Impacts of spekboom thicket degradation & restoration on hillslope hydrology

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Thicket Forum 2012

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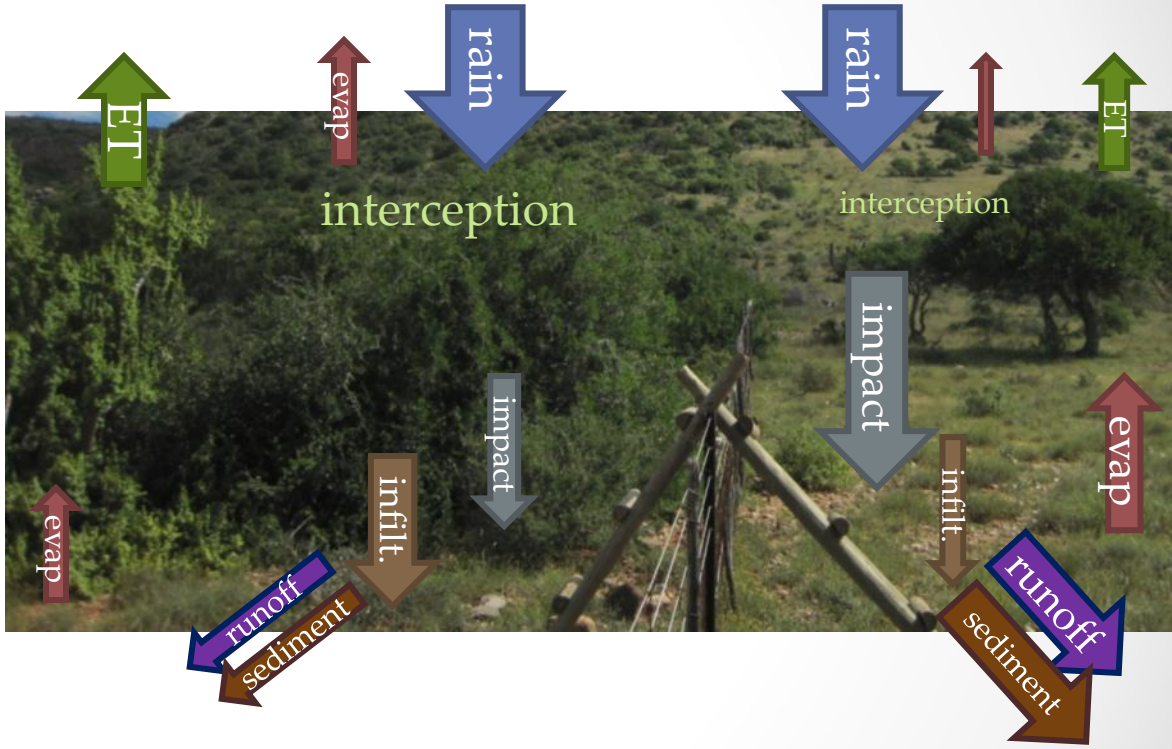
Background

- Semi-arid, water-stressed catchments
- Large potential thicket restoration areas
- Uncertain net hydrologic impacts
  - Watershed services from restoration?

Background

- Processes impacted
  - Canopy interception
    - Evaporation
    - Soil surface rainfall intensity
  - Infiltration into soil
  - Soil stabilization
  - Plant water use (evapotranspiration)
  - Shading – evap. from soil



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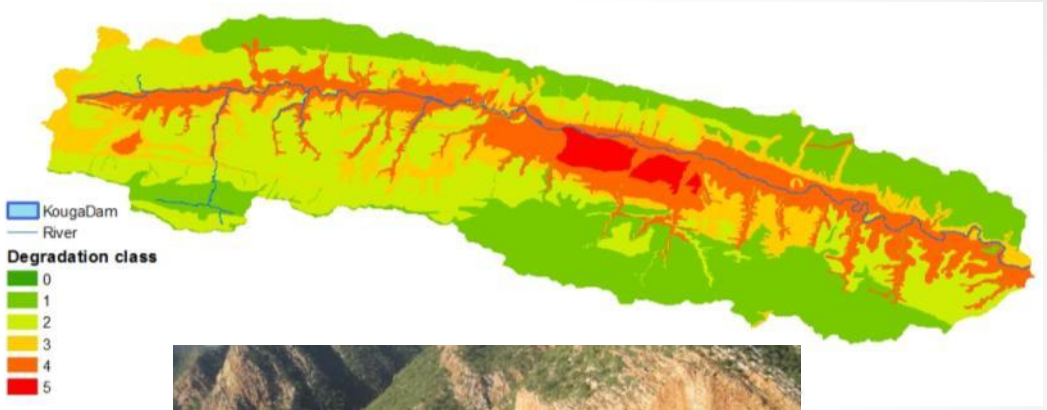


- Net effects at catchment scale?
  - Storm event river flows, flooding
  - Baseflow
  - Total runoff (water yield)
  - Topsoil cover
  - Sediment export

Hypotheses & Questions

- *Restoring* spekboom thicket cover will:
  - Increase canopy interception
  - Increase soil infiltration
    - ➢ Decrease storm event surface runoff
    - ➢ Decrease hillslope erosion
      - →Increase hillslope soil moisture retention

How much?

Methodology

- Fenceline contrast site, Baviaanskloof
  - North facing slope, 15º
  - Highly variable and episodic rainfall (300 mm MAP)
  - Sandy-loam ,rocky soil, 1m thick, TMG sandstone
  - Currently grazed vs. grazing ceased 30 years ago
    - Patchy grass, scattered trees vs. partial spekboom canopy
    - No litter layer, soil crusting vs. >5cm litter under spekboom

Methodology

Canopy Interception =
Gross Rainfall – (Through-fall + Stemflow)

- Rainfall
  - Tipping bucket rainfall gages
- Through-fall
  - Tipping buckets under canopy
  - Through-fall troughs
- Stemflow
  - Stemflow collar

Methodology

- Soil infiltration
  - Mini-disk infiltrometer
- Soil moisture
  - Soil moisture probes
- Surface runoff
  - Gerlach troughs (catchment trough + collection barrel)
- Sediment transport
  - Gerlach troughs

Results

- **Canopy Interception**
  - Average: 40% of rainfall
  - Range :
    - Small events (<5mm):
      55 ± 11%
    - Intense events (>5mm):
      23 ± 11%

- **Effective rainfall intensity**
  - *Max in open:*
    45 mm/hr
  - *Max under canopy:*
    18 mm/hr

- *N.B.: Measured under spekboom canopy - indicates interception under 100% canopy cover!*

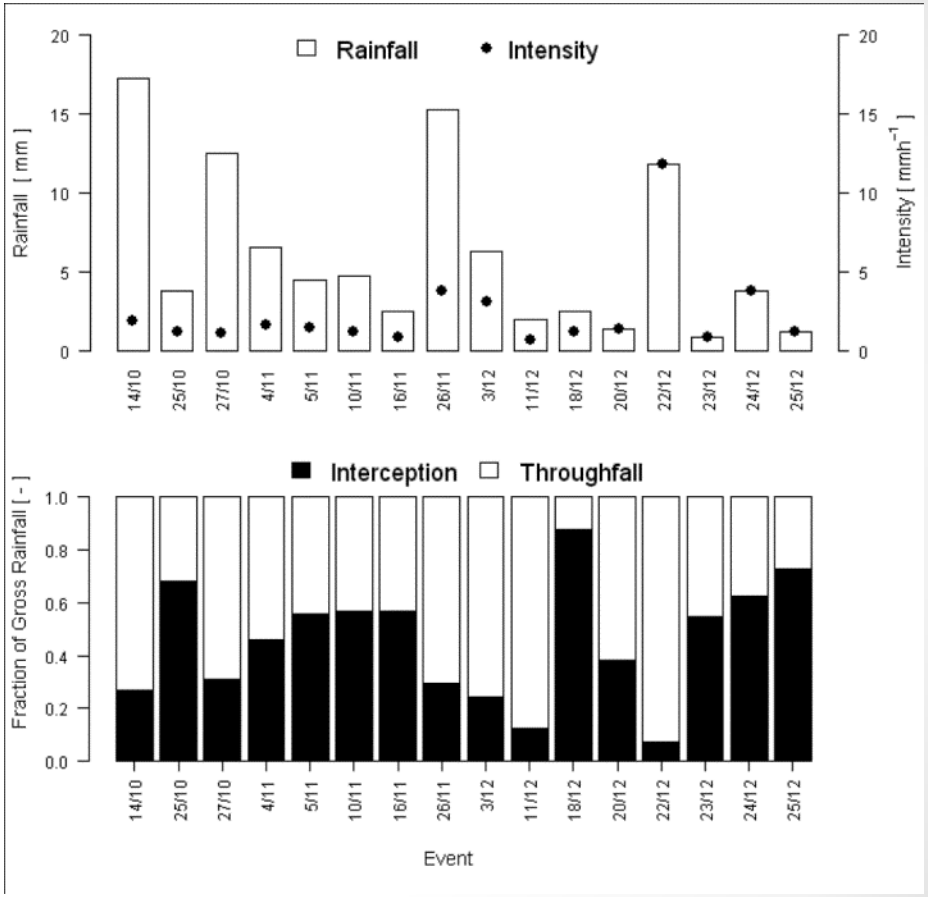


Figure 1. Van Luijk et al. in press (Journal of Arid Environments)

Results

- **Soil maximum infiltration rate**
  - *Degraded:* 0.04 - 0.25 mm/h
  - *Canopy:* 26.1 - 28.7 mm/h
- **Soil moisture patterns**
  - *Degraded:* lower max, fast dry post event
  - *Canopy:* higher max, SM persist post rainfall

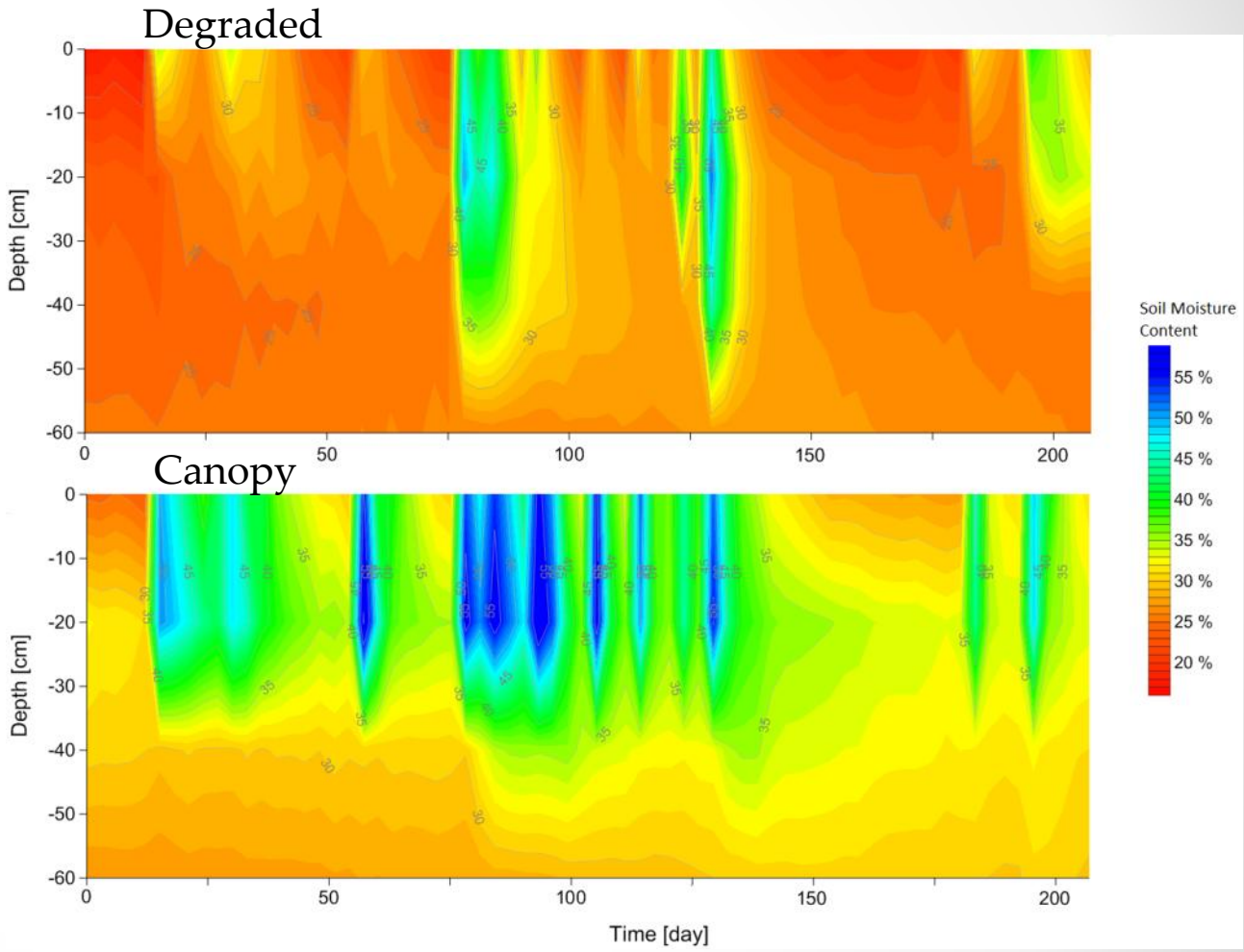
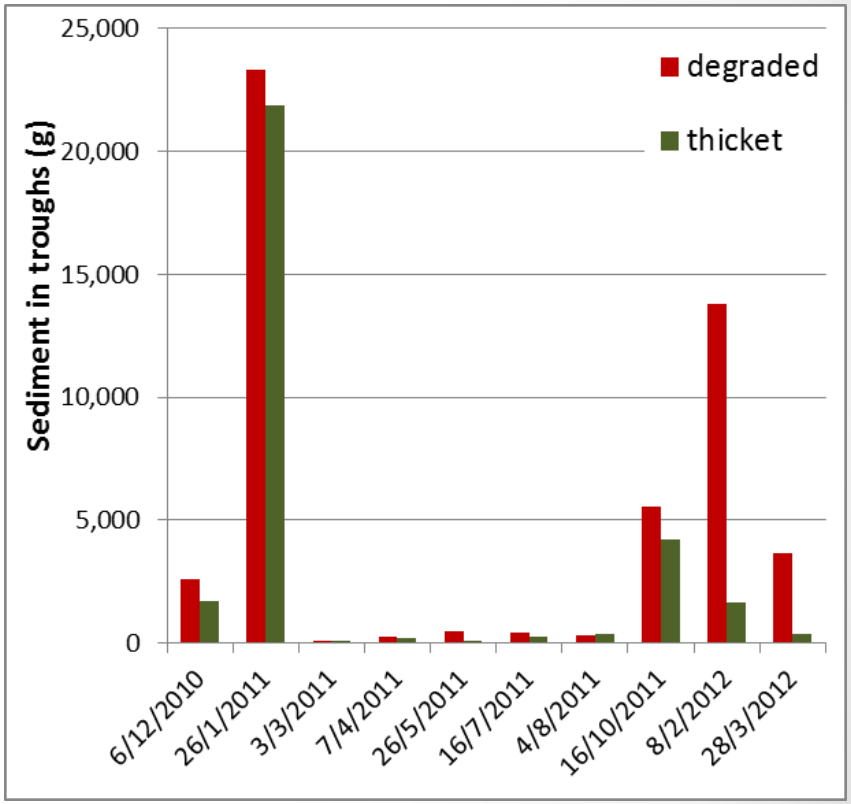


Figure 3. Van Luijk et al. in press (Journal of Arid Environments)

Results

- **Event runoff**
  - 67% more caught on degraded side on average
  - Differences vary with intensity
- **Erosion & sediment transport**
  - 100% more caught on degraded side on average
  - Differences vary with intensity

Trough sediment totals by event

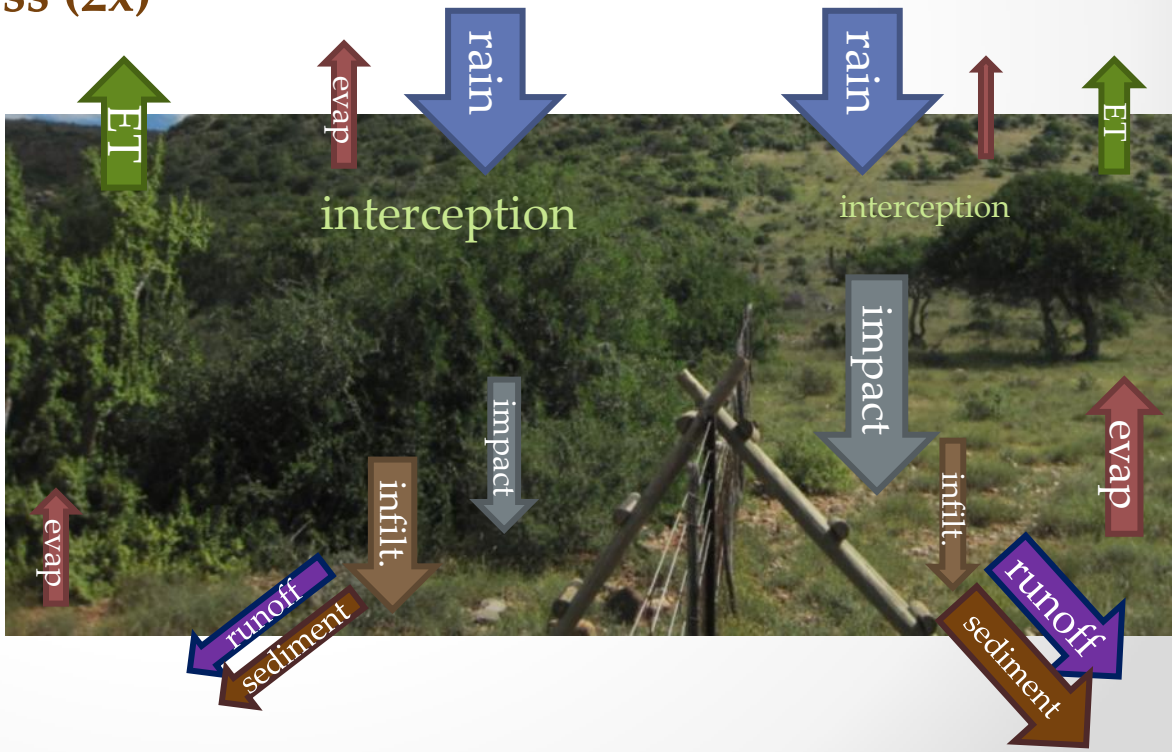


Results summary

- Restoring spekboom canopy at this site:
  - ↑ **canopy interception (6-8x)**
  - ↑ **maximum soil infiltration *rate* (150-650x)**
    - ↑ **time and depth averaged soil moisture**
  - ↓ **surface runoff (1.5x)**
  - ↓ **hillslope sediment loss (2x)**

Parameter	Spekboom	Degraded	Difference
Gross Rainfall	100 %	100 %	0 %
Interception	33 %	5 %	+ 28 %
Effective Rainfall	67 %	95 %	- 28 %
Runoff	7 %	39 %	- 32 %
Infiltration	60 %	56 %	+ 4 %

Van Luijk 2011



So what? Implications

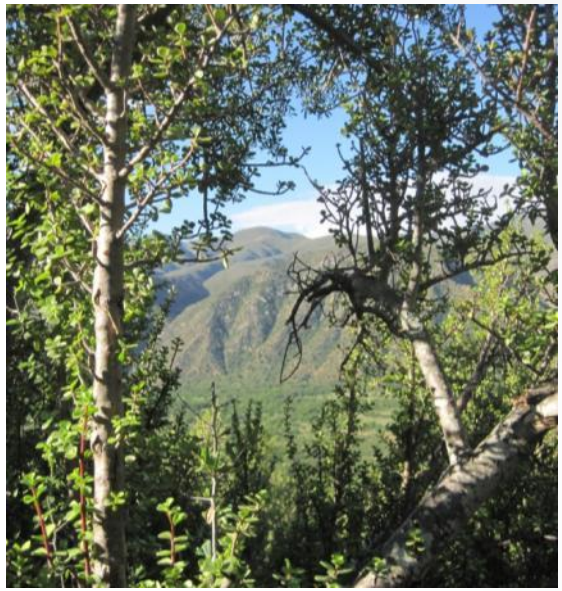
- **Demonstrates some clear, local, hydro-linked benefits of restoring spekboom thicket canopy cover**

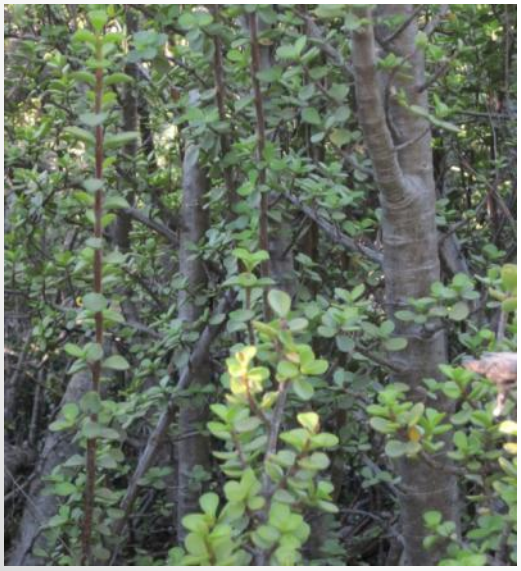
- **Loss of top soil & moisture retention**
  - Ongoing process
  - Lowering hillslope productivity
  - Challenges/considerations for restoration

- **Flood event runoff intensity**
  - Increase gully & river channel erosion/incision
    - Groundwater drainage
  - Increase flood impacts (ecosystems, communities, infrastructure)

Next speks…er, steps

- Other sites, conditions?
- Evapotranspiration?
- Catchment scale impacts
  - Baseflow?
  - Sedimentation?
  - Total downstream water yield?
- Climate change





- Catchment scale modeling + monitoring
  - Incorporate these findings in model
    - **Need: mapped % canopy cover!**
  - Monitor streamflow
  - Monitor stream sediment transport
  - Calibrate & validate modeling of processes
  - Land cover scenarios
  - Climate change scenarios

Thanks!

- The many hands of PRESENCE!