Vizumap: An R Package for Visualizing Uncertainty in Spatial Data

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25 November 2021

www.data61.csiro.au

Introduction

1. Background to Vizumap

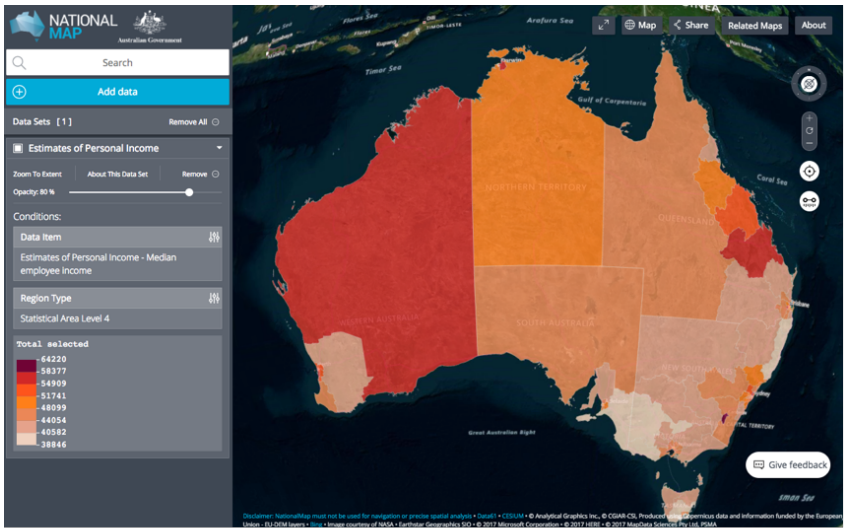
2. Remote Sensing case study

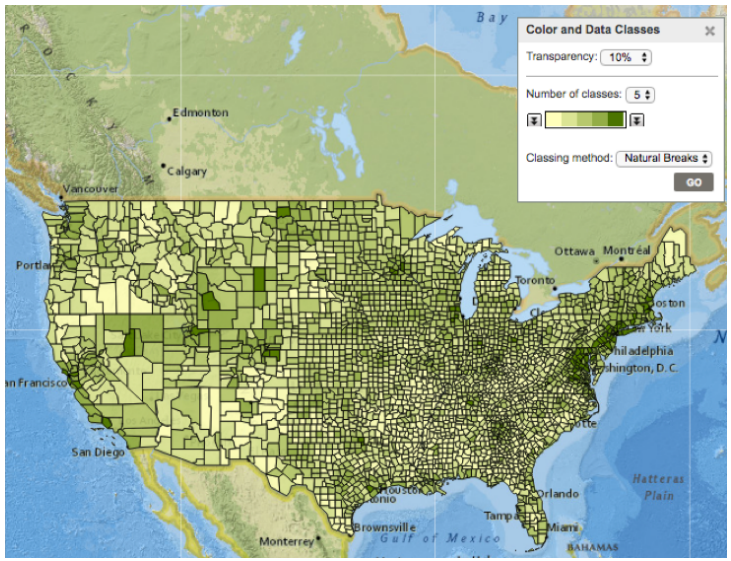
3. Visualisation methods

4. How you can access Vizumap and try it out!

Research Problem

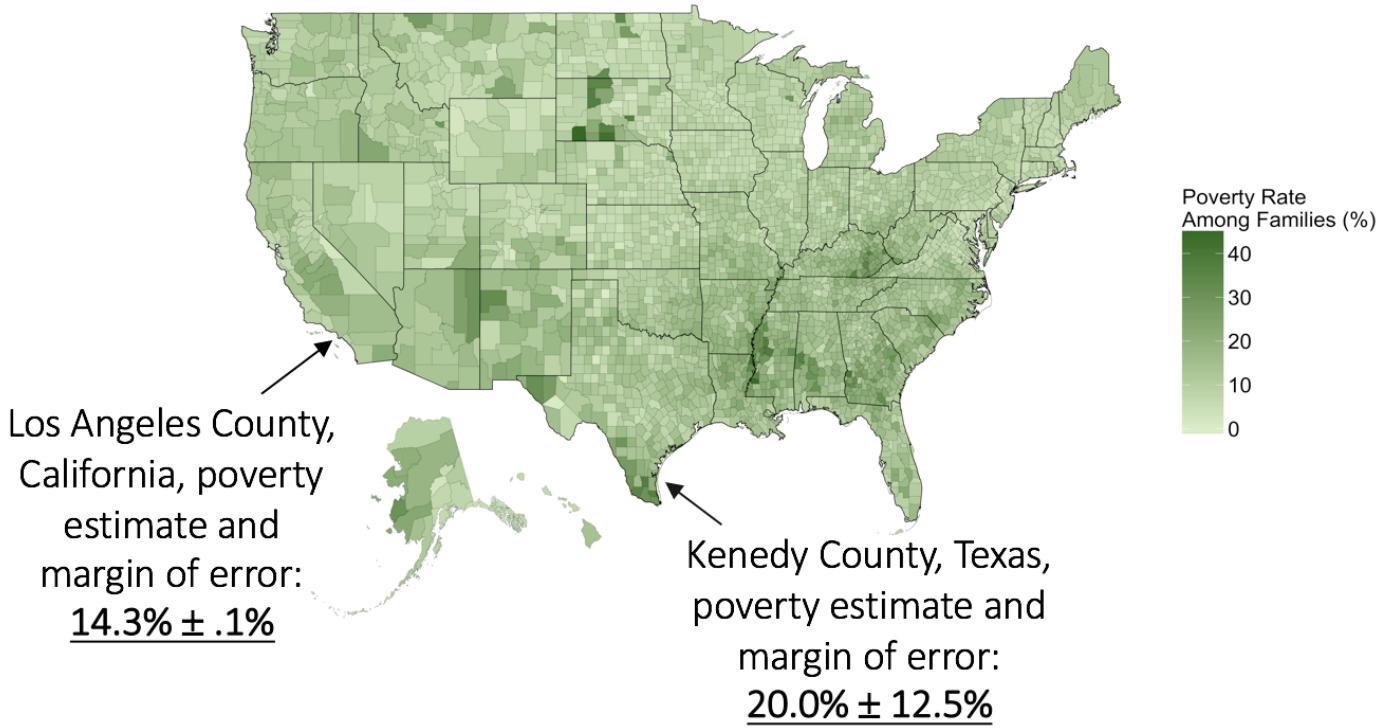
- Missing information on maps





Research problem

- The importance of including uncertainty



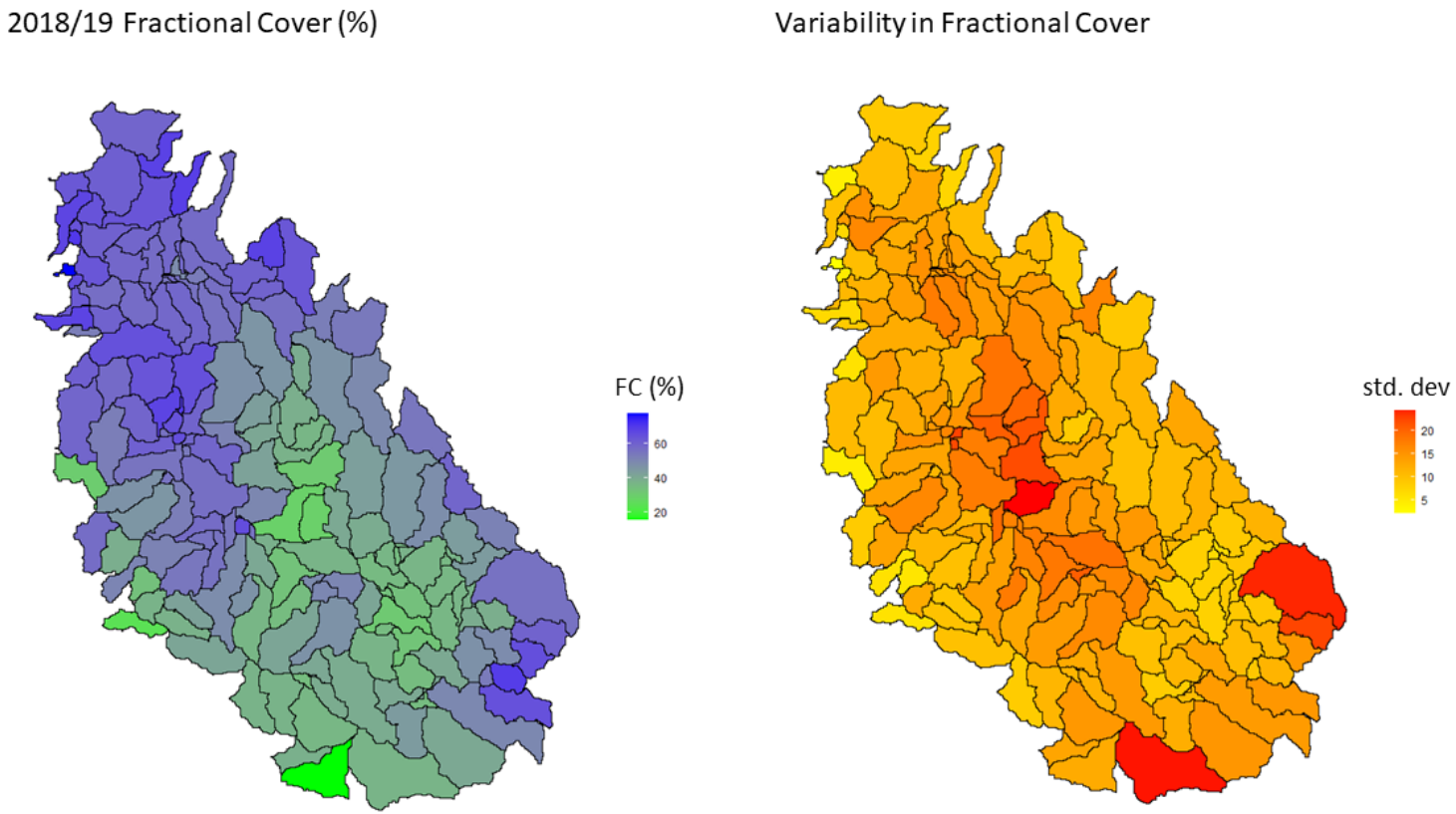
Why map uncertainty?

Why is uncertainty important for decision making?

- Decision makers need some assurance about estimates
- Uncertainty can highlight where data are lacking and where the model performs poorly
- Uncertainty can assist with prioritising actions, spending resources, and informing monitoring regimes

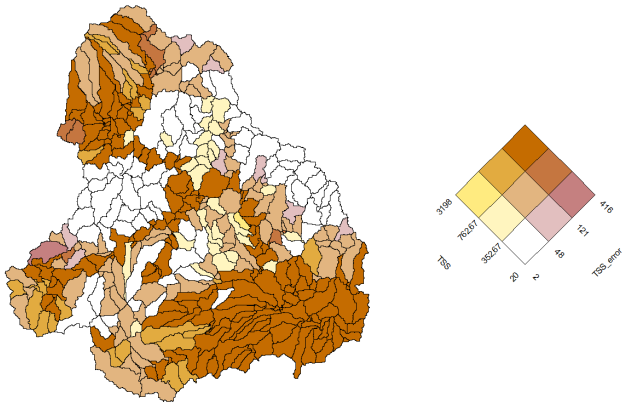
Traditional Visualisation Methods

Fractional Cover of the Bowen Catchment in the Great Barrier Reef (2018/19 Wet Season)

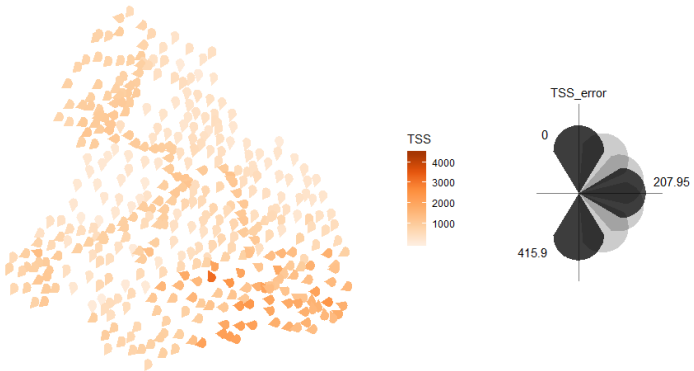


Example: GBR Sediment Runoff

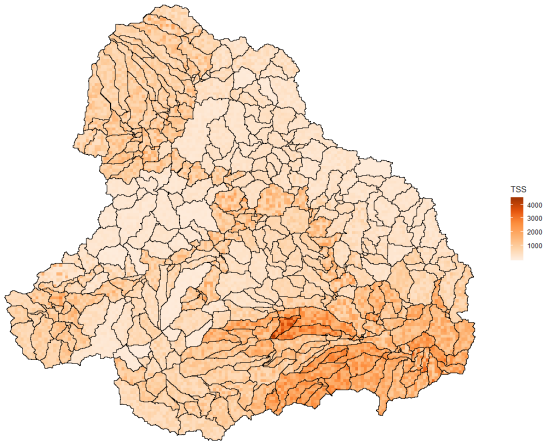
Bivariate Map



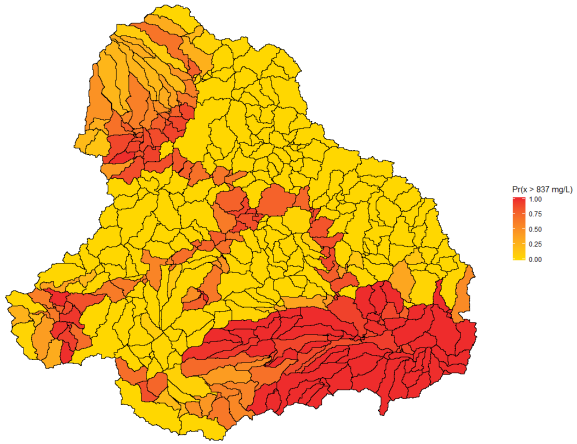
Glyph Rotation



Map Pixelation

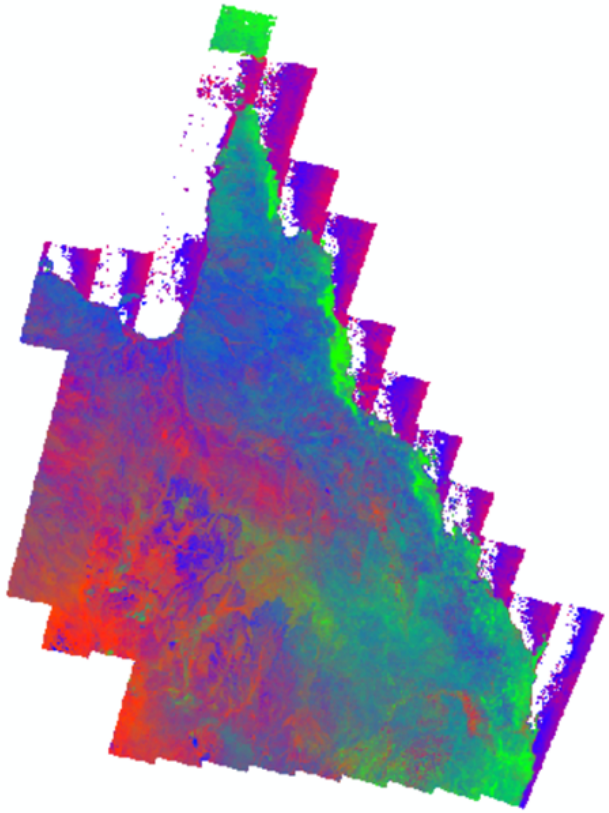


Exceedance Probability



Example: Fractional Cover

- Fractional green cover
  - proportion of exposed green cover within each pixel.
  - derived through spectral unmixing
- Split of Landsat pixels (30m) into bare ground, green cover, non photosynthetic cover
- Seasonal time scales (3 month calendar season)
- Explore two wet seasons 18/19 and 19/20



Joint Remote Sensing Research Program (2021): Seasonal fractional cover - Landsat, JRSRP algorithm, Australia coverage. Version 1.0.0. Terrestrial Ecosystem Research Network (TERN). Dataset. https://portal.tern.org.au/seasonal-fractional-cover-australia-coverage/22026

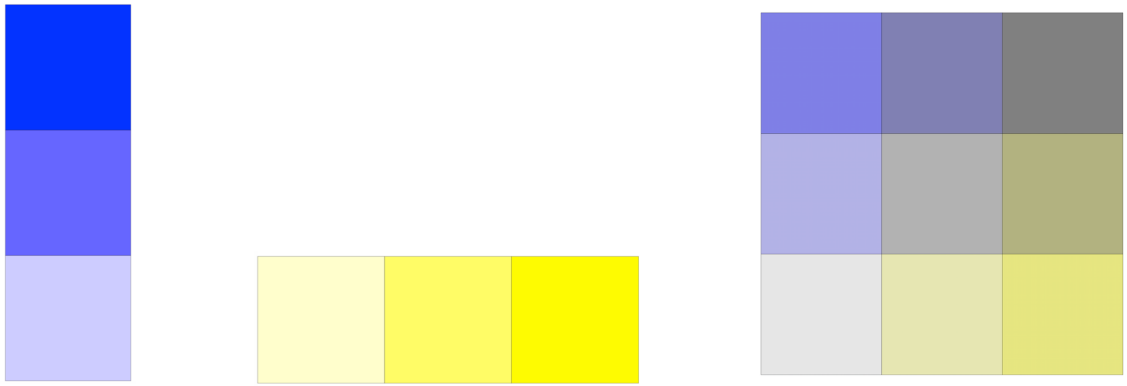
Vizumap Methods

Key visualisations:

- Bivariate choropleth map
- Map pixelation
- Glyph rotation
- Exceedance probability map

Bivariate choropleth map

- Average two single hue colour palettes to get a bivariate colour scheme
- Fill each region with a colour that represents two values instead of one value



Bivariate choropleth map

- Introduced in the 1970s by the U.S. Census Bureau
- Criticised by statisticians and geographers
- Used to visualise two variables

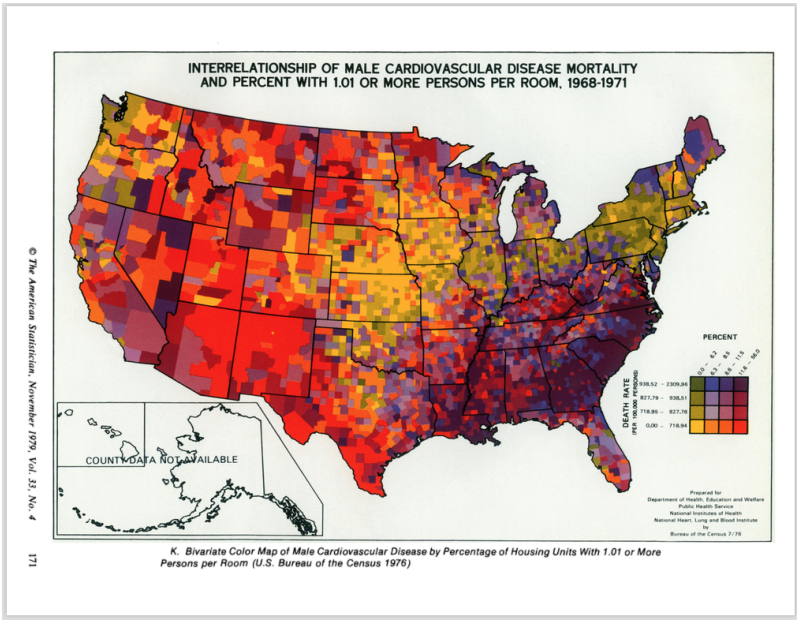
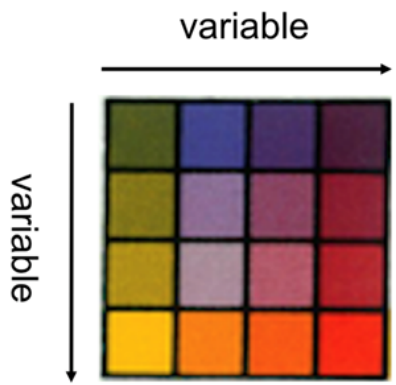


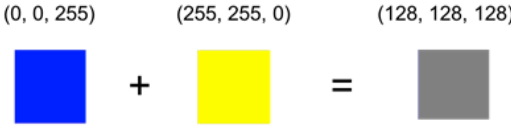
Figure: Fienberg, 1979

Bivariate choropleth map

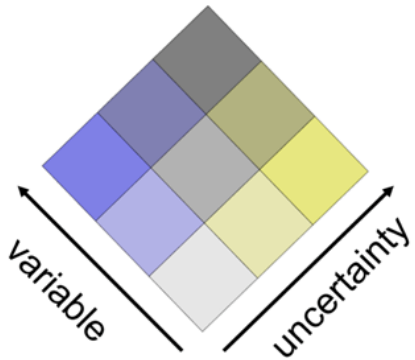
- The 1970s colour grid
  - Too many colours.
  - Difficult to remember.
  - Not intuitive.



- Our changes
  - Average RGB colour codes.

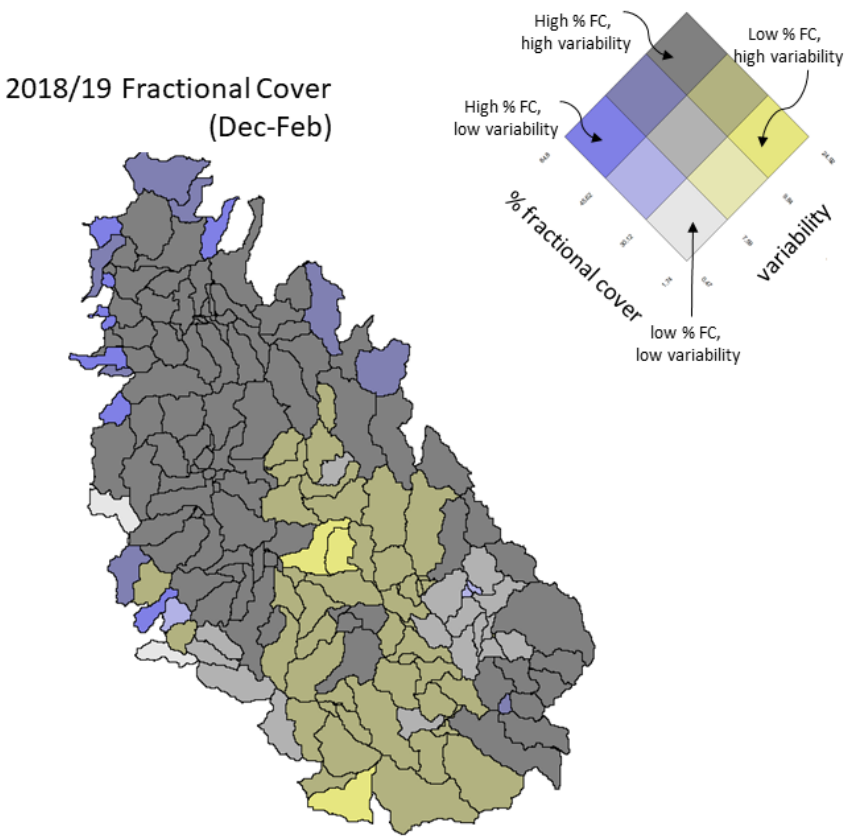


  - Limit to two colours, 3 x 3 grid
  - Rotate 45 degrees



Bivariate Map: FC 2018/19

`build_bmap()`



Bivariate Map: FC 2018/19

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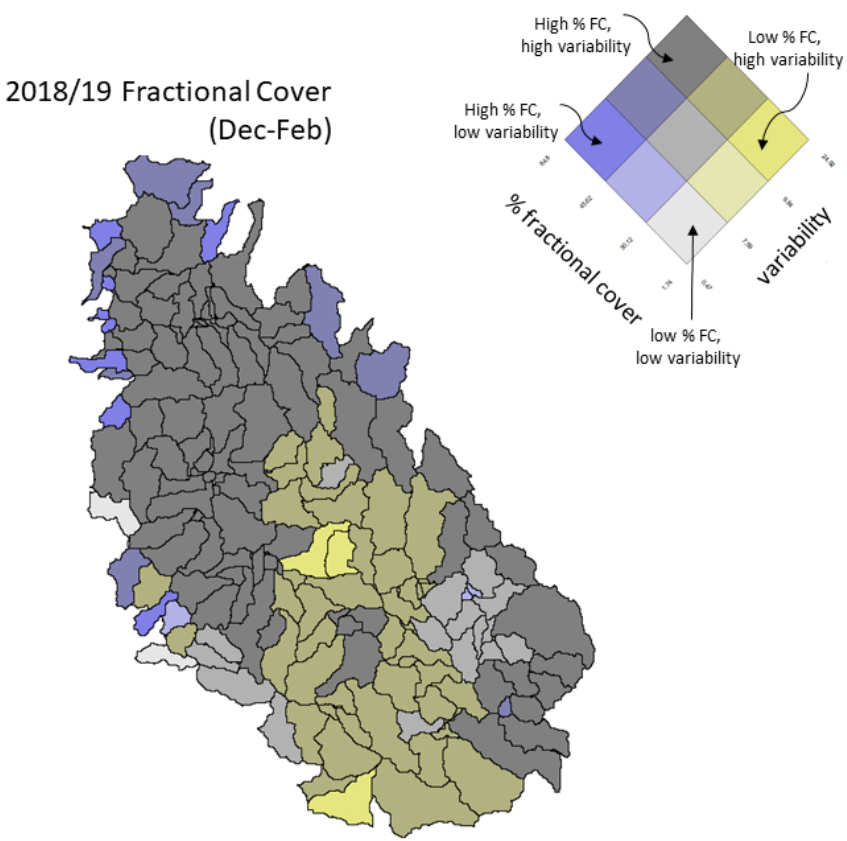
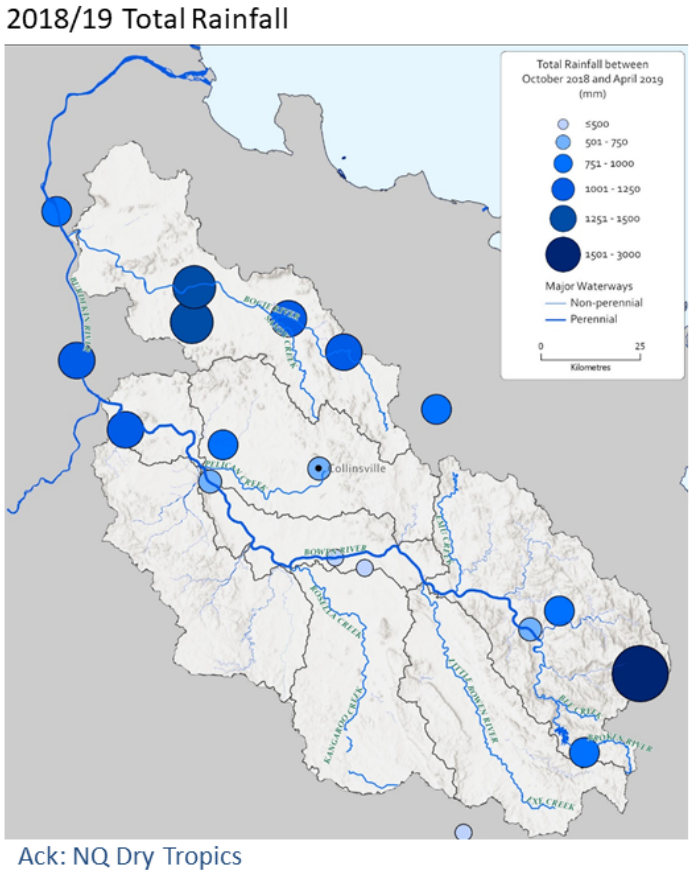
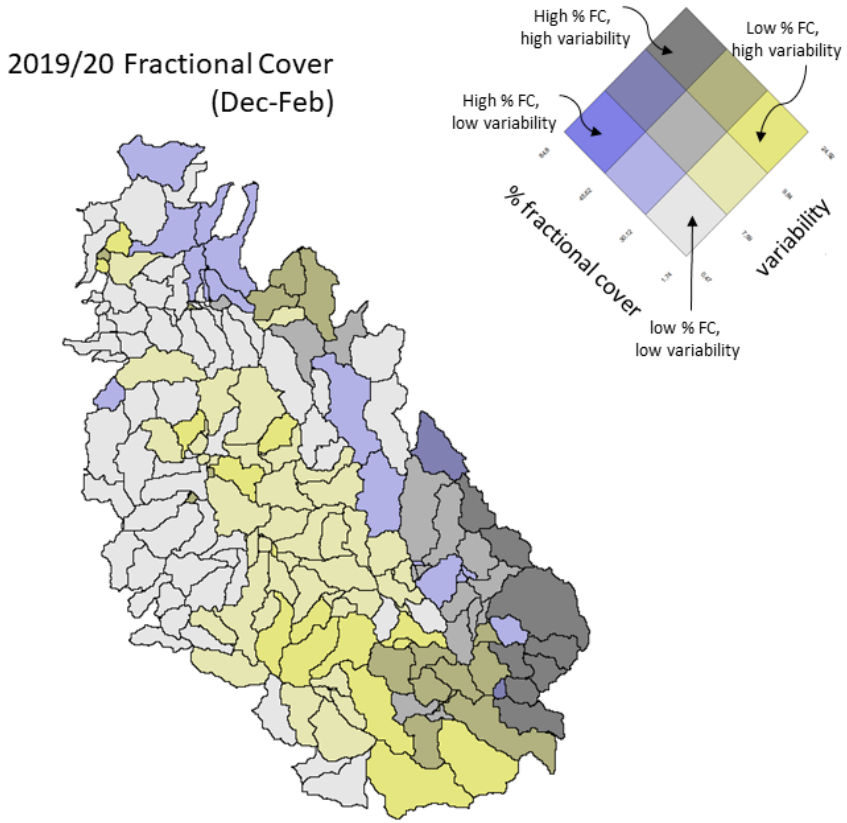




Ack: NQ Dry Tropics

Bivariate Map: FC 2019/20

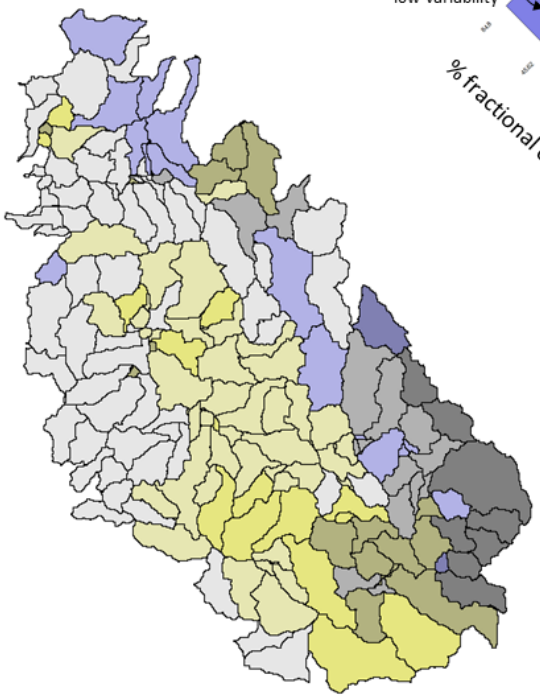
`build_bmap()`

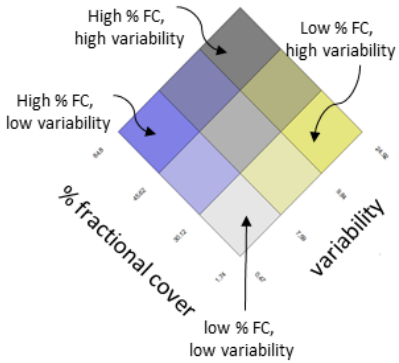


Bivariate Map: FC 2019/20

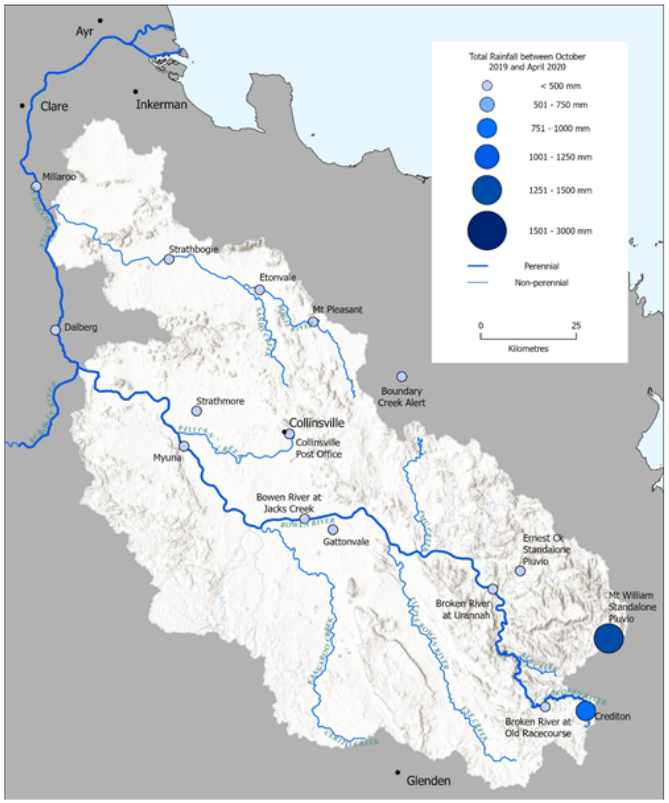
`build_bmap()`

2019/20 Fractional Cover
(Dec-Feb)





2019/20 Total Rainfall



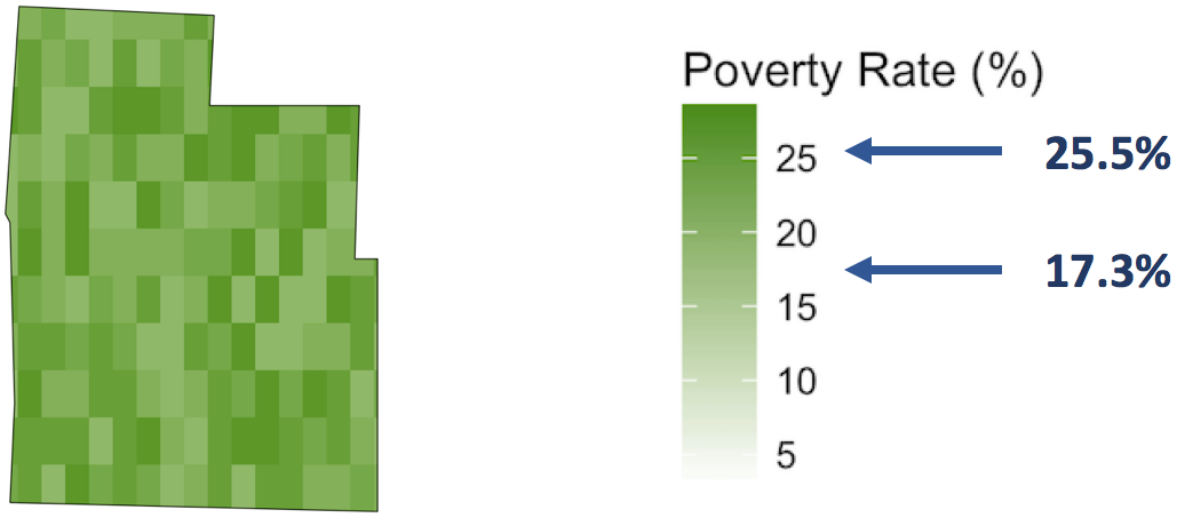
Ack: NQ Dry Tropics

Map pixelation

- Pixelate regions and randomly assign each pixel a value within the estimate's margin of error
- This method builds on two concepts
  - Areas of high uncertainty can be represented by texture and noise (MacEachren et al., 2005)
  - "Masking approach may be the best choice in applications where the goal is to actively prevent map users from making erroneous inferences" (Retchless and Brewer, 2016, p. 1146)
- Static and dynamic maps

Map pixelation

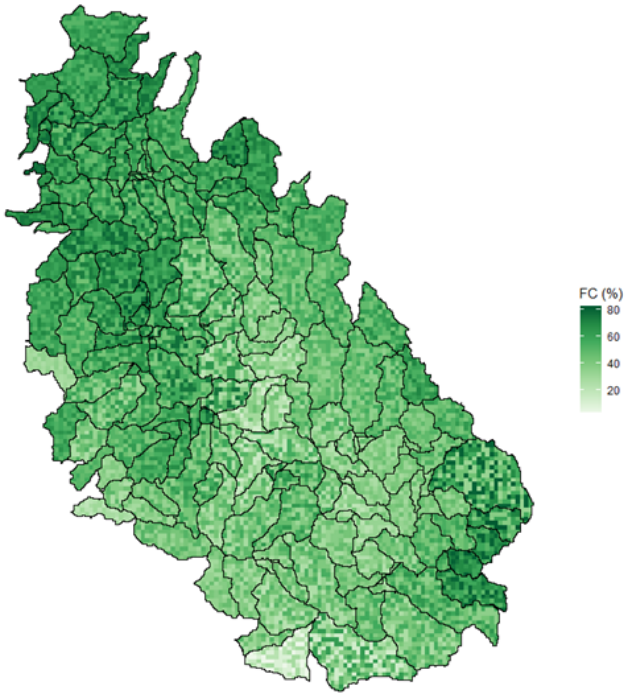
- Cedar County, MO
  - Estimate is 21.4% and margin of error is 4.1%
  - Lightest green represents 17.3% (21.4 - 4.1)
  - Darkest green represents 25.5% (21.4 + 4.1)



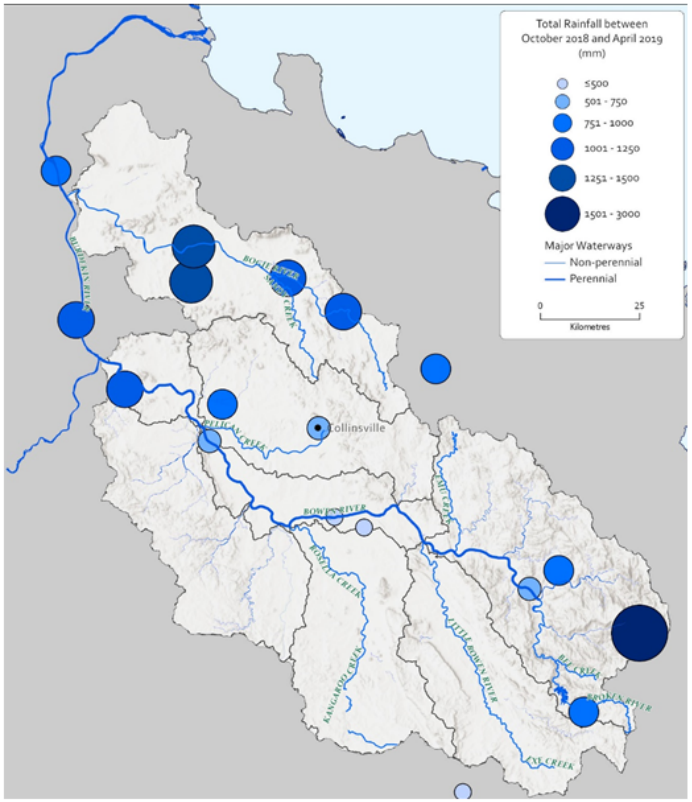
Map Pixelation: FC 2018/19

`build_pmap()`

2018/19 Fractional Cover (Dec-Feb)



2018/19 Total Rainfall



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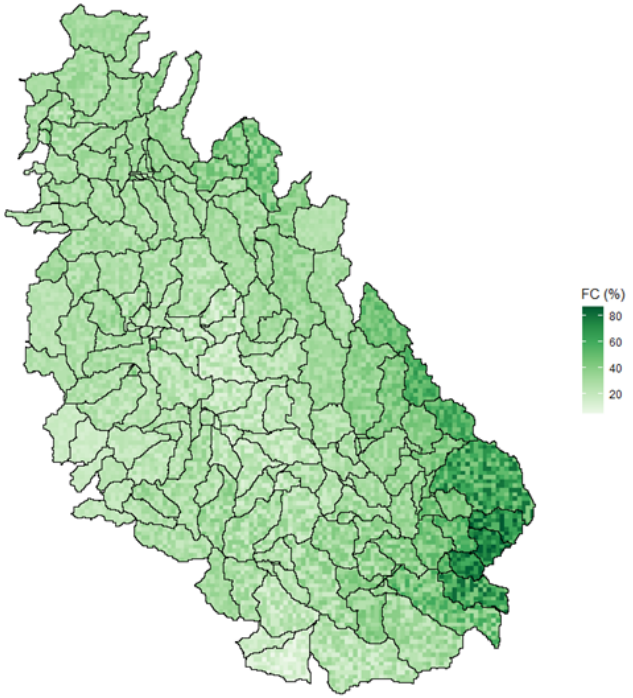
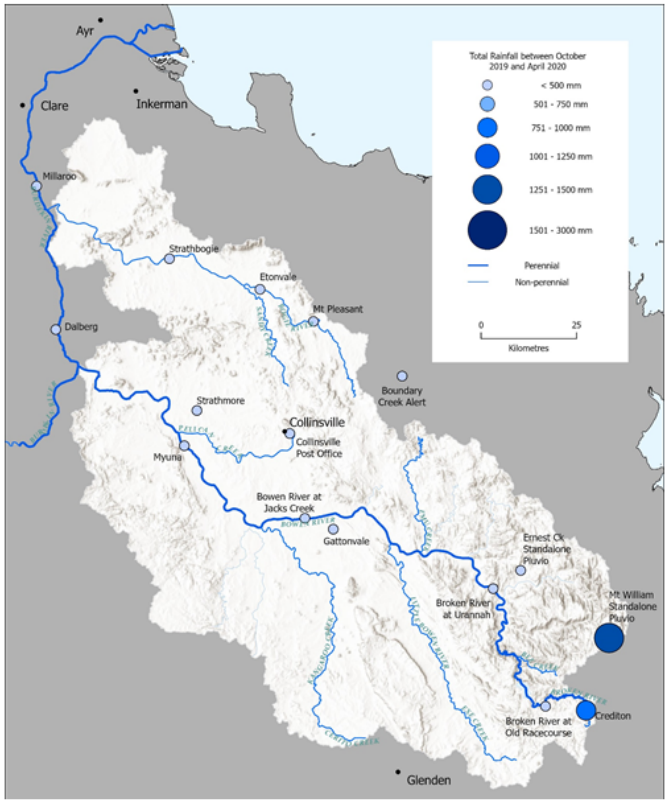
Map Pixelation: FC 2019/20

`build_pmap()`

2019/20 Fractional Cover (Dec-Feb)



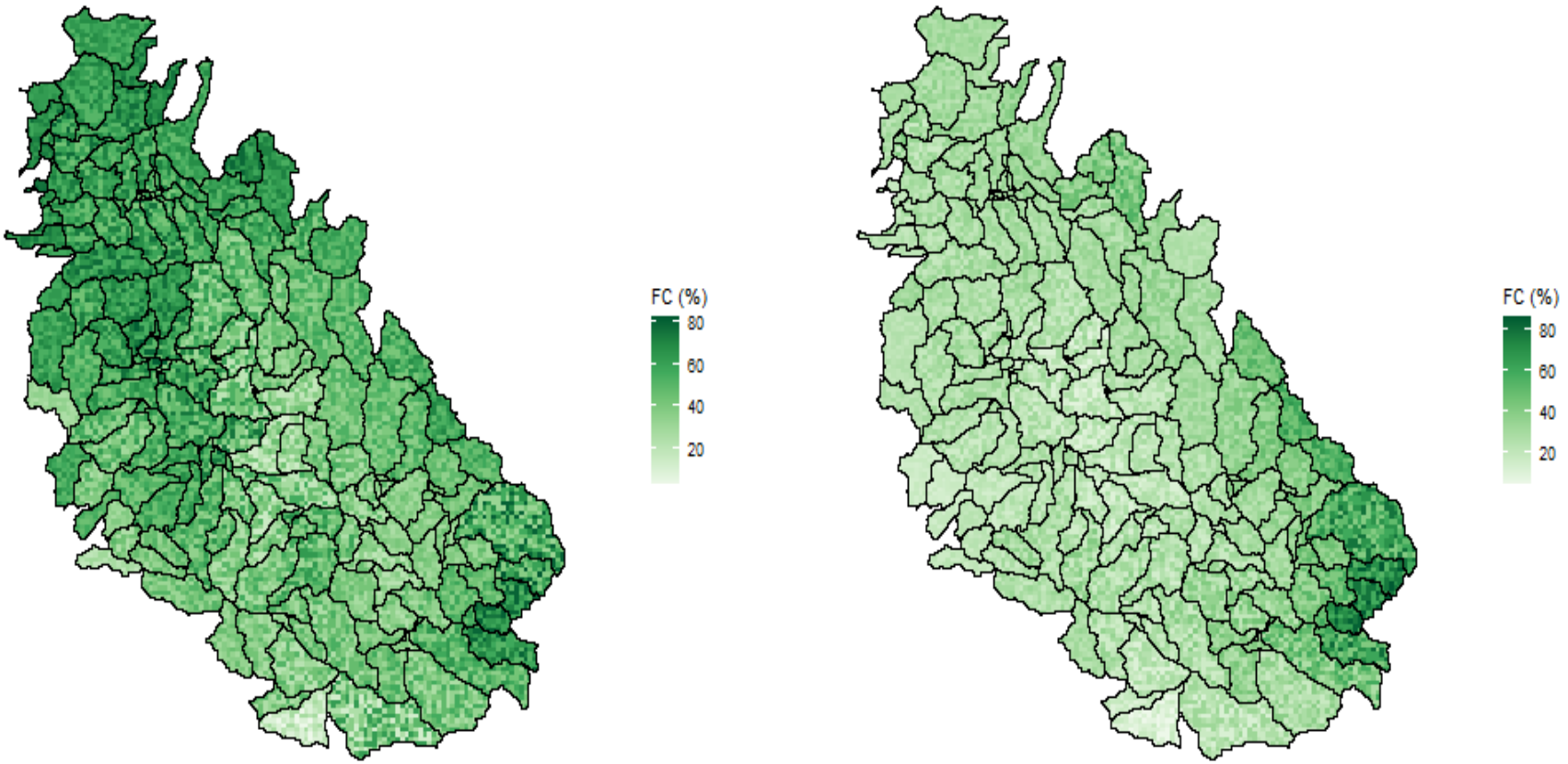
2019/20 Total Rainfall



Ack: NQ Dry Tropics

Fractional Cover Animation

```
build_pmap()
animate()
```



Glyph rotation

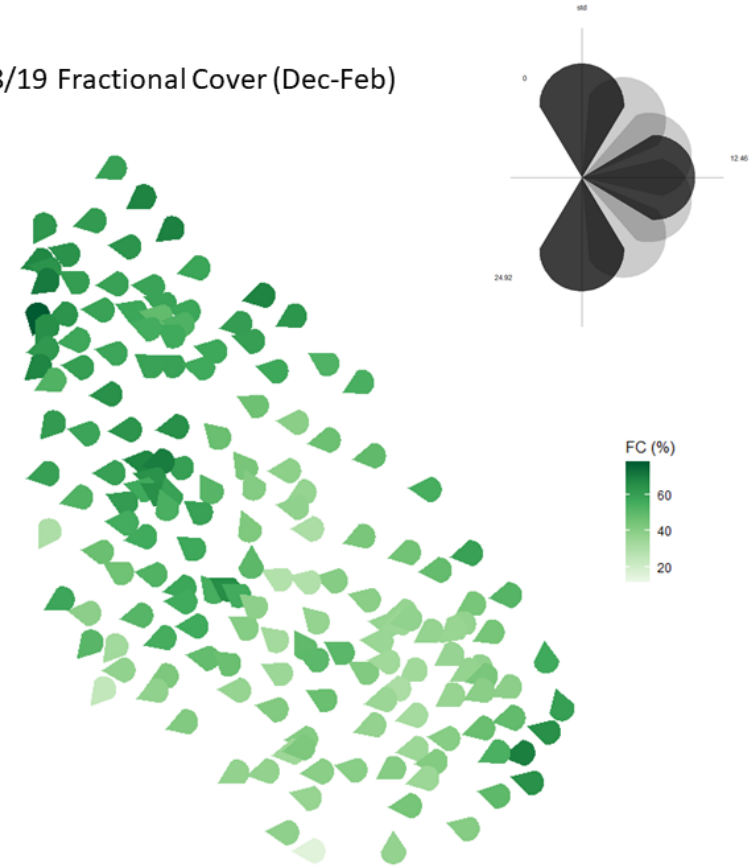
- Inspired by the issue of varying region sizes on a choropleth map
- Glyphs of equal size represent each region
  - Color represents the estimate
  - Rotation represents the error
- Equal area cartogram (tile grid map)

$$\begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix}$$

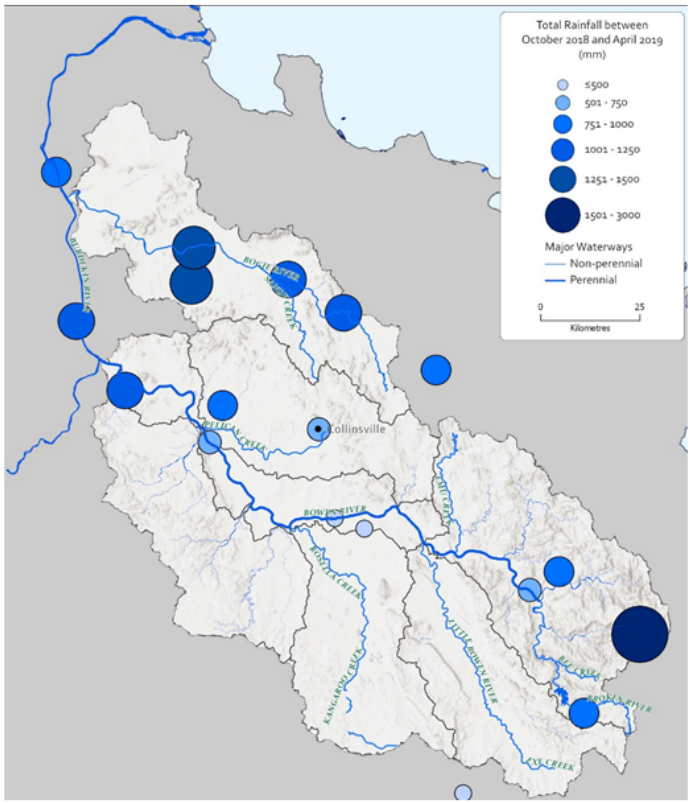
Glyph Rotation: FC 2018/19

`build_gmap()`

2018/19 Fractional Cover (Dec-Feb)



2018/19 Total Rainfall

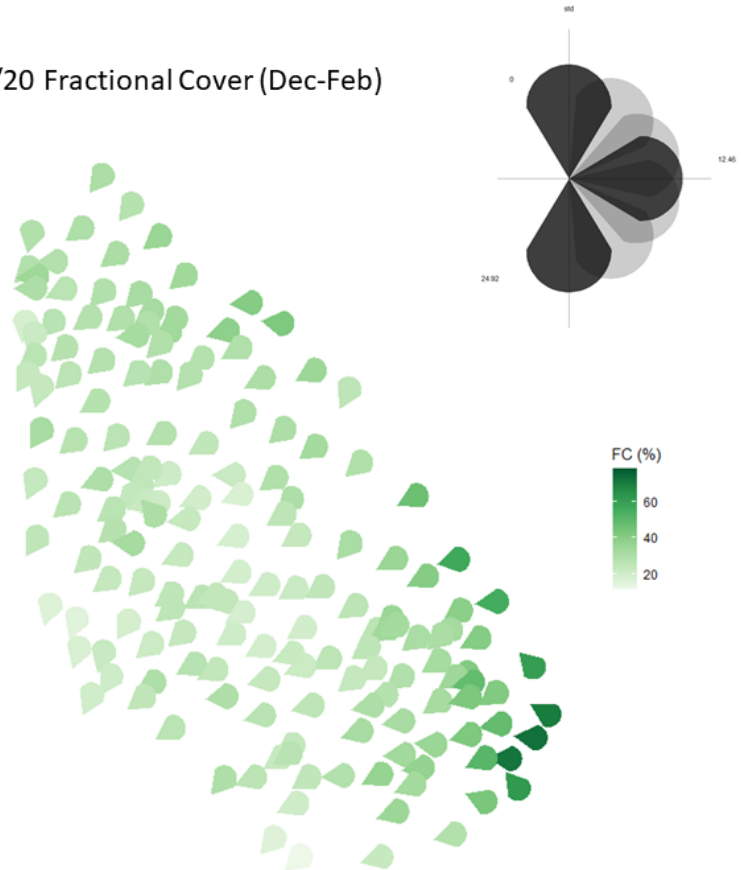


Ack: NQ Dry Tropics

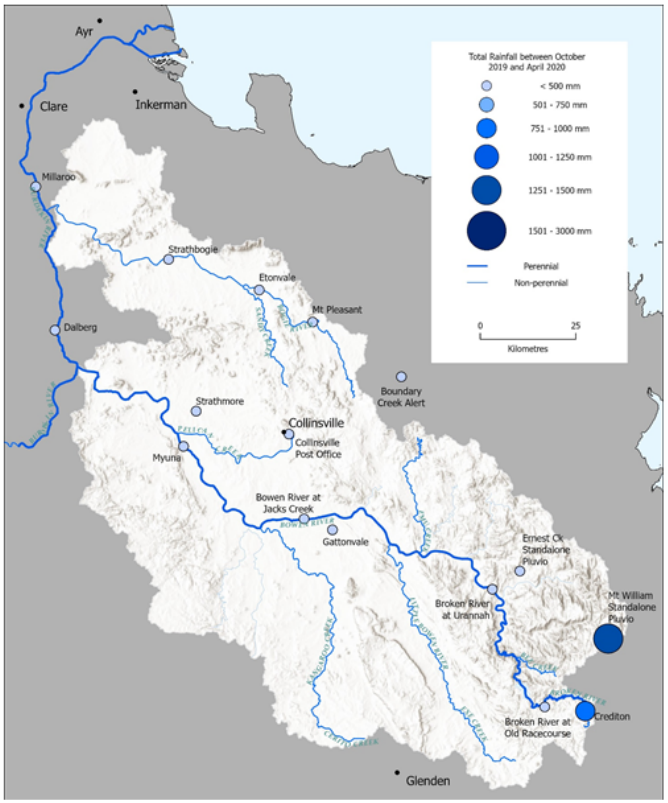
Glyph Rotation: FC 2019/20

`build_gmap()`

2019/20 Fractional Cover (Dec-Feb)



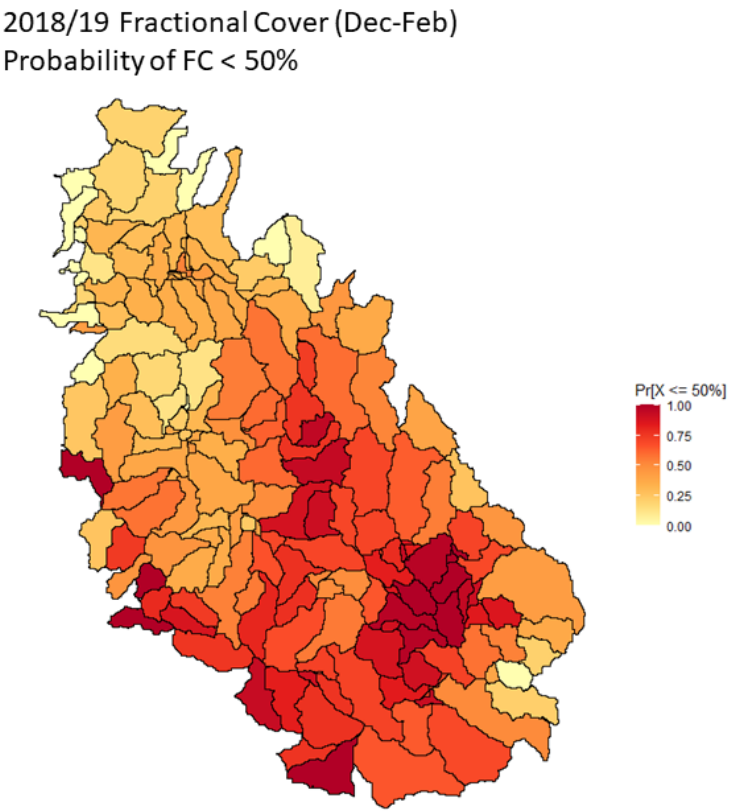
2019/20 Total Rainfall

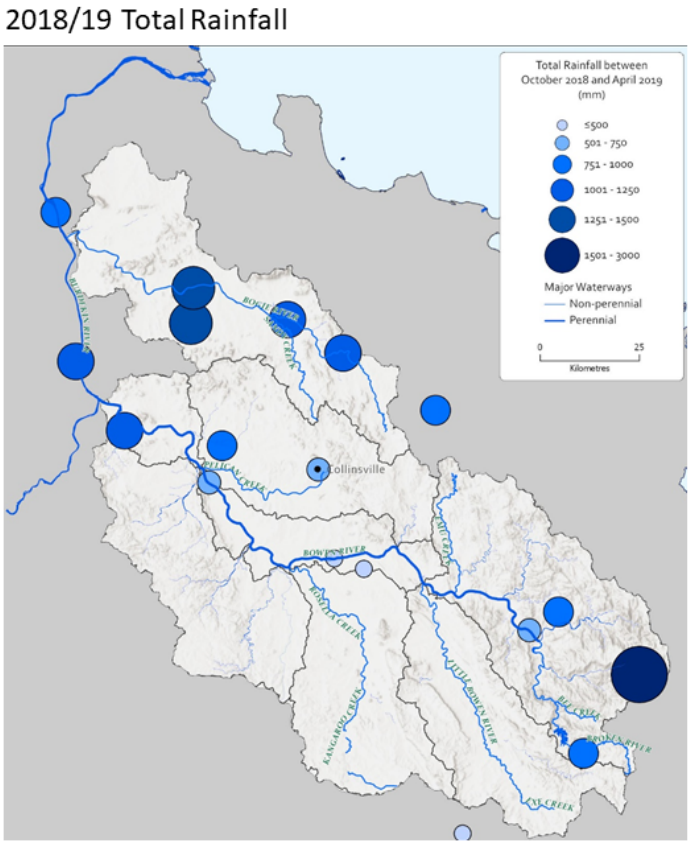


Ack: NQ Dry Tropics

Exceedance Maps: FC 2018/19

`build_emap()`



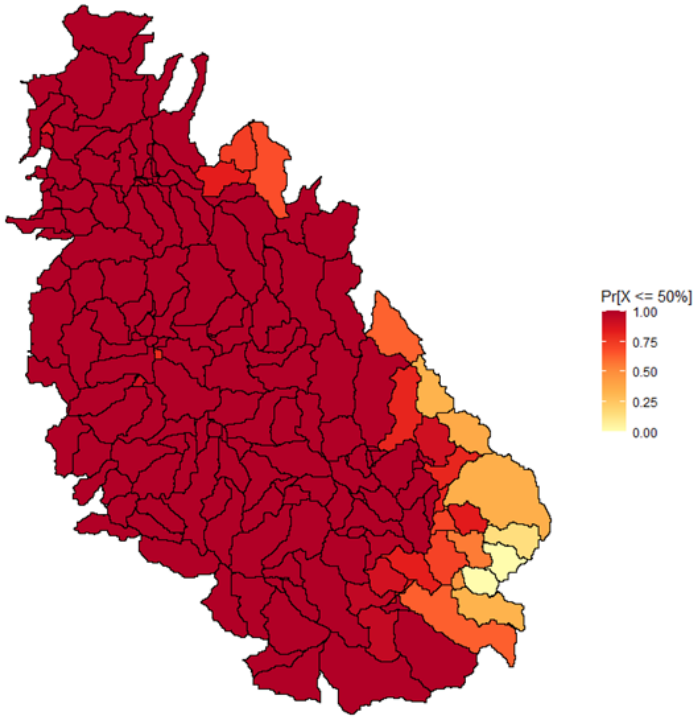


Ack: NQ Dry Tropics

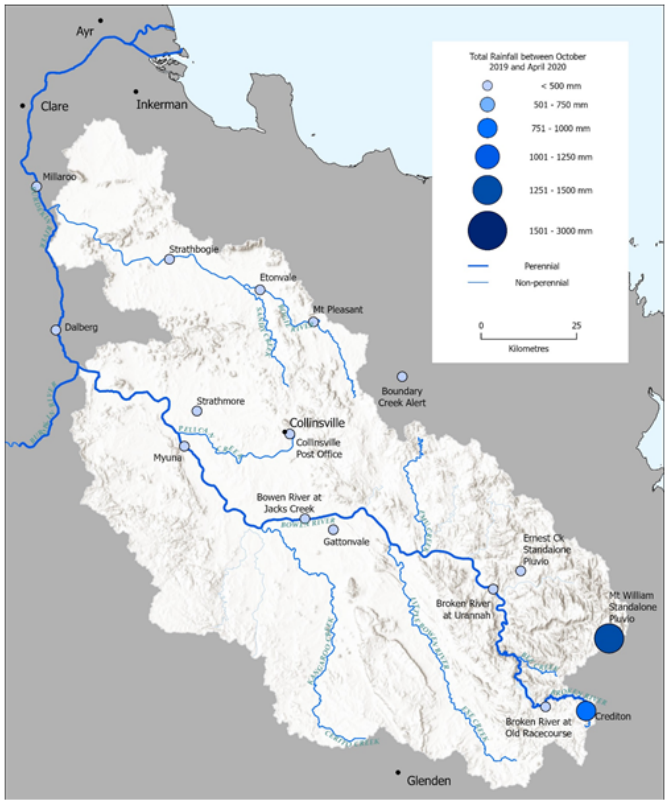
Exceedance Maps: FC 2019/20

`build_emap()`

2019/20 Fractional Cover (Dec-Feb)
Probability of FC < 50%



2019/20 Total Rainfall



Ack: NQ Dry Tropics

Vizumap R functions

R functions/code (S3 Methods):

- Building Map
  - `build_bmap` Build a bivariate map
  - `build_pmap` Build a pixelated map
  - `build_gmap` Build a map with glyph rotation
  - `build_emap` Build an exceedance probability map
- Viewing and Attaching
  - `view` View the colour key
  - `attach_key` Attach a key to a map

Vizumap R functions

R functions/code (S3 Methods):

- Formatting
  - `read.uv` Formats data for Vizumap plots
  - `pixelate` Pixelates a polygon in preparation for `build_pmap`
- Colour Keys
  - `build_bkey` Builds the colour key for a bivariate map
  - `build_gkey` Builds the colour key for glyph rotation
- Palettes
  - `build_palette` Builds palette based on defined colour key (bivariate map)

Collaborators

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CSIRO L&W
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Zoe Bainbridge

JCU
Brisbane Australia

Where to get Vizumap

- Vizumap: an R package for visualising uncertainty in spatial data, Lucchesi, L.R., Kuhnert, P.M. and Wikle, C.K. (2021), JOSS, DOI: 10.21105/joss.02409
- Visualizing uncertainty in areal data with bivariate choropleth maps, map pixelation and glyph rotation,' Lucchesi, L.R. and Wikle, C.K. (2017), https://doi.org/10.1002/sta4.150
- Code for producing these maps: https://github.com/pkuhnert

lydialucchesi/Vizumap

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Send us your maps to add to our Vizumap gallery!