The Mine Woodlands project in the Witwatersrand Basin gold fields of South Africa: Strategy and progress

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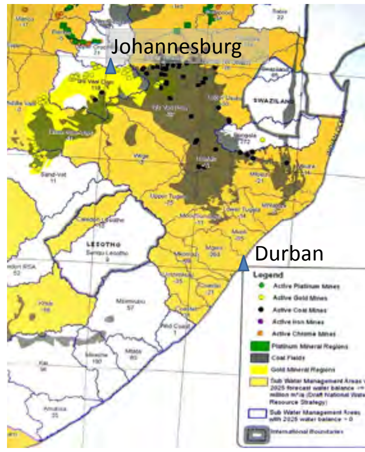


Witwatersrand Basin gold fields

- 25 000 km^2
- Mining since 1880's
- 31% of all gold ever mined globally
- ~ 40 active mines
- Estimated 6 billion tonnes of tailings
- Several hundred unlined TSFs, > 400 km^2

Environmental problems

Dust

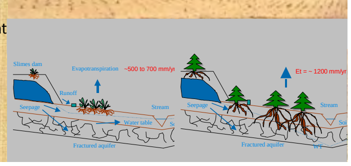
Greatly reduced by vegetative covers of pasture grasses, and tolerant indigenous and exotic plant species

Water (acid mine drainage)
many years of contamination
groundwater, soils, water courses/rivers
sulphates, chlorides, heavy metals, R/A ions
sometimes exceed environmental standards

mines approaching end of life,
greater awareness of need to clean up
tighter controls by Govt regulators

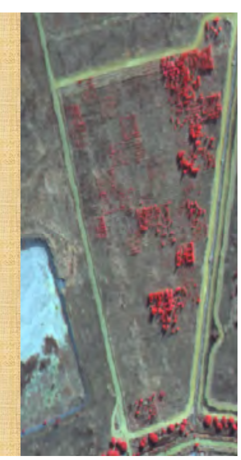
Solutions?

- **WATER TREATMENT?** Meeting costs into an indefinite future?
- **PHYTOTECHNOLOGY** (Mine Woodlands Project)
  - Replacing seasonally-dormant grassland with evergreen woodlands
    - Higher annual evapotranspiration
    - Deeper root systems
    - Higher biomass and potential for contaminant sequestration / immobilization
  - Hydraulic control of seepage
  - Enhanced uptake / immobilization of contaminants



Establishment of woodland trials

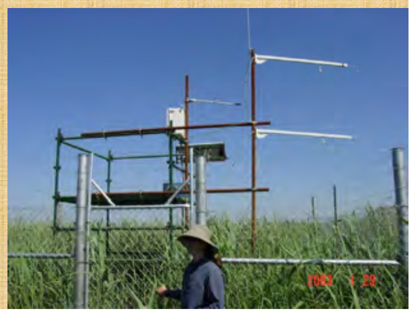
- Species
  - Indigenous (48)
  - Exotic (12)
- Sites
  - Three mining regions
  - numerous site types
- Planting
  - 2003 – 2008, total of 320 ha
- Silvicultural trials (site preparation, nursery practice, planting, spacing, fertilizing, felling cycle, etc)



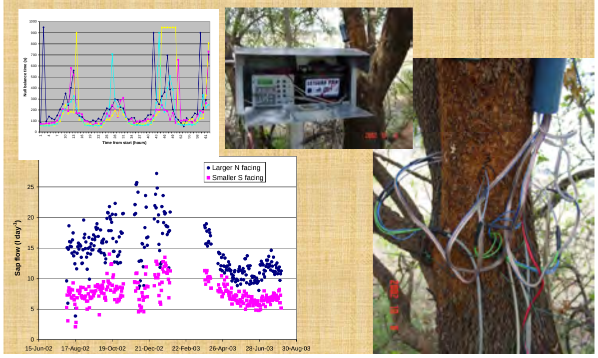
Annual evapotranspiration studies

Bowen ratio, Eddy covariance, site water balance

- ET from original vegetation
  - grasslands
  - *Phragmites* reeds
  - *Acacia* woodland



Sap flow studies in trees



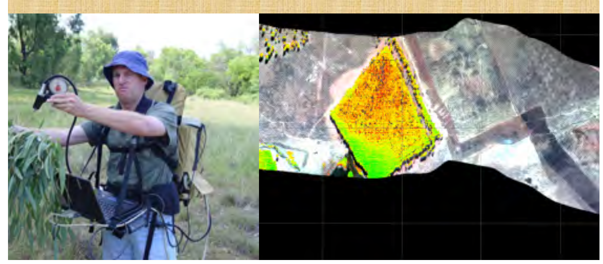
Estimated annual ET

Species	Water availability	Site	Method	Annual Tr/ET (mm)
Eucalyptus sideroxylon	High	Riparian	Sap flow	~1400
Eucalyptus dunnii	Low	Non riparian	Sap flow	673
Eucalyptus GXC	Low	Non riparian	Sap flow	767
Eucalyptus camaldulensis	Full range	N/A	3-PG model	527 - 1277
Searsia lancea	High	Shallow WT	Sap flow	1094
Grassland	High	Riparian	Eddy covariance	576
Grassland	Low	Non-riparian	Regression model	566
Phragmites reeds	High	Riparian	Eddy covariance	1170

Scope for increasing annual ET
Access to mine-affected groundwater crucial for high ET and seepage impact

Importance of access by trees to mine water

- Difficult to assess from root excavation studies
- Spatial patterns of dry season water stress



Most successful species:
Exotic: *Eucalyptus spp (dunnii, macarthurii, camaldulensis, grandisXcamaldulensis, melliodora, grandisXnitens*). Fast growth, high biomass, high ET, fire resistant, low contaminant uptake, short rotations

Indigenous: *Searsia (Rhus) lancea, S. pendulina, Tamarix usneoides, Combretum erythrophyllum*, Slow growth, moderate ET, contaminant uptake moderate to very high, moderate fire resistance, long rotations

Is the phytotechnology approach viable?

- From results to date:
  - ET can be raised substantially by planting trees where they can access mine water
  - Increased ET can balance seepage rates
    - Case study: 484 ha, annual seepage = 547500 m^3, increased ET = 400 mm, area of trees required = 137 ha
  - High contaminant uptake in some species, especially *Tamarix usneoides*
  - Relatively low cost containment of seepage
  - Small business opportunities, jobs
- Risks
  - Build-up of contaminants over time
  - Tree pests, drought
  - Public resistance to the use of exotic trees
  - Concern by Government regulators over streamflow reductions

Some major challenges remaining

- Matching tree species to sites

E.g. *Tamarix usneoides* hyperaccumulation of sulphates on moist saline soils

- Integrated hydrological / contaminant modeling
- RS-based woodland monitoring techniques
  - vigor (build-up of contaminants)
  - tree water use rates (effectiveness)