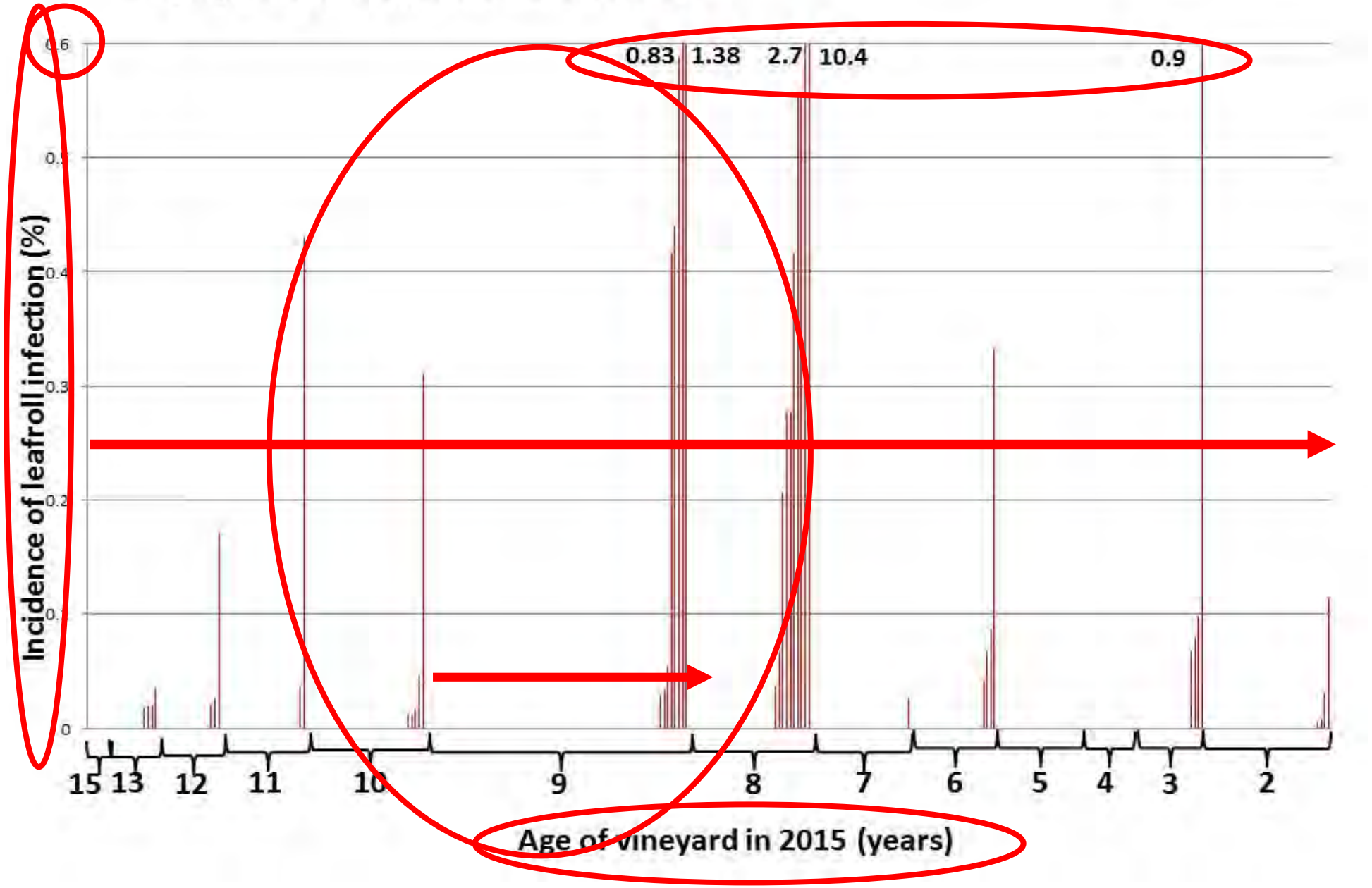
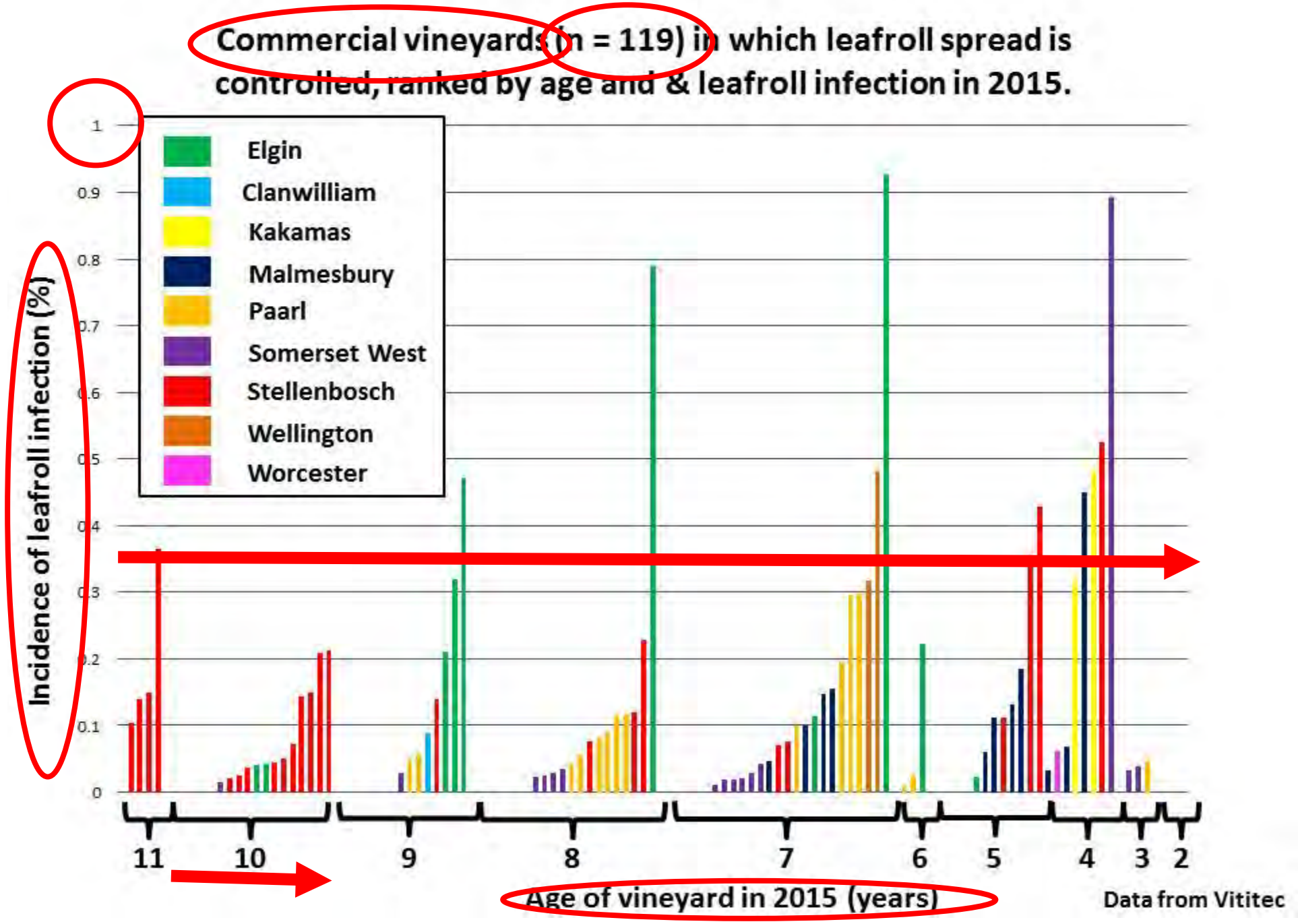
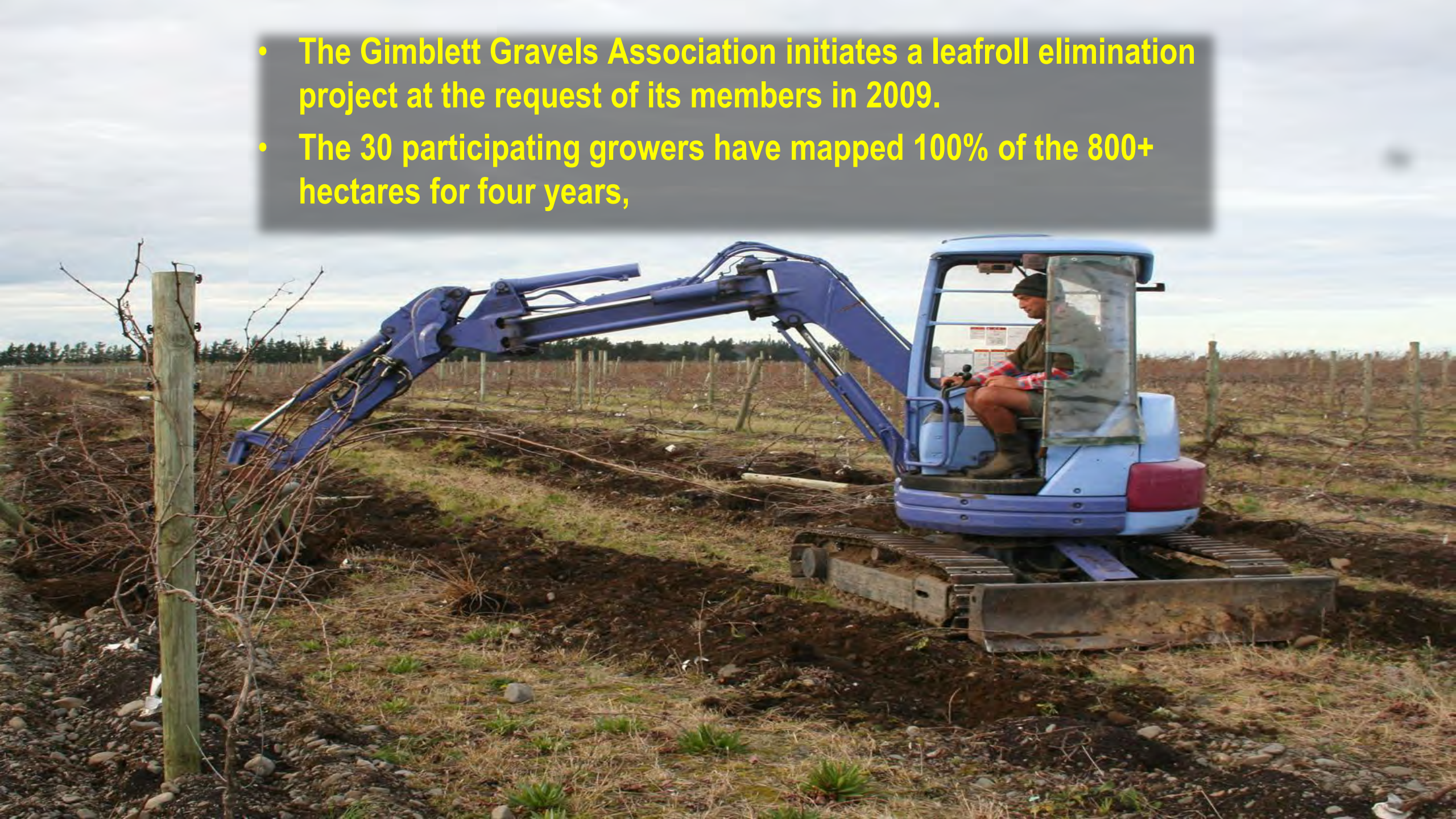

Foundation vineyards (n = 335) in which leafroll spread is controlled, ranked by age and & leafroll infection in 2015
0.83
1.38
2.7
10.4
0.9
Incidence of leafroll infection (%)
0.6
0.4
0.3
0.2
0
15
13
12
11
10
9
8
7
6
5
4
3
2
Age of vineyard in 2015 (years)

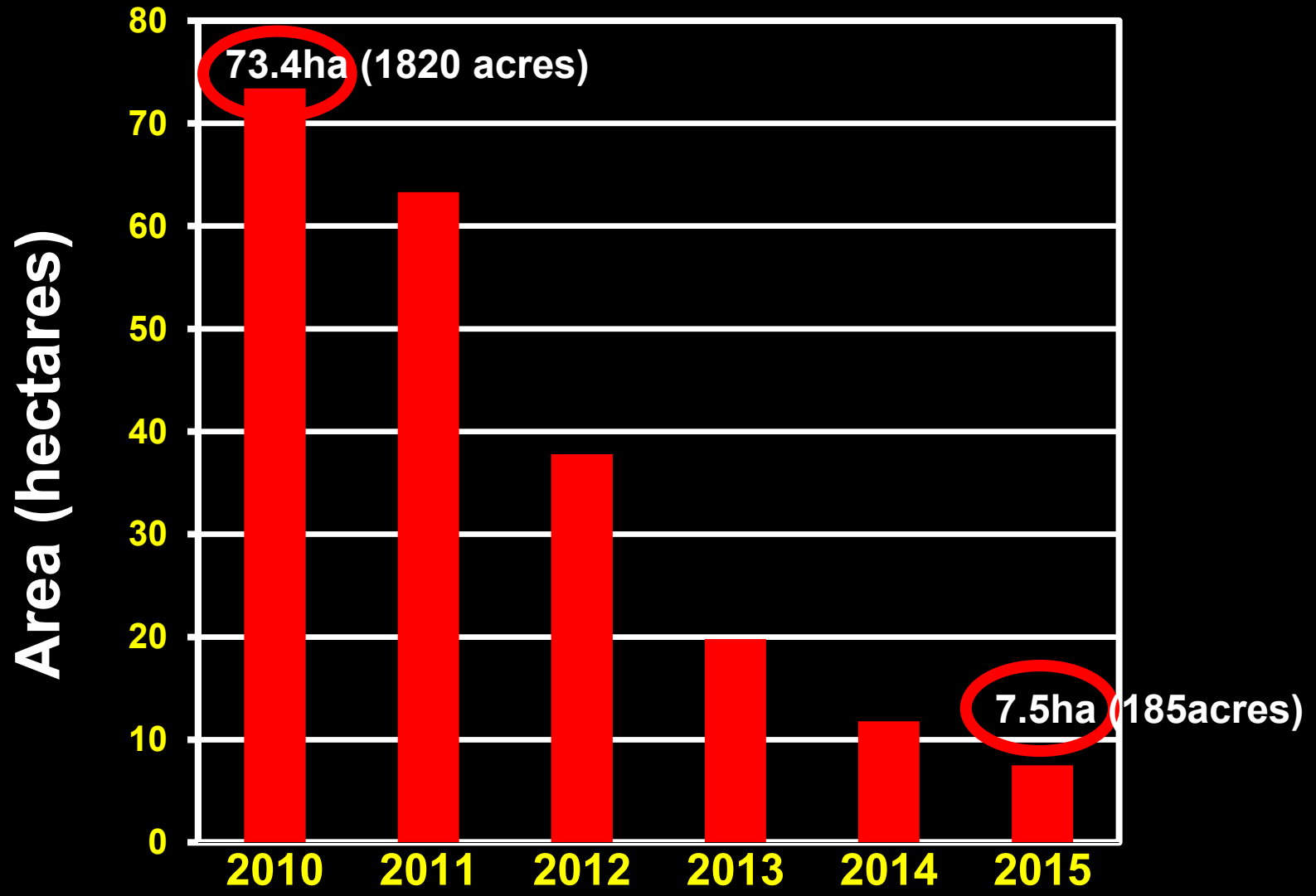

Commercial vineyards (n = 119) in which leafroll spread is controlled, ranked by age and & leafroll infection in 2015.
Incidence of leafroll infection (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Elgin
Clanwilliam
Kakamas
Malmesbury
Paarl
Somerset West
Stellenbosch
Wellington
Worcester
11
10
9
8
7
6
5
4
3
2
Age of vineyard in 2015 (years)
Data from Vititec

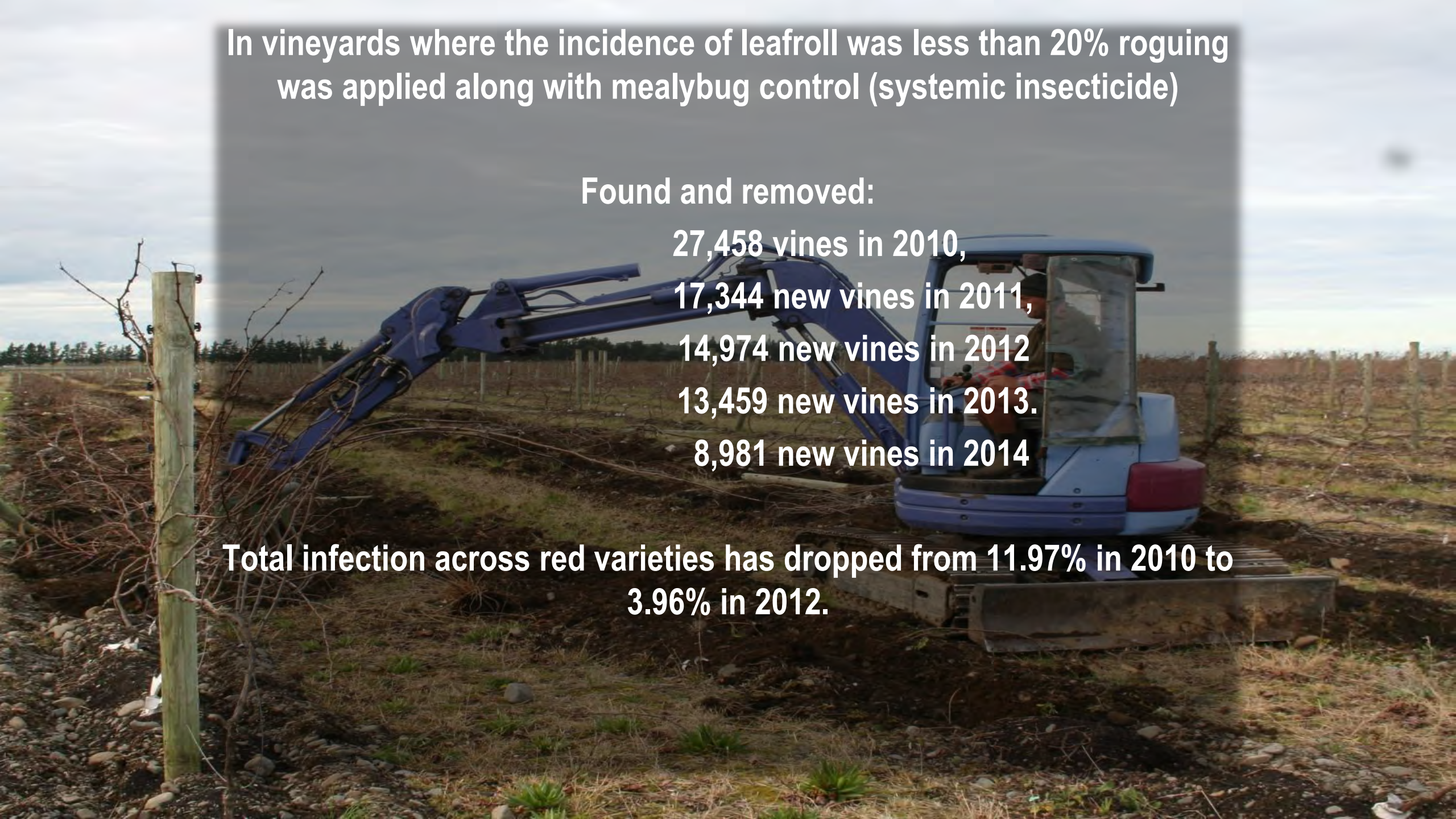
Collaboration (2009-2015) with New Zealand Winegrowers to implement leafroll control.

- The Gimblett Gravels Association initiates a leafroll elimination project at the request of its members in 2009.
- The 30 participating growers have mapped 100% of the 800+ hectares for four years,



Heavily-infected areas (> 20% infection): Gimblett Gravels, 2009-2015





In vineyards where the incidence of leafroll was less than 20% roguing was applied along with mealybug control (systemic insecticide)

Found and removed:

27,458 vines in 2010,

17,344 new vines in 2011,

14,974 new vines in 2012

13,459 new vines in 2013.

8,981 new vines in 2014

Total infection across red varieties has dropped from 11.97% in 2010 to 3.96% in 2012.


Conclusion: At least all new vineyards
should be managed using the leafroll control
methods developed.

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Image: M. van Rensburg, 2019

Acknowledgments

Kris Beale
“The Vineyard Team”
Clifford Ohmart

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Stellenbosch University

Winetech
Wine Industry Network of Expertise and Technology
Netwerk van Kundigheid en Tegnologie vir die Wynbedryf

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The IGWS leafroll fact sheets are available at:
http://igws.co.za/content/fact-sheets/leafroll
http://www.winetech.co.za/knowledge-transfer/topical-issues
A case study of control of Grapevine Leafroll Disease spread at a commercial Wine Estate in South Africa. American Journal of Enology and Viticulture. 64:296-306
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