Natural Resources and Mines
Managing Queensland's natural resources ... for today and tomorrow

Regression Modelling Approach to Deriving FPC from Landsat Data

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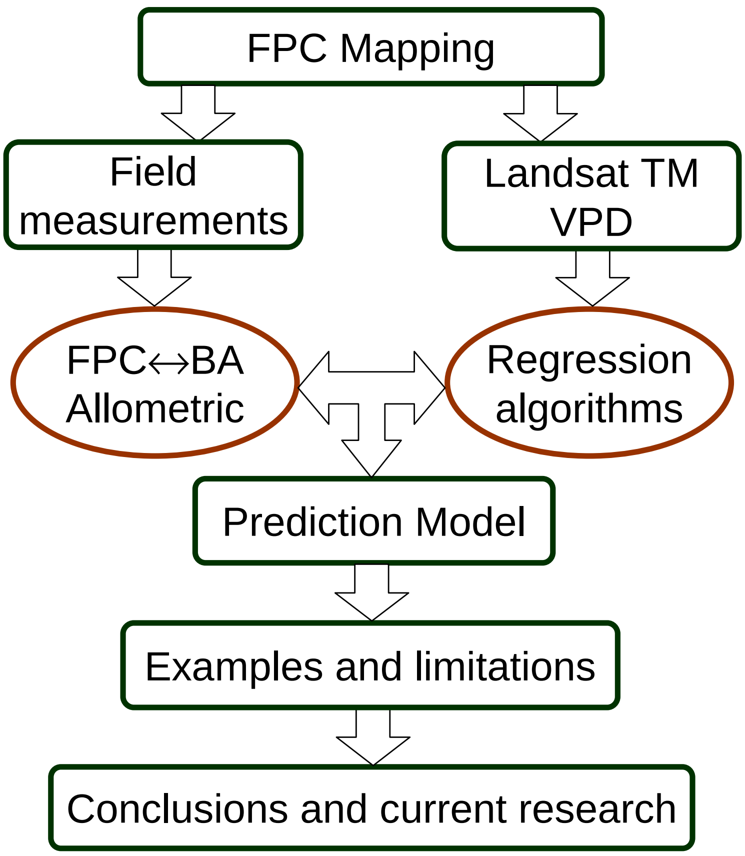
Statewide Landcover and Trees Study

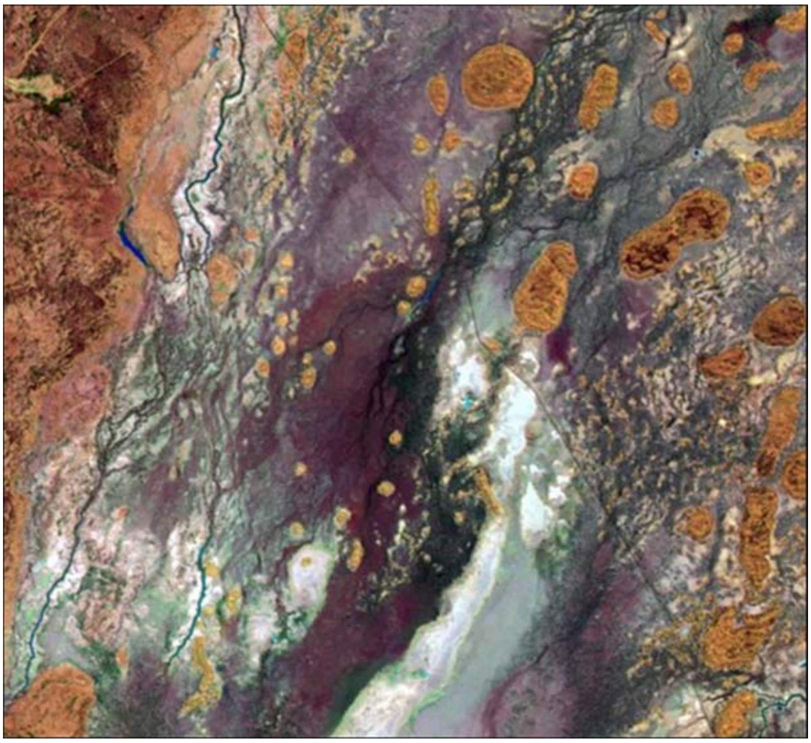
Outline

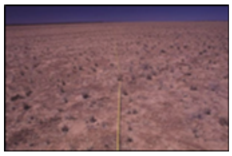


Spatial variation in soil reflectance
Landsat-5 TM

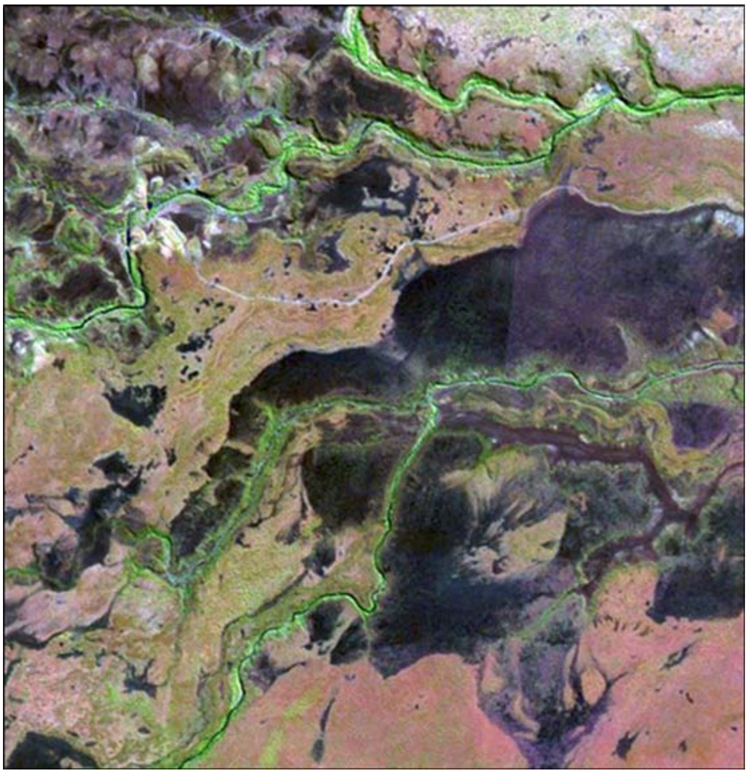






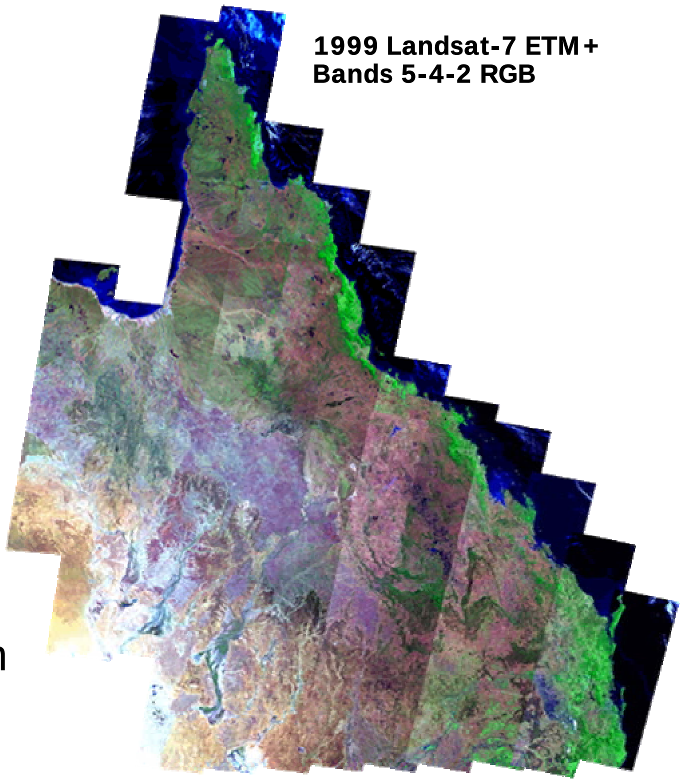




Fire scars - spatial and temporal variation
Landsat-5 TM



Satellite Data

- Image acqusition
  - Landsat-5 TM
    - 1986 to date
  - Landsat-7 ETM+
    - 1999-2003
  - Dry season
- Pre-processing
  - Ortho-rectification
  - Sensor calibration
  - Empirical BRDF correction



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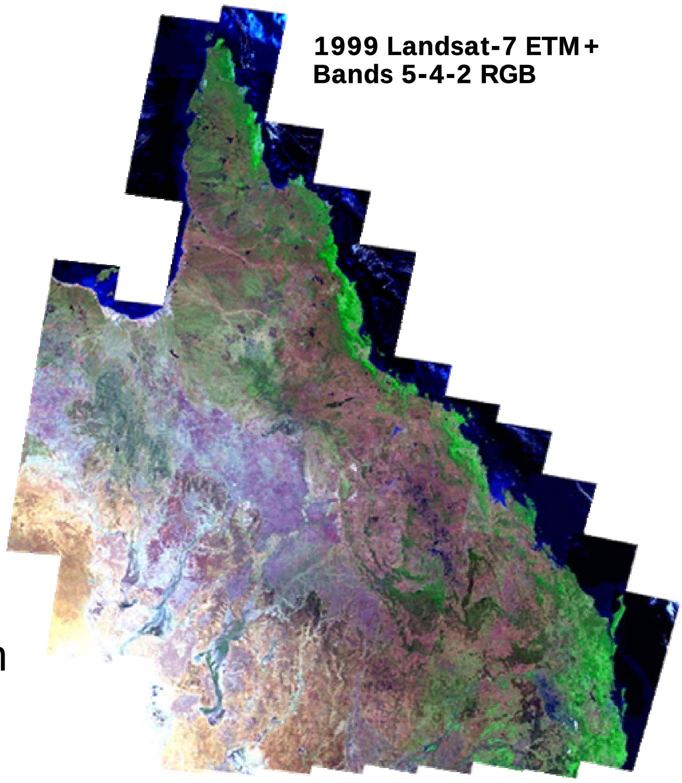
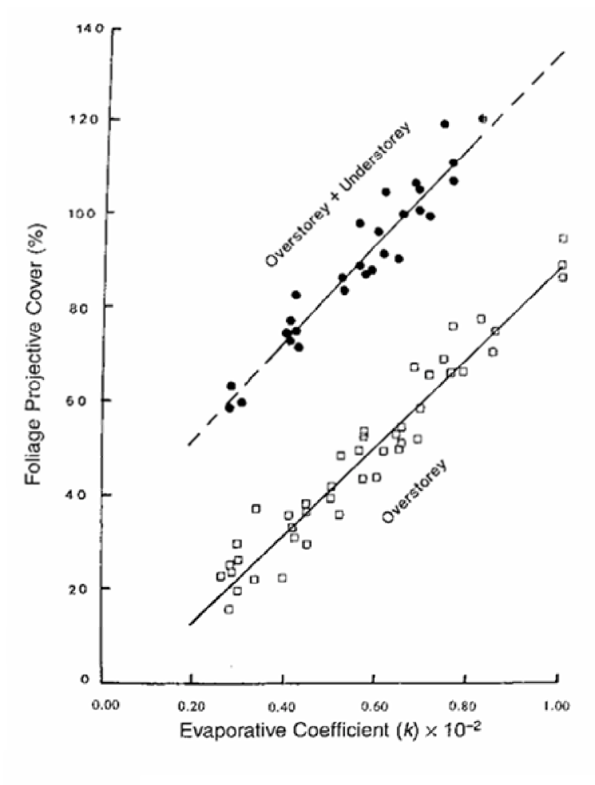
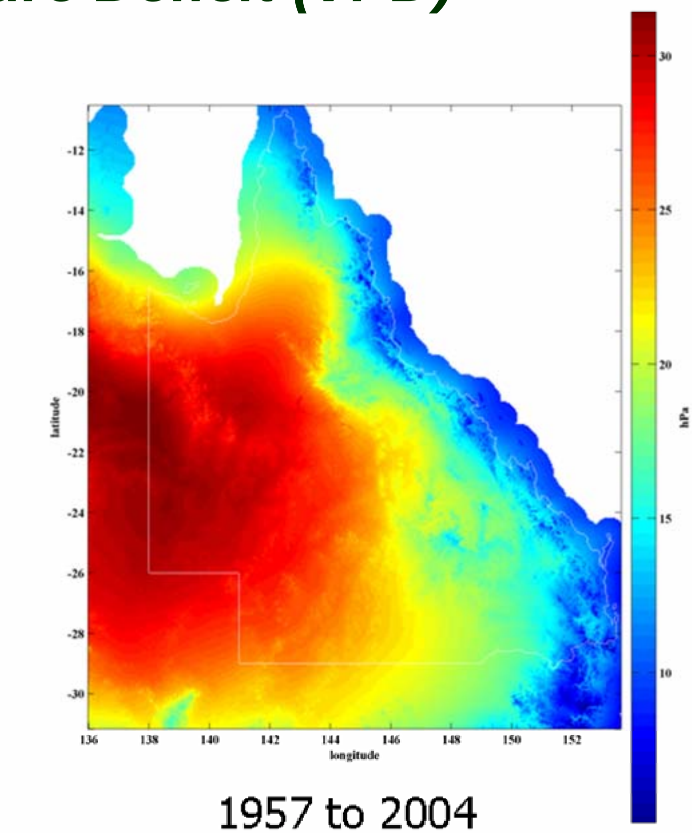


Vapour Pressure Deficit (VPD)



Specht (1983)

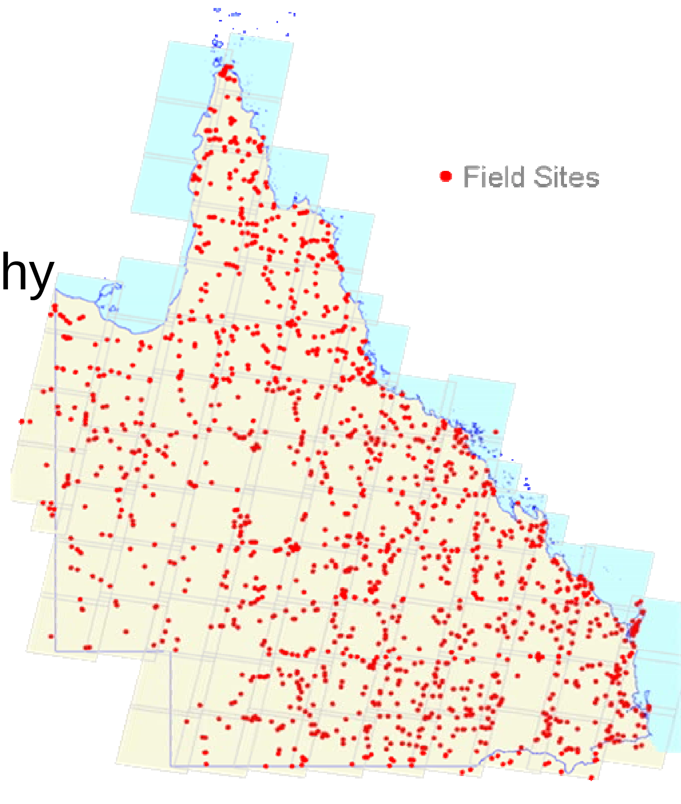


1957 to 2004

SILO annual daily average VPD

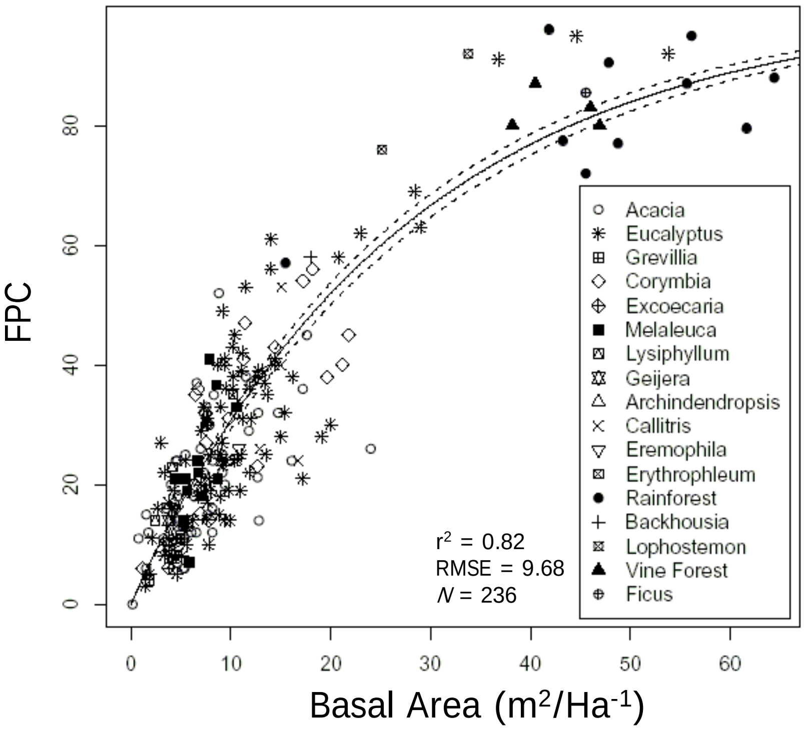
Field Measurements

- Site measurements
  - 1996-1999
  - Basal Area (BA)
  - FPC (~20% sites)
- NR&M aerial photography
  - Verification of 0 BA
  - Dark and bright soils
  - Fire scars



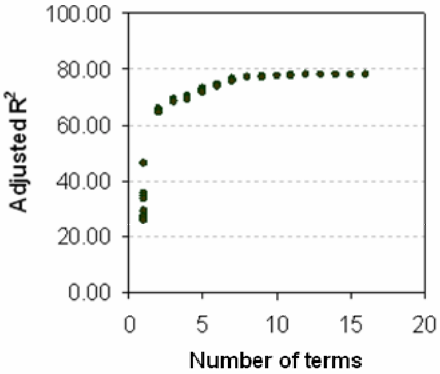
Basal Area ↔ FPC Relationship

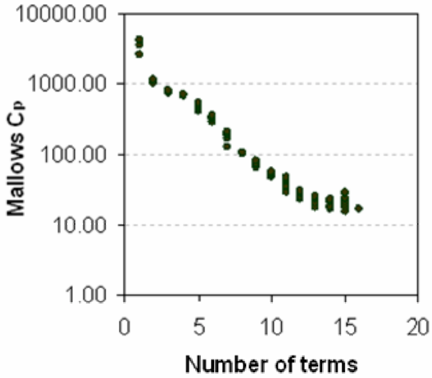
$$FPC = 100\left(1 - e^{-0.0355 \bullet BA}\right)$$

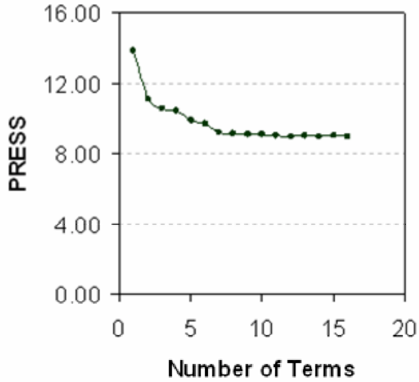


Multiple Linear Regression

- All-subsets multiple linear regression (MLR)
  - Explanatory transformations
  - Minimise PRESS
  - Maximise adjusted r^2
  - Minimise Mallows C_p







Selected Regression Models

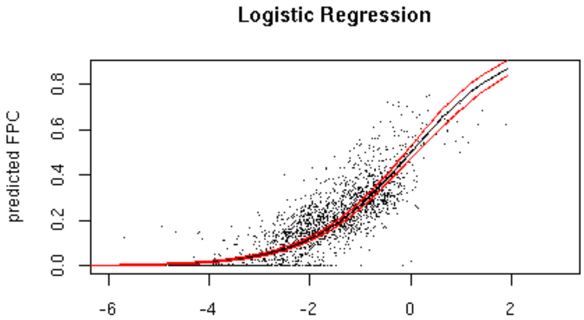
Result	Landsat-5 TM Model	Landsat-7 ETM+ Model
Terms	$B3^{0.5}$, $B4^{0.5}$, $B5^{0.5}$, $B7^{0.5}$, VPD^{-1} $B2^{0.5}$ to $B7^{0.5}$ interactive terms	$B3^{0.5}$, $B4^{0.5}$, $B5^{0.5}$, $B7^{0.5}$, VPD^{-1} $B2^{0.5}$ to $B7^{0.5}$ interactive terms
R^2	0.815	0.801
S.E.	7.98	8.26

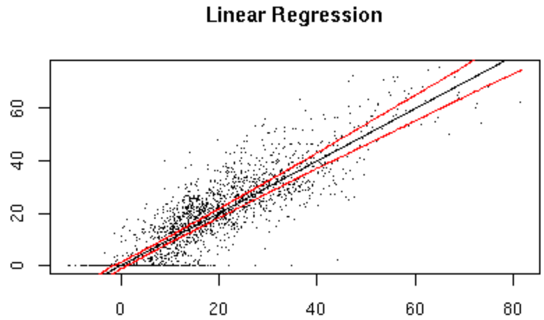
Alternative Regression Algorithms

- Generalised Linear Models
- Multiple Regression with splines
- Regression Trees
- Support Vector Machines Regression

Generalised Linear Models

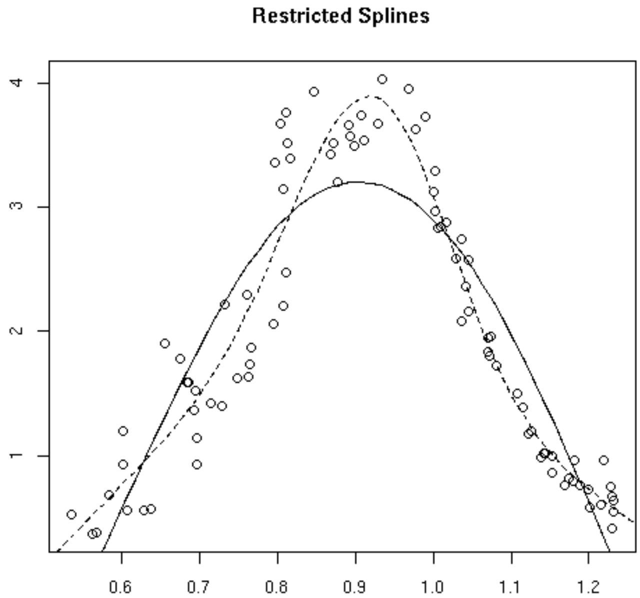
- Don't need to assume that residuals ~ $N(0,\sigma^2)$
- Better model distribution of response





Multiple Linear Regression with Splines

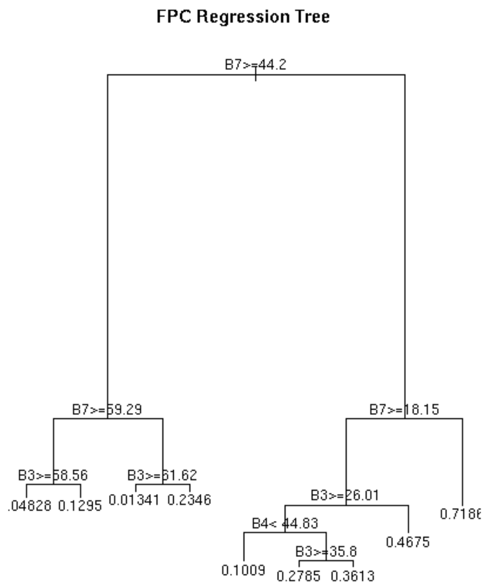
- Can relax assumptions of linearity



- piecewise polynomials, smooth at the joins (knots)
- Typically use 5,4,3 knots.
- More data support more knots, more flexible

Regression Trees

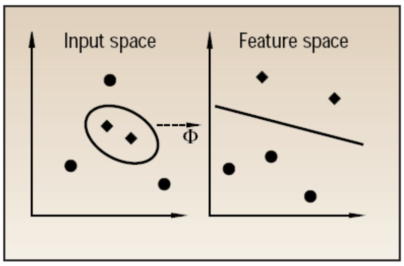
- Interaction handled automatically
- Monotonic transformations handled automatically
- Often accurate on non-linear problems



- Random forest extenstion
- Grows many trees based on random selection of data
- Feed a new observation into each tree and average results

Support Vector Machines

- Flexible modelling for classification/regression
- Hype or Hallelujah?



- Uses hyperplanes to separate groups
- Maps input space to feature space using mathematical functions (kernels)
- Extension to regression (ε-SVM regression)

Comparison of Algorithms

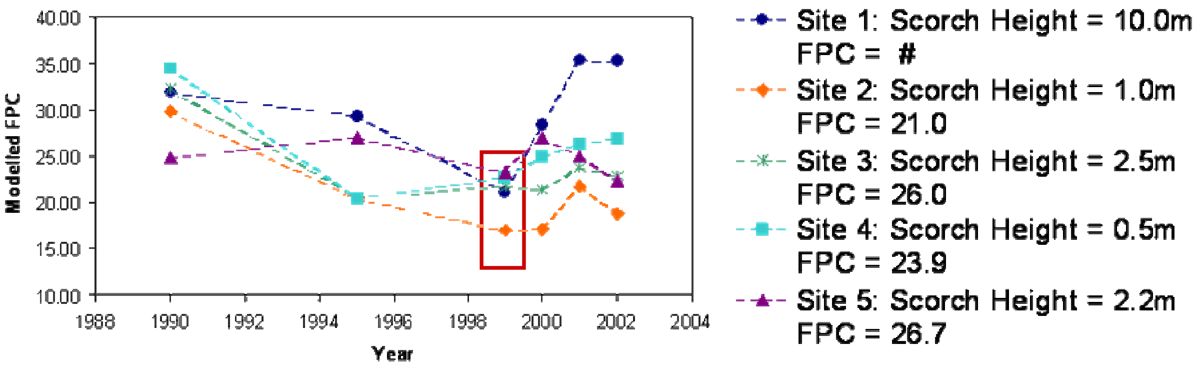
- Five approaches compared
- Same predictors as the selected model
- Assessed using c.v predictive accuracy

Method	$RMSE_{cv}$
Linear Reg.	8.6
GLM	8.2
Tree (RPART)	8.2
Splines	7.1
SVM	7.1
Random Forest	7.0

- Small increase in predictive accuracy in newer methods
- Cost is added complexity
- Some practical problems

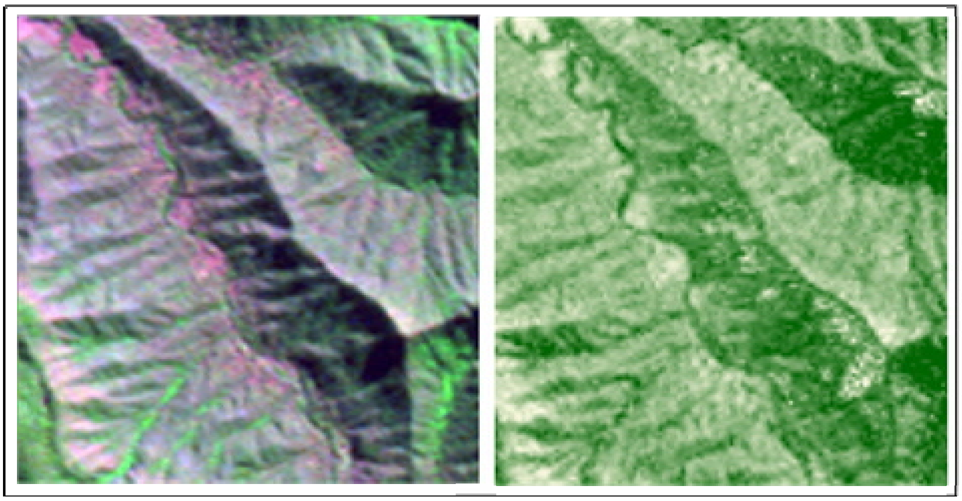
Example of model predictions: Fire scars

Modelled FPC Landsat-5 TM Site Photo



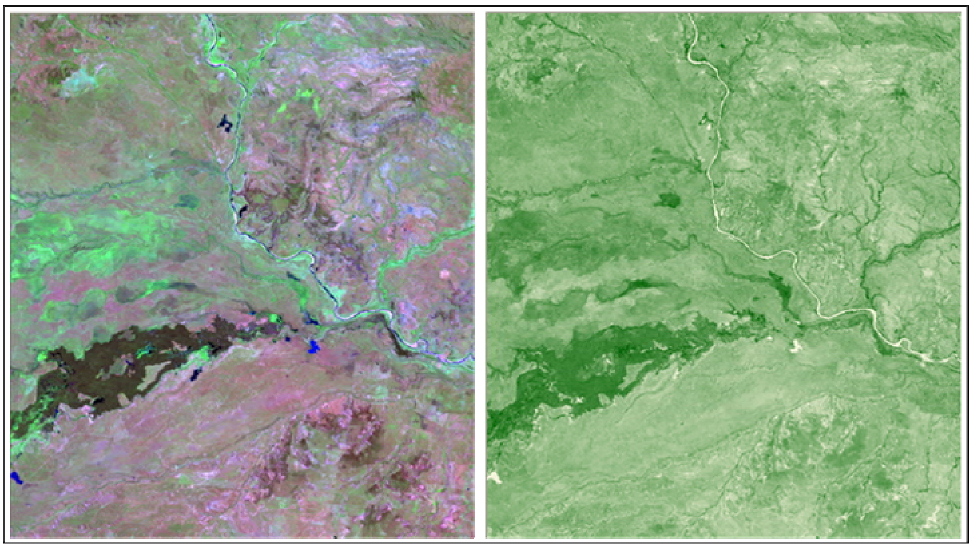
Regression model limitations

- Topographic effects



Regression model limitations

- Herbaceous effects



Conclusions

- Existing regression models do a good job
  - Representative field data
  - Minimised prediction error
  - Different regression algorithms performed similarly

- Primary limitations
  - Topographic effects
  - Herbaceous green cover

- Current work
  - Topographic correction
  - Relationships between different structure measurements
  - Airborne LIDAR validation of FPC products
  - Linking uncertainty between field ↔ LIDAR ↔ Landsat models
    - Bayesian approach
  - Decoupling perennial and herbaceous FPC
    - Trend analysis of Landsat FPC products
    - MODIS time-series decomposition