UNSW
THE UNIVERSITY OF NEW SOUTH WALES

AFAC 2016
Brisbane
30 August – 1 September

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IMPACTS OF TOPOGRAPHY AND POST-FIRE REGROWTH ON WITHIN CANOPY WIND SPEED REDUCTION

or

WIND SPEED REDUCTION INDUCED BY POST-FIRE VEGETATION REGROWTH

R. Quill[1], K. Moon[2], J. J. Sharples[1], L. A. Sidhu[1], T. Duff[2], K. Tolhurst[2]
[1] School of Physical, Environmental and Mathematical Sciences, UNSW Canberra
[2] Department of Forest and Ecosystem Science, Faculty of Science, University of Melbourne, Creswick, Victoria

Corresponding Author: rachael.quill@student.adfa.edu.au

AIM

bushfire&natural HAZARDSCRC

Background

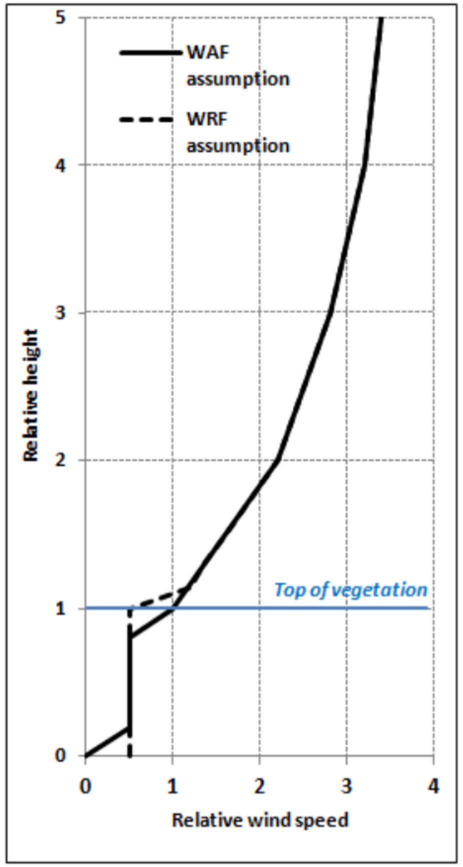
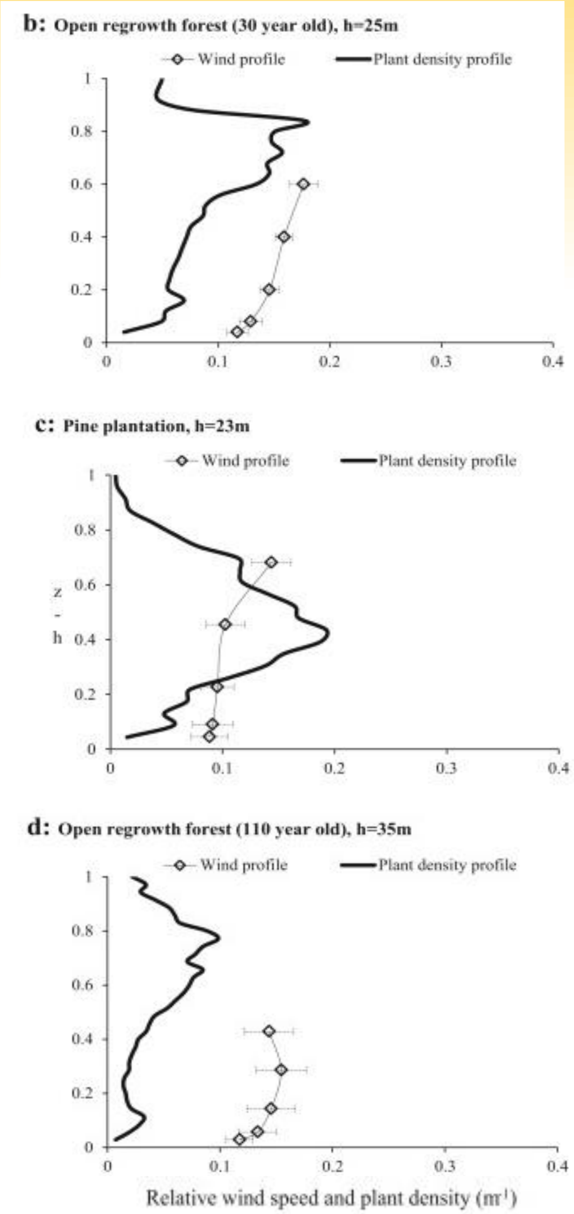


Figure 2 from Moon et al. (2013)

- Traditional log wind speed profile (Touma, 1977).
- Wind speed at ***mid-flame height***
  - Wind Reduction Factors, WRF = open (10m) /sheltered (Cionco, 1972; Rothermel, 1972).
  - In the US, Wind Adjustment Factors, WAF = sheltered/open (20ft) (Andrews, 2012).
- These are calculated according to vegetation properties, but assume uniformity beneath the canopy.
- **But**, we know that winds beneath the canopy are anything but uniform (e.g. Finnigan, 2000, Belcher et al.,2012).

Background

- ***Variation in wind = Variation in fire!***
- Kangmin Moon et al. (2013, In Press)
  - (*referred to as **M13** and **M16** herein*)
  - Empirical wind speed reduction profiles characterised for vegetation types.
  - Conducted over flat terrain to minimise impacts of topography.
- **Study Aim:** to evaluate the empirical wind speed reduction profiles of M13 and M16 using data from complex and undulating terrain.



Sections of Figure 2 from Moon et al. (In Press)

Case Study I: Flea Creek Valley

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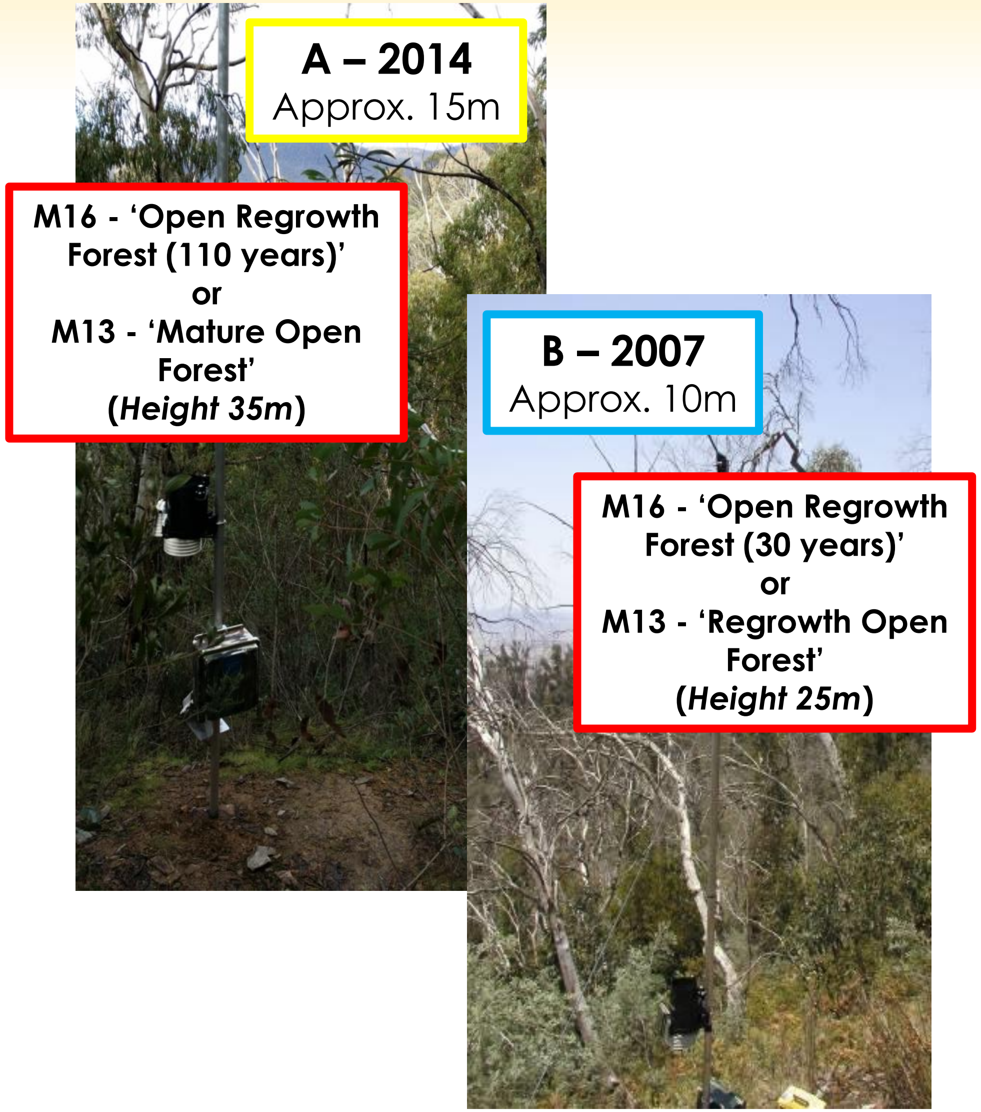
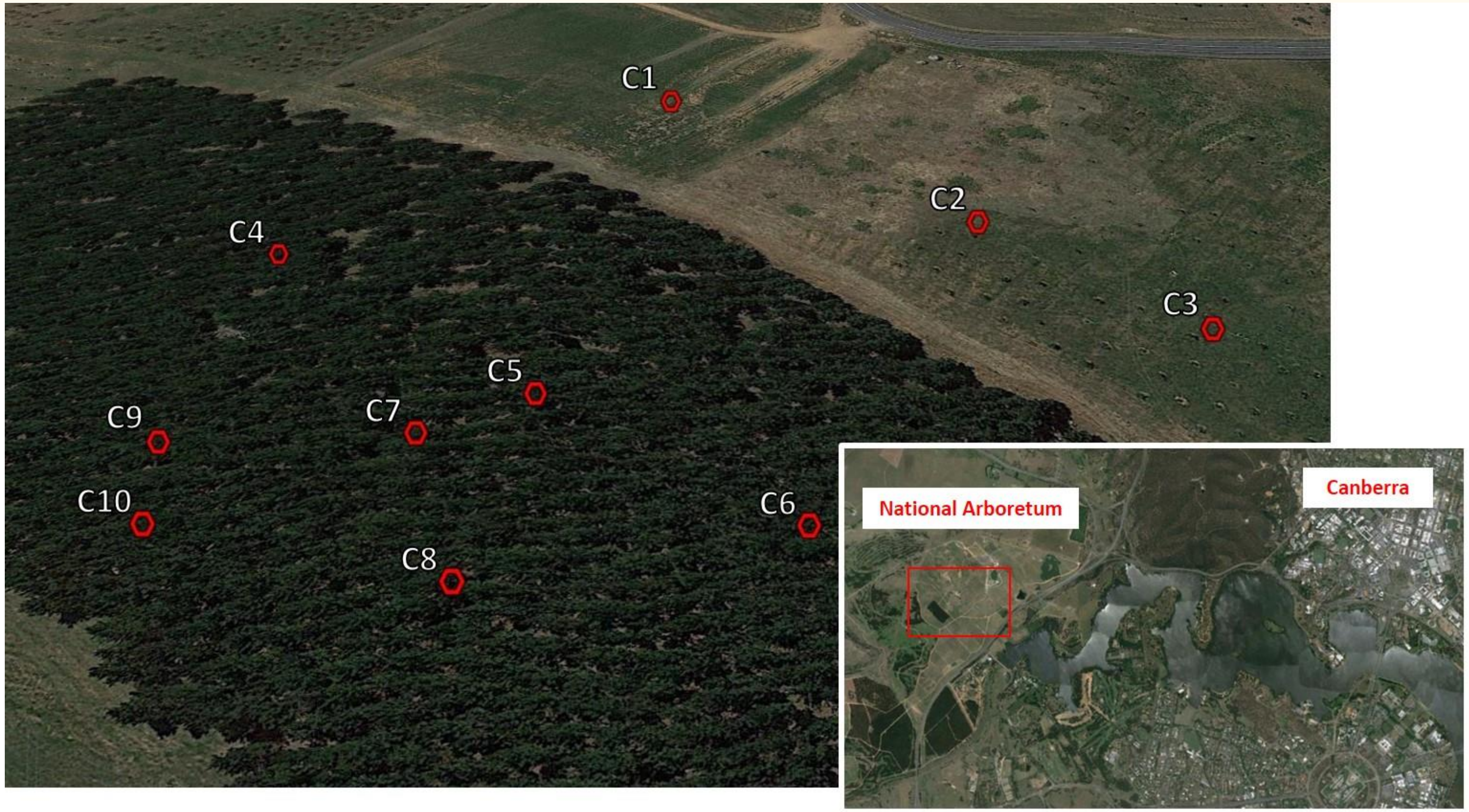


Case Study II: National Arboretum Canberra



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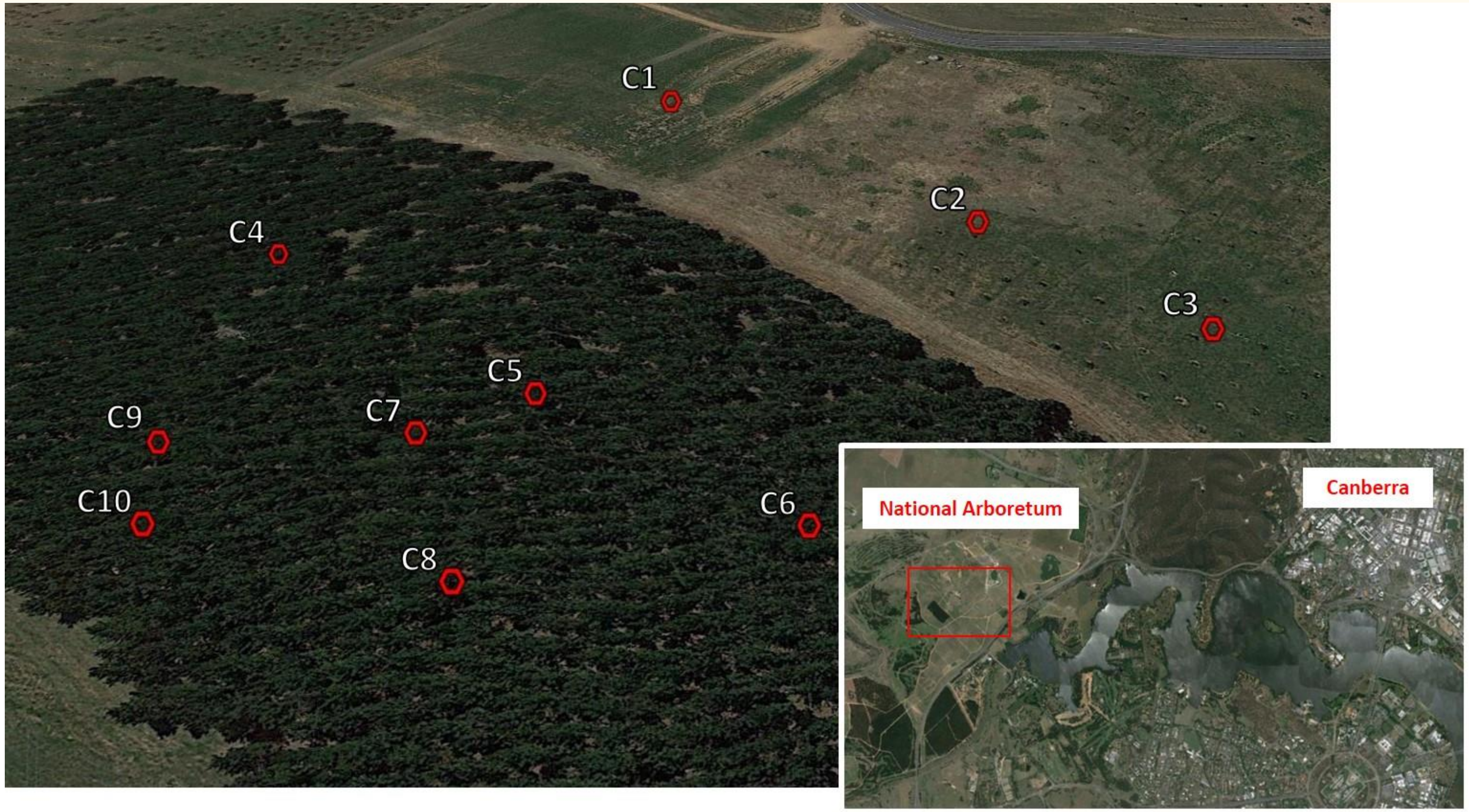

Empirical Wind Speed Profiles

M13 and M16

- Collection of wind data at seven vegetation types across Victoria.
- Collected at 1, 2, 5, 10 and 15m.
- Averaged 30 min wind speed from four stations.
- Data collected over 1 month periods.
- Stations located in areas approximately 20 times the height of vegetation from the edge.

- Low wind speeds (< 1 kmh^{-1}= 0.3 ms^{-1}) removed from analysis.

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This Study

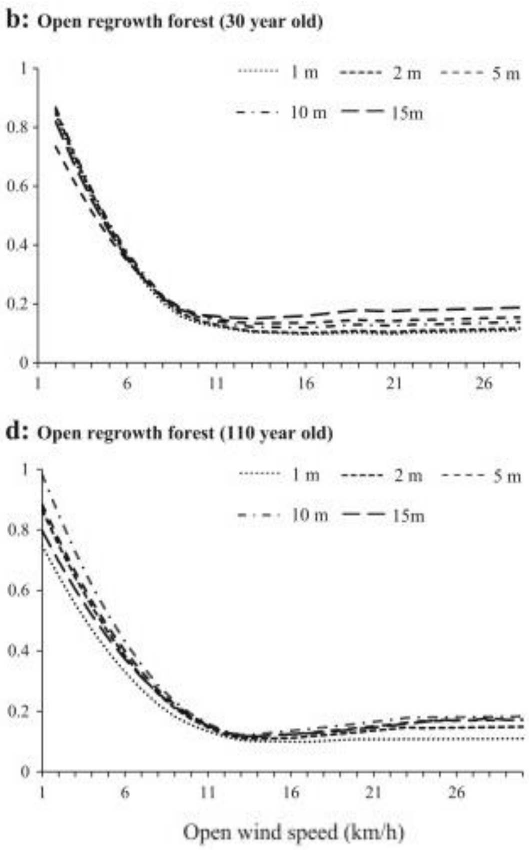
- Collection of wind data over two case studies in ACT/NSW.
- Data collected at 5m.
- Collection of 30 min and 1min average wind speed at individual stations.
- Data collected over 9 month periods.
- At FCV, stations 100m from roads.
- At NAC, only metres from edge but no edge effects evident in wind direction data.
- Low wind speeds (< 0.4 ms^{-1} = 1.4 kmh^{-1}) removed from analysis.

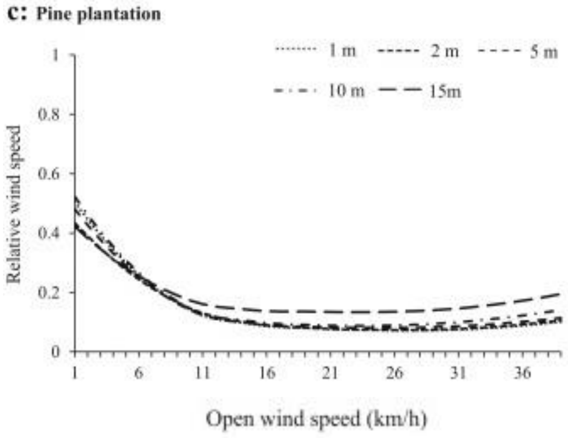
Empirical Wind Speed Profiles

Relative Wind Speed is defined as

$$RWS = U_V / U_O$$

where U_V is wind speed measured within vegetation and U_O is wind speed measured in the open.





Sections of Figure 3 from Moon et al. (In Press)

Wind speeds across FCV and NAC relatively low, so results are compared to those given for 10 to 20 kmh^{-1} in M13, and average open wind speeds are read directly from M16.

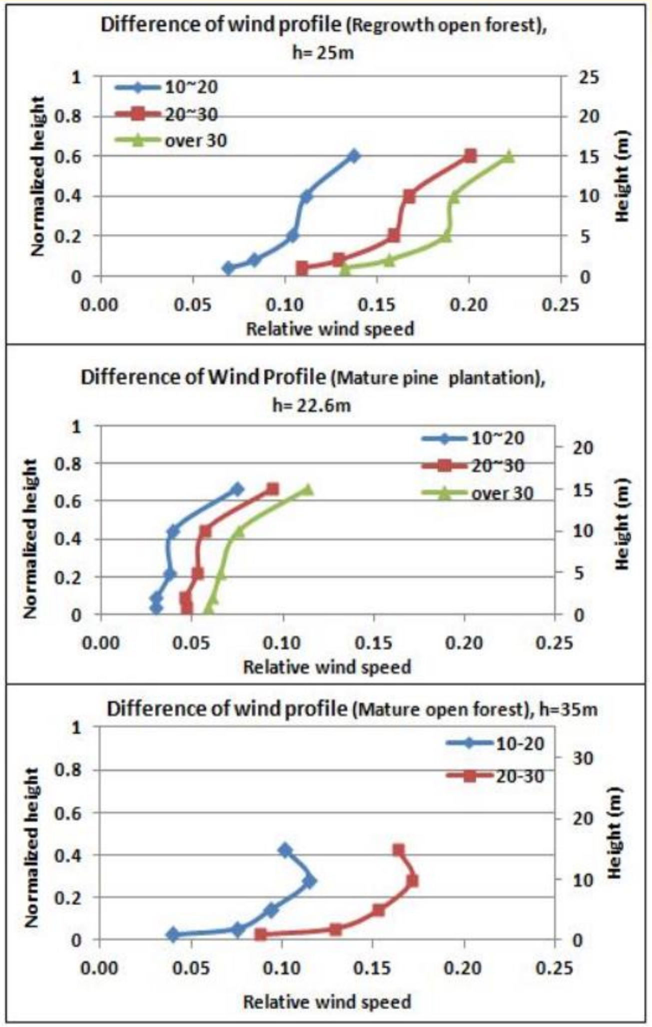
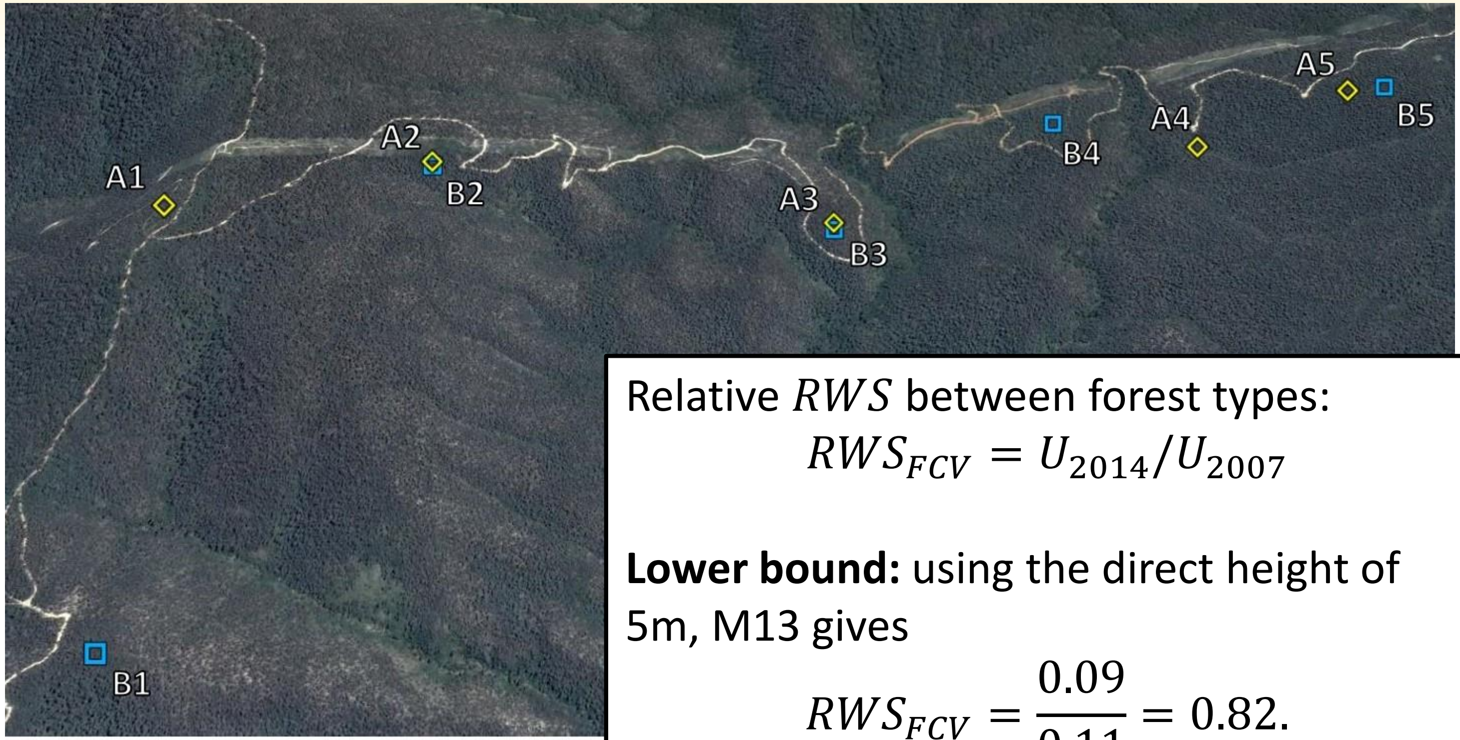


Figure 3 from Moon et al. (2013)

Case Study I: Wind Speed Reduction



Relative RWS between forest types:

$$RWS_{FCV} = U_{2014}/U_{2007}$$

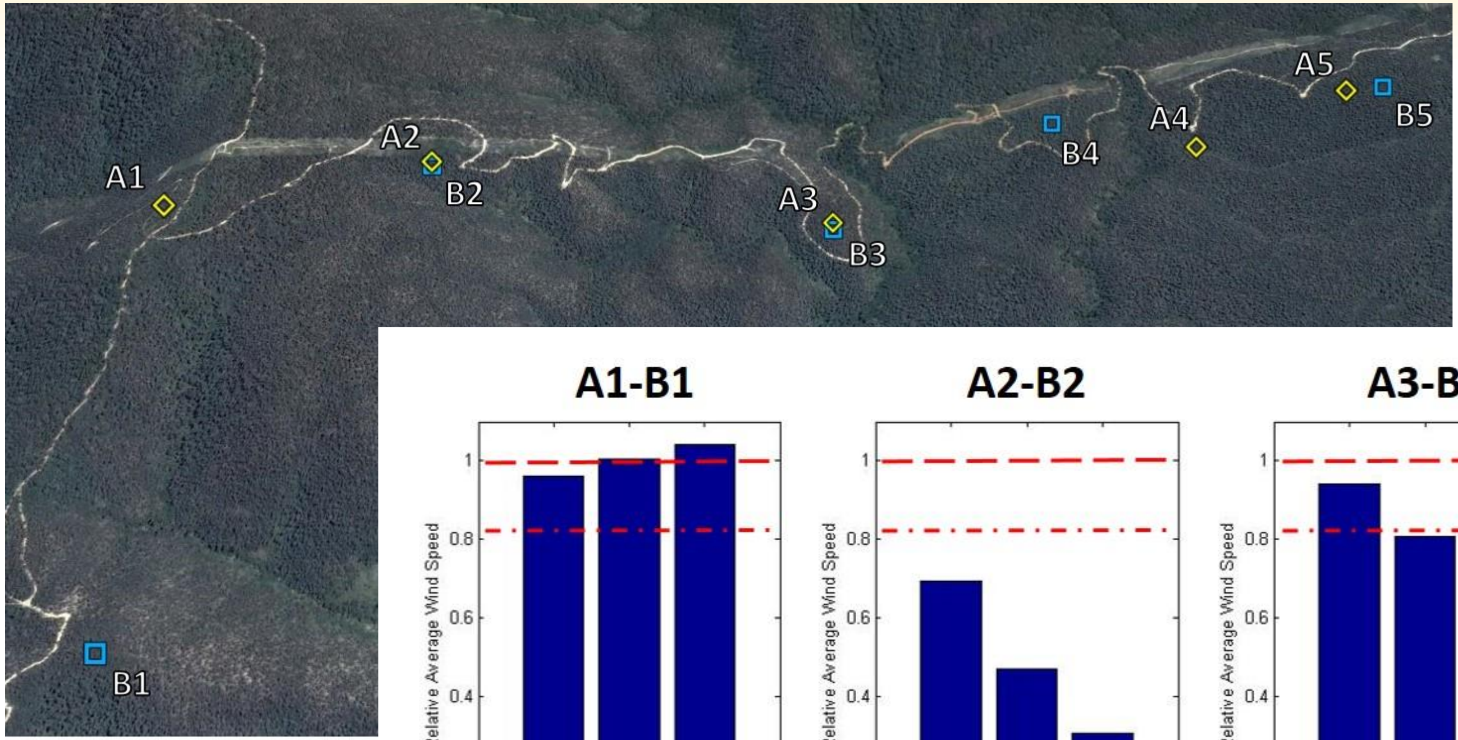
Lower bound: using the direct height of 5m, M13 gives

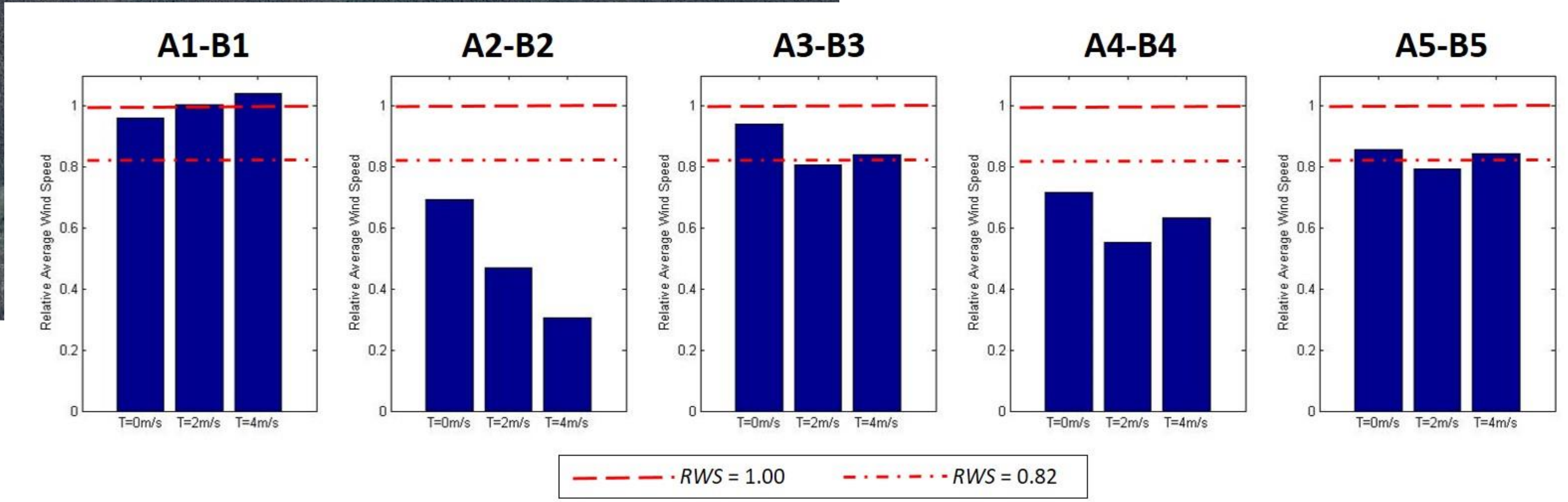
$$RWS_{FCV} = \frac{0.09}{0.11} = 0.82.$$

Upper bound: using a normalised height of approx. 0.3-0.5, M16 gives

$$RWS_{FCV} = \frac{0.15}{0.15} = 1.00.$$

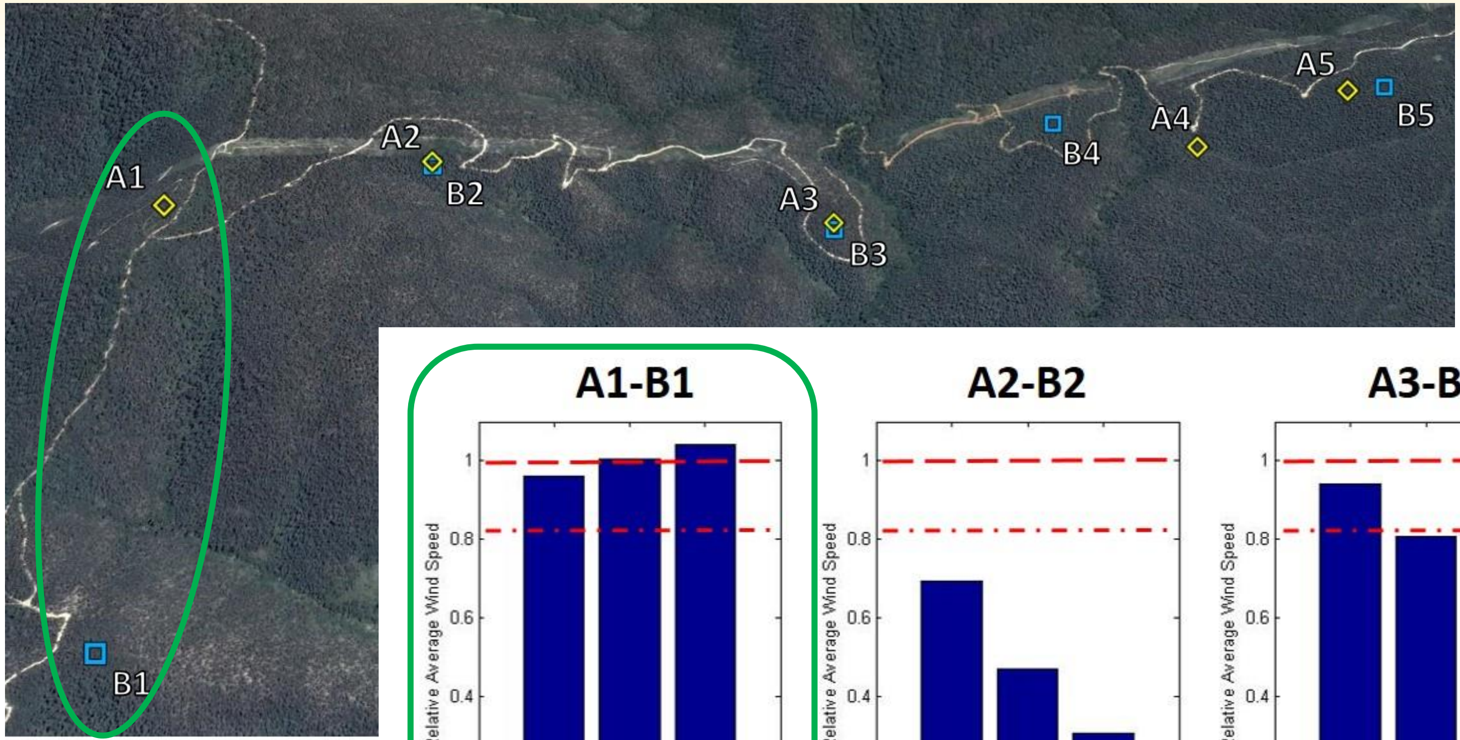
Case Study I: Results

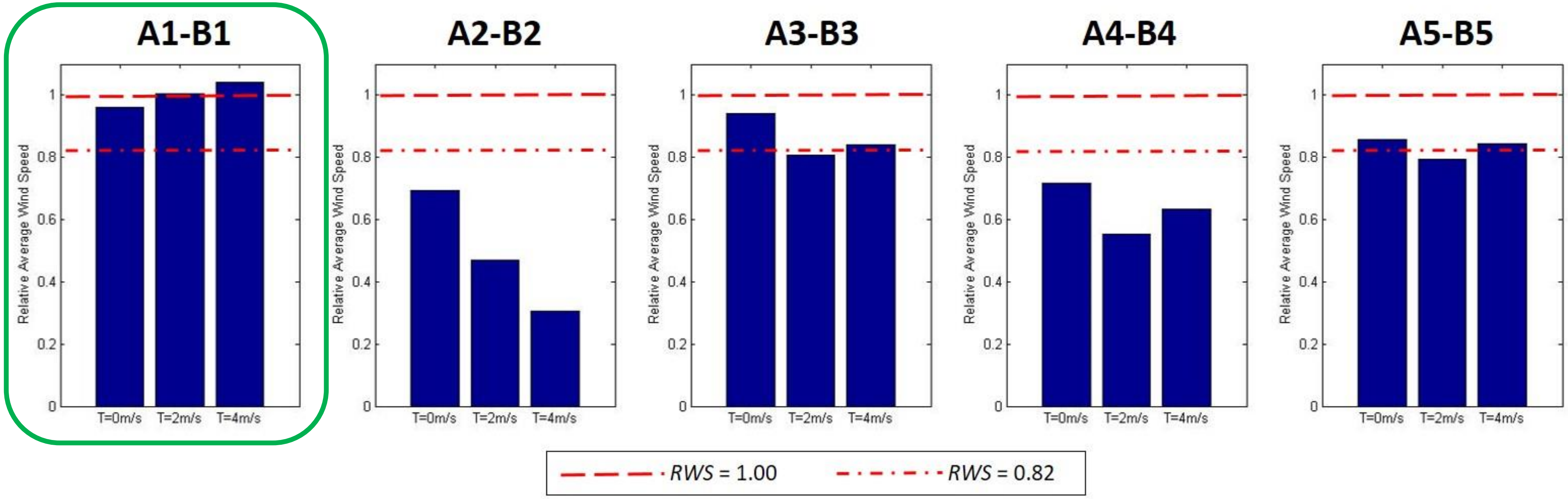




Case Study I: Results

Western ridge top shows very high RWS values – concurring with M16 and suggesting that changes in vegetation have had little or no effect on wind speed recorded at this site.





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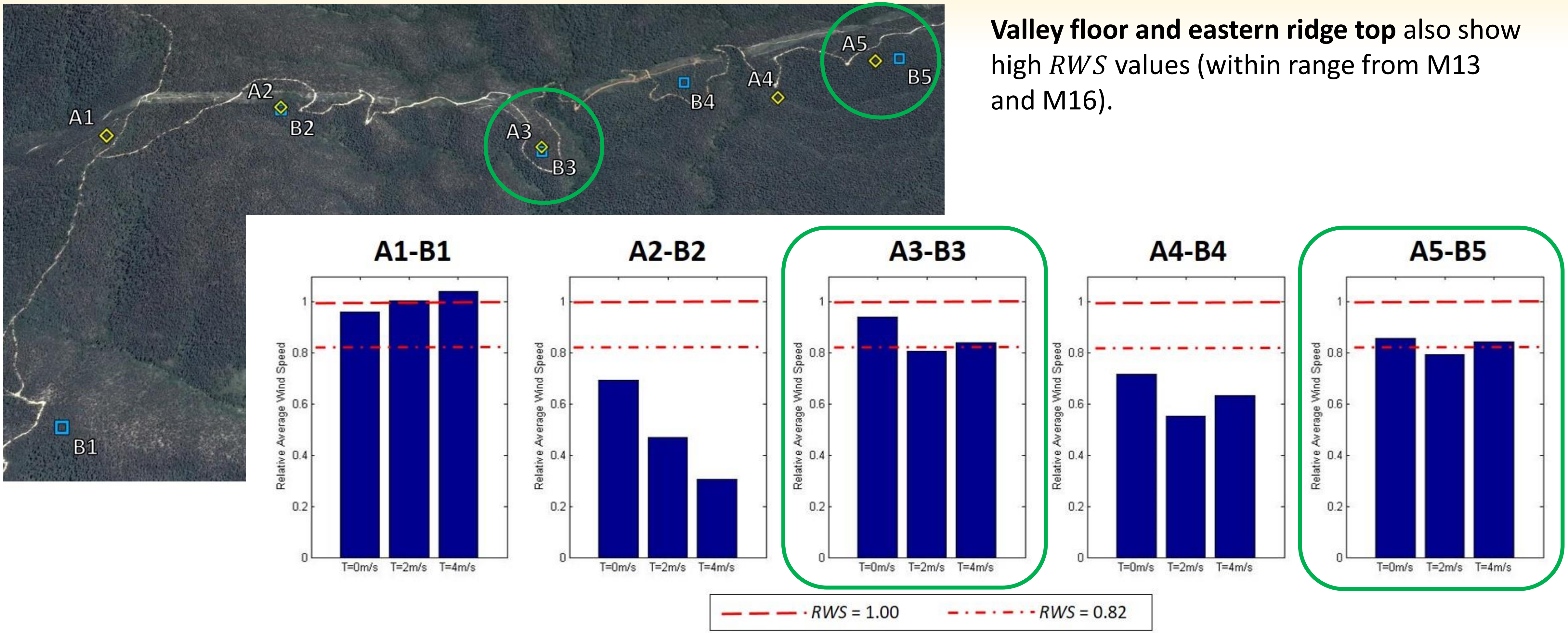
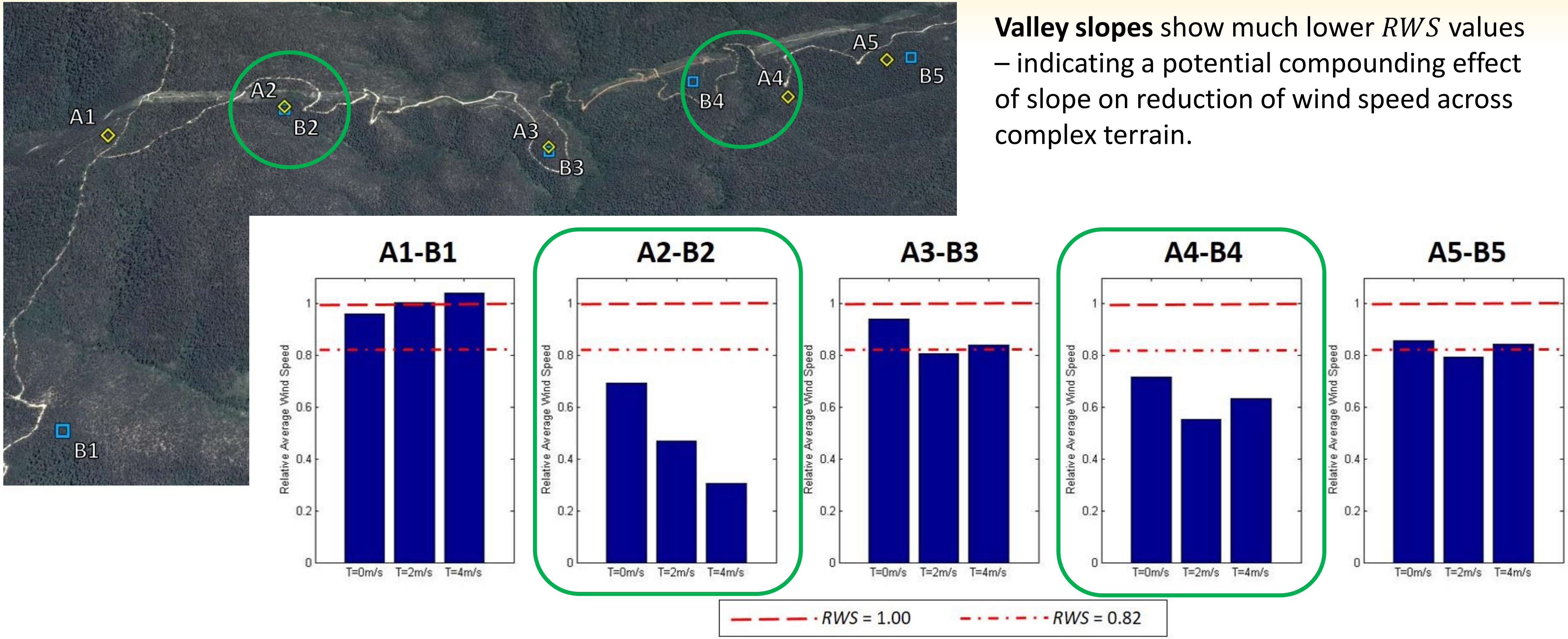


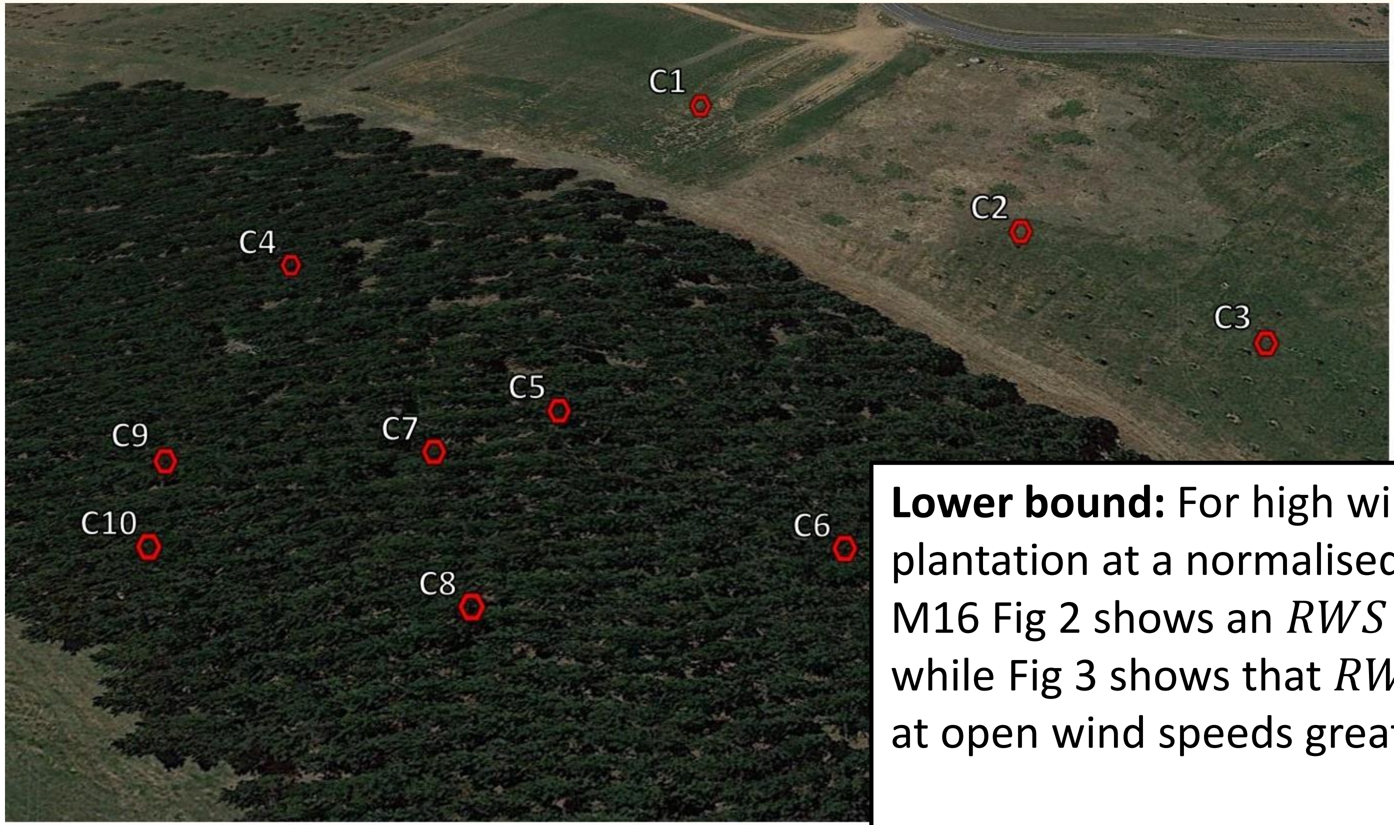
Valley floor and eastern ridge top also show high RWS values (within range from M13 and M16).

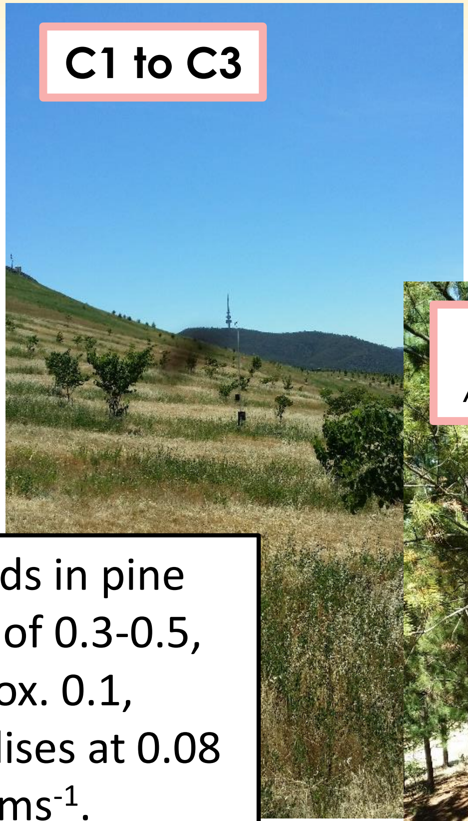
Case Study I: Results



Valley slopes show much lower RWS values – indicating a potential compounding effect of slope on reduction of wind speed across complex terrain.

Case Study II: Wind Speed Reduction



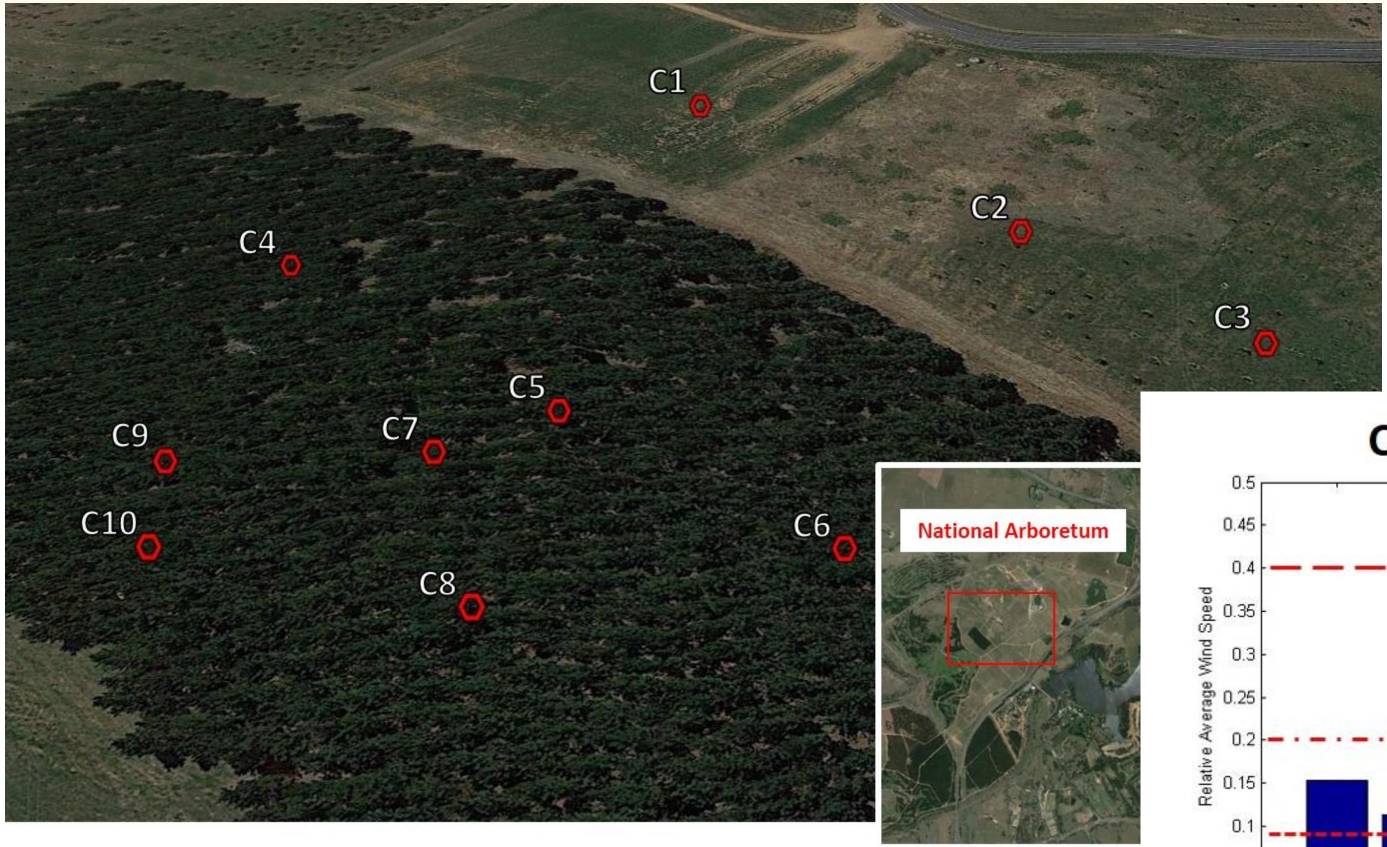


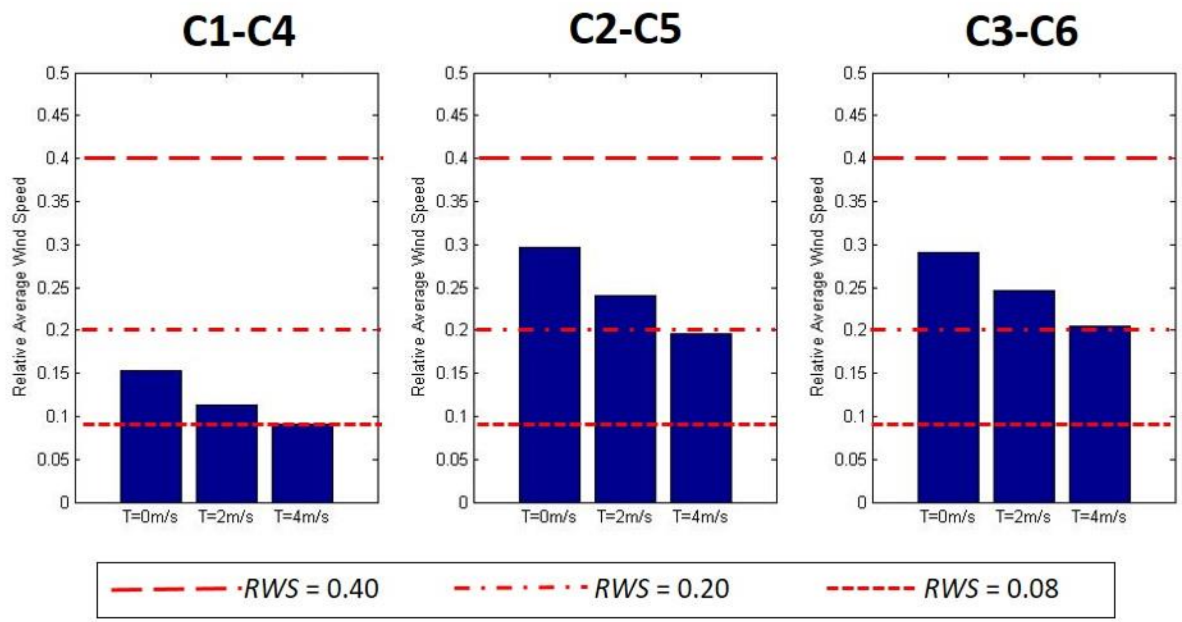
Lower bound: For high wind speeds in pine plantation at a normalised height of 0.3-0.5, M16 Fig 2 shows an RWS of approx. 0.1, while Fig 3 shows that RWS stabilises at 0.08 at open wind speeds great than 4ms^{-1}.

Upper bound(s): For lower wind speeds, RWS increases to 0.2 (for 2ms^{-1}), and as high as 0.4 for very low wind speeds of 0.4ms^{-1}.

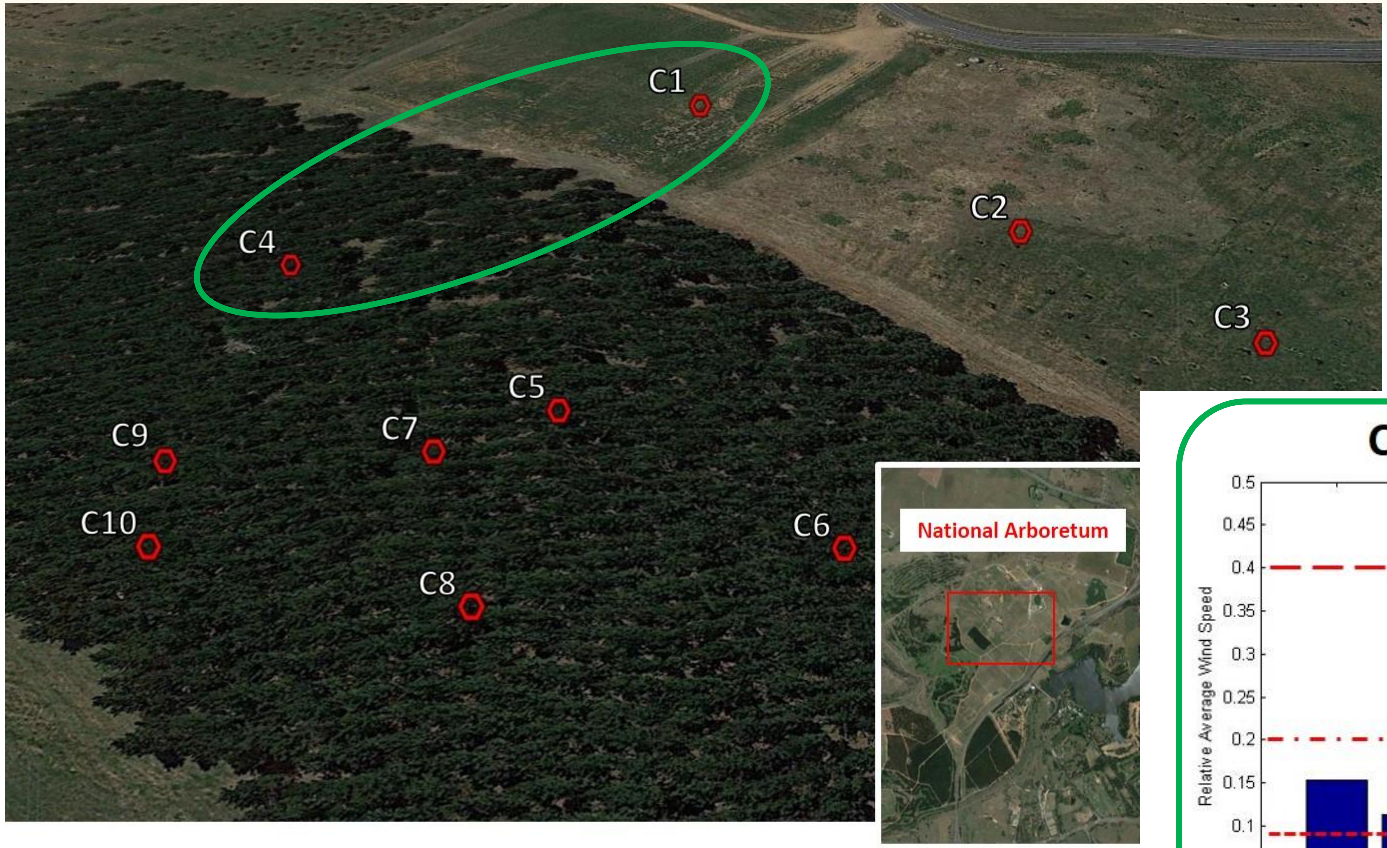
Case Study II: Results

$\boldsymbol{RWS}$ **values** given by M13 and M16 appear to give a good representation of wind speed reduction induced by the pine plantation along the entire transect.

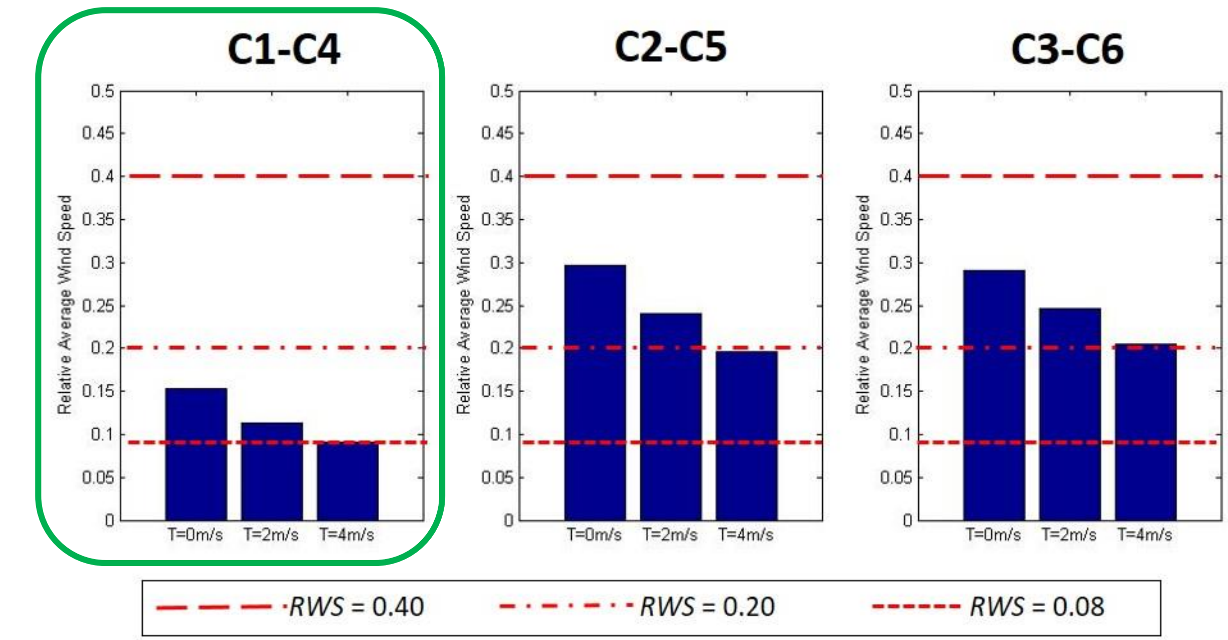




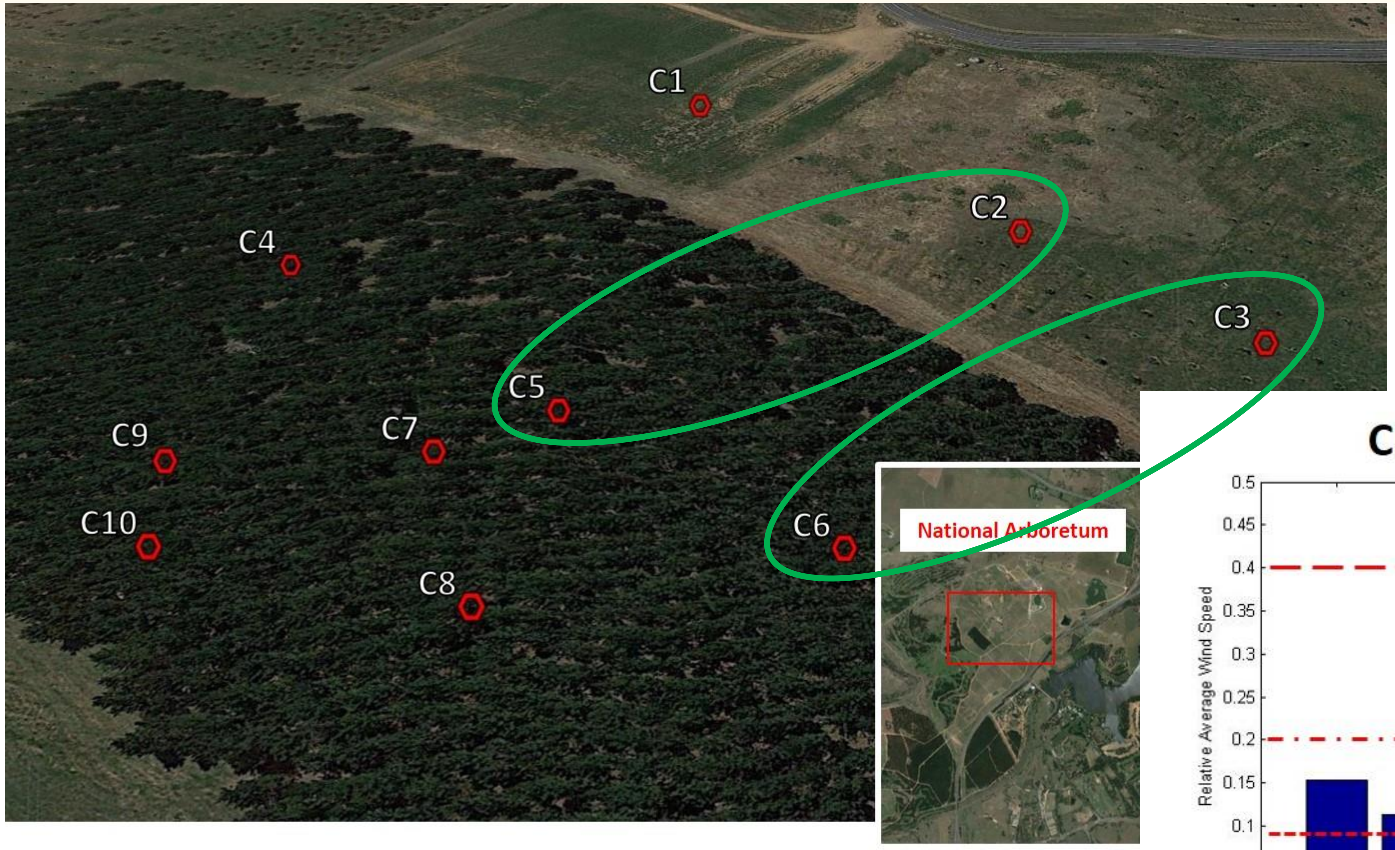
Case Study II: Results



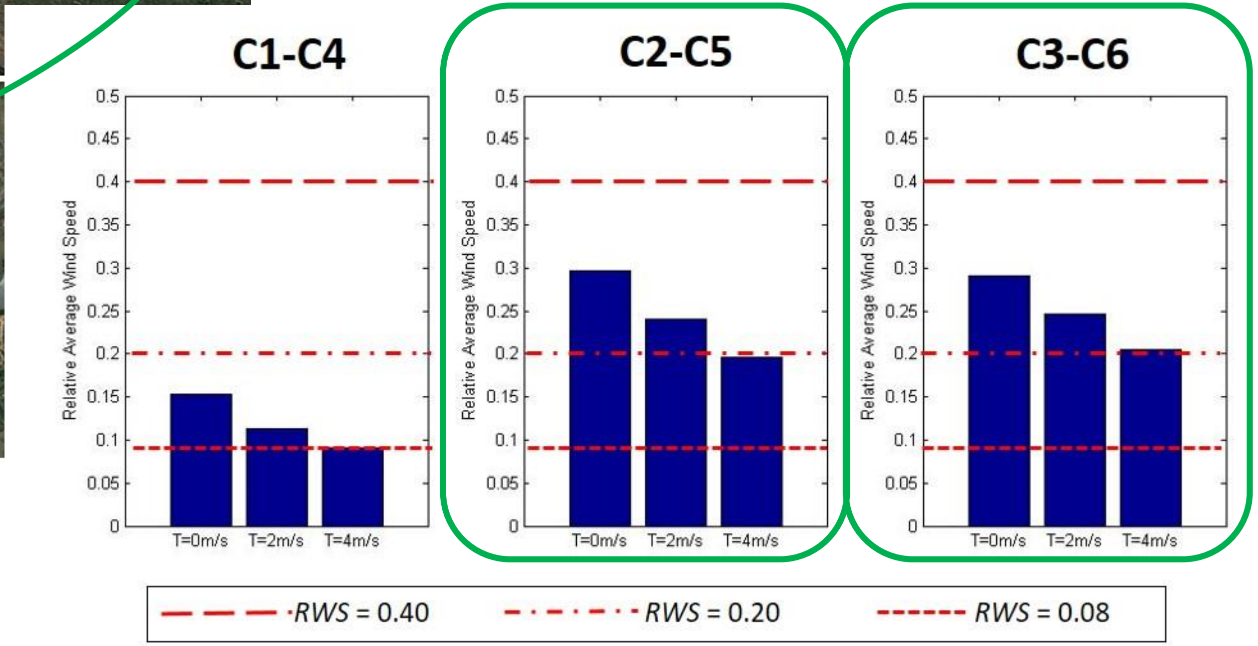
On the ridge top, RWS values clearly approach the stabilisation value given by M16 of 0.08 as the wind speed threshold increases and average wind speeds increase from $4ms^{-1}$ to $6.5ms^{-1}$.



Case Study II: Results



On the slope, where average wind speeds range from 2.25ms^{-1} under the lowest threshold to 4.25ms^{-1} under the highest threshold, the RWS values are higher, but concur with the lower wind speed results given by M16.



Final Conclusions

- Good agreement with M13 and M16 across broad scale or undulating topography.
- But the increased wind speed reduction evident on the slopes of Flea Creek Valley, suggests that perhaps complex terrain features may have compounding affects on wind speed reduction beneath the canopy.
- Further Research
  - Consider the impacts of drag, streamlining and vegetation penetrability in complex terrain.
  - Consider the changes to such phenomena at higher wind speeds with further data collection

Limiting Factors and Further Research

- **Vegetation heights** were lower than those studied by M13 and M16 – but normalised heights were considered. Future quantification of vegetation structure, and modelling of turbulence through and above the canopy, may highlight the impacts of vegetation structure on these results.
- **Vegetation structure** is also dynamic and varies through time – the seasonal impacts of vegetation growth are not considered here. However, results appear comparable despite comparing 9 months of data to 1 month of data. Further work could use these longer data sets to determine whether intra-annual changes have a significant affect on wind speed reduction.
- **Cup anemometers** restrict this analysis to horizontal wind speeds; as noted by M16, 3D sonic anemometers would allow for more details analysis of wind flow beneath the canopy.
- **Edge effects** may have caused issues with data collection at NAC – but analysis of wind direction does show any significant indicators of edge effects at the stations and the results seem to concur with M13 and M16.
- **Low wind speeds** may indeed be less relevant for extreme bushfires. Despite this, it is important to understand the dynamics beneath the canopy for surface fires which have the potential to expand, or in fact for prescribed burns where conditions are ideally mild.

Acknowledgements

Thanks to **Jason Sharples** and **Leesa Sidhu** for supervision, access to previous work and data, and help with initial deployment, and acknowledgement is given to the **Bushfire and Natural Hazards CRC** for financial support and supervision from **Graham Thorpe**. Thanks to **Julia Piantadosi**, **Natalie Wagenbrenner** and **Kangmin Moon** for ongoing discussions and collaborations.

Thanks also to many volunteers for assistance with deployment of stations and data collection, including **Ben Quill**, **Bob Cechet**, **Peter**, **Nick**, **Katie**, **Hud**, **Hannah**, **Sarah**, **John** & **Therese**. Special thanks to **Colin Symons** for work in developing and deploying the Raspberry Pi system. Finally, thanks to **NSW National Parks & Wildlife Service** for allowing the research to be conducted in Brindabella National Park, and to the **National Arboretum Canberra**.

Thank you

Email: *rachael.quill@student.adfa.edu.au*

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