Application Of The Sednet Model In Partnership With The Fitzroy Basin Community

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EXTENDED ABSTRACT

Recent policy directions aimed at improving water quality entering the Great Barrier Reef lagoon require targets to be set for catchment sourced contaminants. Catchment models can assist in identifying pollutant loads and quantifying the impact of ameliorative land management practices on these loads at a variety of spatial and temporal scales. However, the use of catchment models by natural resource management organisations, has been hindered by a lack of transparency and hence confidence in model outputs. To address these issues an approach was adopted that involved the engagement, participation and communication of the strengths and weakness of the SedNet model to the Fitzroy Community. The aim of the approach was to 'demystify' the SedNet model, and obtain ownership in a process that would inform community target setting requirements.

To assist in regionalising the approach best available data were used to undertake the Fitzroy SedNet modeling. Additional improvements included the calculation of a variable bank height to replace the previous global default and use of an alternative return period for bankfull discharge. Both parameters were derived from local hydrological data.

Community confidence levels and model interpretation protocol were determined at a series of workshops throughout the basin. Particular attention was paid to highlight areas of uncertainty. Stakeholders had highest confidence in hillslope erosion. Low confidence was reported for gully erosion and unknown levels for stream bank erosion and floodplain deposition.

Wherever possible, model results were compared against soil loss studies undertaken within the Fitzroy. Simple validation was attempted at basin (142 000 km^2), sub basin (30 000km^2), and sub catchment scale (300 km^2). Suspended sediment loads compared favorably with recent studies at a basin scale; however some discrepancies are present at a sub basin scale. While encouragingly, there are some strong correlations between observed and model outputs at a sub catchment scale.

Outputs from the current condition scenario of SedNet indicated that hillslope erosion was the dominant source of suspended sediments making up around 50% of the total contribution. Gully and bank erosion contributions were 29% and 21% respectively.

A set of alternative scenarios were developed with stakeholder input. The principal management change to reduce suspended sediment export from the catchment was an increase in percentage grazing ground cover. In comparison, scenarios that produced marked changes to the management of intensively cultivated regions produced negligible changes in sediment contribution – a result that has challenged previous beliefs.

The application of alternative scenarios based on spatial changes to hillslope erosion, gully erosion, and riparian vegetation produced substantial changes in suspended sediment contributions. These community-requested scenarios further identified three prominent sources of uncertainty in regards to spatial data layers, which are:

1. A lack of detailed information on gully erosion extent and severity,

2. The extent and rate of bank erosion for the Fitzroy catchment, and

3. The spatial description of soil cover.

The application of the SedNet model has identified a number of knowledge gaps which the community can now use to direct funding and improve data for future model applications. The paper highlights the value of a transparent approach, to catchment modelling.

INTRODUCTION

The largest of the Great Barrier Reef (GBR) catchments at (142 000 km^2) is the Fitzroy Basin. Since European settlement in the Fitzroy (c.1850), large-scale alterations of natural systems have occurred, including recent widespread vegetation clearing under the Brigalow Development Scheme (1962-1976). Landuse impacts include changes in hydrology, landscape water balance, and declining water quality. Importantly increased sediment and nutrient loads have been linked to the degradation of GBR in-shore ecosystems (Furnas 2003).

In response to water quality threats, the Great Barrier Reef Marine Park Authority have suggested end of valley targets, to reduce pollutant loads entering the GBR lagoon (Brodie *et al.* 2003). In addition target setting mechanisms have been attached to the Reef Water Quality Protection Plan and the National Action Plan for Salinity and Water Quality. As a consequence Natural Resource Management (NRM) organisations are using targets to direct business and assess progress towards targets. These policies have produced an increasing demand for information on catchment pollutant loads and the impact of land management practices on these loads at a variety of spatial and temporal scales.

Recent spatial modelling in the Fitzroy that has attempted to address these knowledge gaps includes continental scale SedNet modelling for the National Land and Water Audit (Prosser *et al.*, 2001) and more detailed work in GBR catchments by McKergow *et al.* (2005). However within the NRM community, national scale data and models in general are treated with skepticism. Without broader ownership and transparency in model outputs it will be difficult to arrive at meaningful targets. Intuitively these challenges can only be addressed with local data, parameters, validation, community engagement and learning.

This paper outlines new SedNet modelling work undertaken in the Fitzroy basin. Specifically;

1. Population of SedNet with best available data

2. Community engagement and model validation

3. Model scenarios and results.

The approach used in this modelling exercise has been one of communication and involvement with NRM groups. Community confidence levels and model interpretation protocol were determined at a series of workshops throughout the basin.

The application of the SedNet model has benchmarked and highlighted a number of knowledge gaps, which the community can now use to direct funding and improve data for future model applications. The paper highlights the value of a transparent approach, to catchment modelling.

1. MATERIALS AND METHODS

Spatial modelling in the Fitzroy Basin was undertaken using the windows version (1.41) of the SedNet model (available at http://www.toolkit.net.au/). SedNet is a mean average annual link based model that generates hillslope, gully, and bank erosion. The Fitzroy SedNet model outlined here builds upon previous work undertaken by Prosser *et al.* (2001) and McKergow *et al.* (2005). Due to paper length constraints the traditional model description component of the methodology primarily deals with changes in data and parameters from previous work (McKergow *et al.* 2005). Full details on Toolkit SedNet theory and operation are given in Wilkinson *et al.* (2004).

1.1 Parameter and Data modifications

Data and parameter changes were made to surface erosion, gully erosion, bank erosion and floodplain deposition. Spatial data and cover factor changes for surface erosion are outlined in Table 1.

Table 1. Surface erosion spatial data and cover parameters.

Spatial Data		Source
Rainfall erosivity		(Brough *et al.* 2004)
Slope		50m DEM
Landuse		1999 QLUMP (150m)
Mean Annual Rainfall		(Brough *et al.* 2004)
Riparian Cover		NRM (2001)
Landuse	**C**	**Source**
Grazing	0.05	(McKergow *et al.* 2005)
State forest	0.05	(McKergow *et al.* 2005).
Cropping	0.127	Current mix
Conservation	0.005	(Bartley et al. 2004)
Irrigation	0.1	(McKergow *et al.* 2005).
Mining	0.5	(McKergow *et al.* 2005).
Urban	0.003	(Bartley et al. 2004)
Horticulture	0.1	(McKergow *et al.* 2005).
Other	0.003	Estimated

Cropping cover factors were generated using the PERFECT model (Littleboy *et al.*, 1989). PERFECT was parameterised to the Capella runoff and soil loss project (Carroll *et al.*, 1997), with model runs of conventional, reduced and zero tillage undertaken for a forty year period (1960-2000). Resultant cover factors were then applied to a current management mix. Current management mix was derived using a survey of over seventy growers; (32% zero till, 50% reduced and 18% conventional). Current cropping cover condition was then calculated by weighted distribution.

A new function of SedNet is the option for simulating variable bank heights for the stream network. Bank height was calculated by plotting gauge bank height against catchment area, for around 50 stream gauges. Coefficient and exponent values of 0.777 and 0.2805 respectively (R^2 0.82) were then used to replace the default global value of 3m.

A Bankfull recurrence interval of six years was calculated by inspecting cross section and discharge data for 50 gauges within the catchment. Other hydrology changes included an increase in the number of stream gauges used for flow generation. In this study, we used 70 unregulated and 36 regulated gauges.

Gully erosion reduction factor was changed from 1.0 to 0.5. This was done due to a belief within the region that gullies had potentially stabilised within the last fifty years.

1.2 Comparison against other studies

Where possible model runs where compared against soil loss studies undertaken within the Fitzroy. Simple validation was attempted at basin (142 000 km^2), sub basin (30 000km^2), and sub catchment scale (300 km^2). During interpretation it is important to remember that SedNet outputs in this instance are 100 year average annual. Comparison datasets are over much shorter timeframes. Unfortunately direct temporal comparisons, were outside the scope of this project.

1.3 Community engagement

To increase ownership and transparency a series of workshops were run to explain model operation and interpretation. An approach similar to that of Chen *et al.* (2004) was used to determine confidence levels. Stakeholder scenarios with a view to target setting were also generated. Listed scenarios were then graded on perceived importance and subsequently run and interpreted.

2. RESULTS AND DISCUSSION

2.1 Community engagement "Interpretation"

A significant result of the engagement was the development of confidence levels and model interpretation protocol (Figure 1.) Model function was split into generation, delivery and transport. Under this delineation sub components were rated on the user's confidence in the science of the approach. The limit or scale of the data was also rated, from Basin (142 000 km^2), sub basin (30 000km^2) sub catchment (300 km^2) through to property scale (80km^2).

Stakeholders had highest confidence in hillslope erosion and sediment delivery ratio. Low confidence was reported for gully erosion and unknown levels for stream bank and floodplain deposition. A reason for this outcome was insufficient comparative data within the Fitzroy. Data limits for interpretation could be improved with finer resolution data and or comparative studies that validate the conceptual approach within SedNet in the Fitzroy.

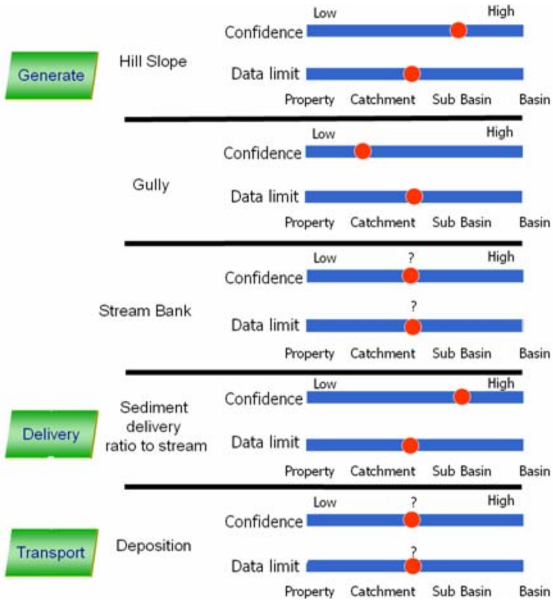

Figure 1. Community protocol and confidence levels for use of the current model.

2.2 Comparisons to other studies

Basin Scale Sediment Studies

Previous basin scale sediment studies for the Fitzroy include sediment rating curves (Belperio, 1979; Kelly and Wong 1996; Horn *et al.* 1998; Franz and Piorewicz 2003; Furnas, 2003; Joo *et al.* 2005), weighted discharge transport relationships (Neil and Yu, 1996) and models of land use runoff and sediment delivery (Moss *et al.*, 1992). More recently loads have been calculated using the spatial model SedNet (Prosser *et al.,* 2001; McKergow *et al.,* 2005). There is a wide variation in load estimates ranging from 2 to 10 million tonnes, highlighting the uncertainty currently attached to load calculations (Table 2). This study calculates loads within the range of recent studies 3-5 million tonnes. In addition end of valley concentrations of 1 gram per litre compare favorably to that of recent event monitoring (Packett *et al.,* "in preparation").

Table 2. End of valley load calculations.

Study	TSS (kt/y)
Belperio (1979)	2500
Moss *et al.* (1992)	1861
Neil *et al.* (1996)	10466
Kelly and Wong (1996)	8800
Horn et al. (1998)	4330
Franz and Piorewicz (2003)	5270
Furnas (2003)	2230
Joo *et al.* (2005)	3090
Prosser *et al.* (2001)	2640
Mckergow *et al.* (2005)	2911
This Study	**4575**

Sub Basin Scale Sediment Studies

Within the Fitzroy sub basin scale sediment studies are scarce. Of note is an erosion study of the upper Nogoa catchment (Skinner *et al.* 1972) This study describes spatial, surface, gully, and bank erosion, including a cumulative total for the upper Nogoa of 14 million tonnes. By comparison SedNet calculates total erosion at this point at around 4 million tonnes. There is a good match between studies for gully erosion patterns. Suspended sediment loads have also been calculated by Joo *et al.* (2005) and comparisons with this study are comprehensively outlined in Fentie *et al.* (2005). Loads from the Comet and Mackenzie sub-catchments compare favorably, however, there are considerable discrepancies for the other sub basins (Fentie *et al.*,2005).

Sub-Catchment Scale sediment studies

Within the Basin, two relatively small catchments, Gordonstone (260 km^2) and Spottswood Creek (285 km^2) have comprehensive water quality data since 2000. Encouraging correlations are present, with discrepancies for Gordonstone, at 260km^2 due to climate conditions (Table 3).

Table 3. Comparison of SedNet outputs against Gordonstone and Spottswood Creek, study data: (Period January 2000 to June 2004).

Scale (km^2)	T(ha/y)	EMC (g/L)	Runoff (mm/y)
Gordonstone			
50	0.29	2.3	15.1
SedNet	***0.18***	***1.2***	***14.4***
80	0.33	2.2	14.4
SedNet	***0.13***	***0.8***	***15.4***
260	0.03	1.4	2.1
SedNet	***0.19***	***0.6***	***17.2***
Spottswood			
72	0.03	0.3	7.8
SedNet	0.43	0.7	55
285	0.28	0.6	40.1
SedNet	0.29	0.6	46

2.3 Base Conditions

The base condition sediment summary budget is given in Table 4.

Table 4. Fitzroy sediment budget

Sediment inputs	Annual rate (kt/y)
Gully	3006
Bank	2137
Hillslope	5266
Suspended sediment outputs	
Reservoir deposition	370
Floodplain deposition	2391
Suspended valley export	***4575***

Hillslope is the dominant erosion source comprising (50%) of the total sediment input; however contributions from gully (29%) and bank (21%) erosion are also are substantial.

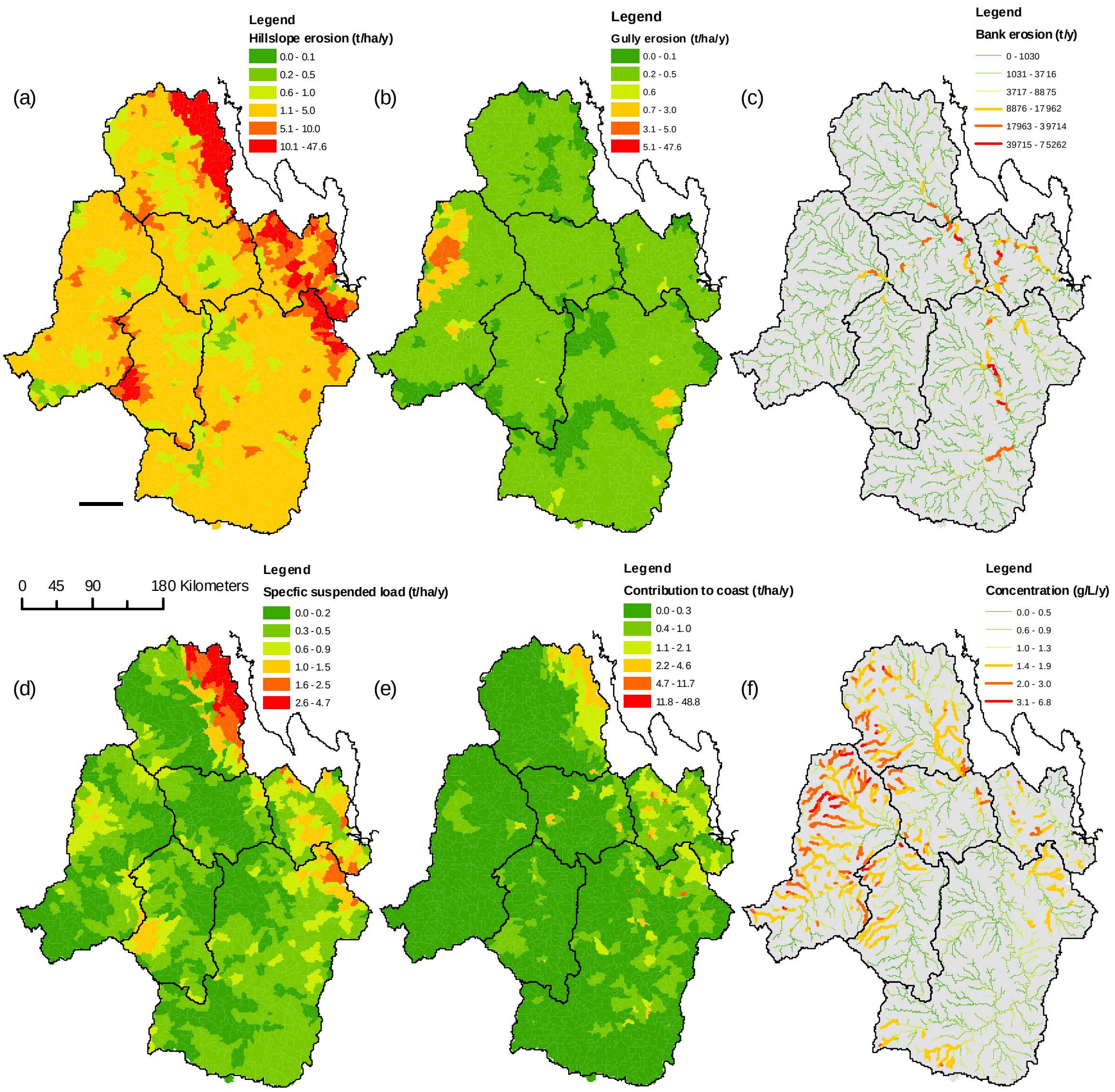

Figure 2. Modeled, hill (a) gully (b) bank erosion (c) Specific sediment load (d), contribution to coast (e) and concentration (f) for base conditions in the Fitzroy.

Spatial patterns for gully erosion, hill erosion, bank erosion, specific sediment load, sediment concentration and contribution to coast are given in figure 2. Higher surface erosion values (>10 t/ha/y) are present, closer to the coast, in areas of high slope, and rainfall energy. Gully erosion values are higher in the most western catchment, within an even coverage across the rest of the basin. Higher bank erosion values are present on the main trunk stream.

Although western catchments are large distances from the coast they have significant erosion coastal influence. Sediment concentration is highest in the western catchments. Mean annual concentration at the end of valley is 1 gram per litre.

2.4 Scenario analysis

Global cover changes for grazing highlight the sensitivity of ground cover to end of valley loads (Table 5). As a management change practice, improvements in cover produce the greatest reduction in end of valley loads. Cover values of 30% can periodically occur over large areas within the catchment expressing the potential inadequacy of a global cover value for grazing. Scenario 7 indicates that an error in gully mapping within close proximity to the coast, can have substantial impact on suspended loads, due to efficient transport of suspended sediments

Table 5. Scenarios and impact on end of valley suspended sediment loads, where + is an increase in export and – a decrease in export (kt/year).

Scenario	Impact TSS Kt/yr
Base	**4575**
Grazing	
1. Cover 30%	+4141
2. Cover 40%	+2173
3. Cover 50%	+606
4. Cover 60%	-586
5. Cover 70%	-1453
Spatially explicit changes	
6. Cover 30%- Isaac hotspot catchments (8000km^2)	+942
7. Gullies (3km/km^2) Boomer Range (960km^2)	+1051
Cropping	
8. Conventional tillage	+222
9. Reduced tillage	-18
10. Zero tillage	-86
Riparian	
11. Trunk riparian cover 100%	-418

Within the Fitzroy cropping has historically been associated with high erosion; the modeled scenario runs suggest that changes in practice will not have a large difference on loads at the end of valley. Within the model, bank erosion was isolated to the trunk stream and riparian cover was calculated as low in some of these areas. However this may not be the case, due to spatial inaccuracies attached to model stream definition. Scenario 11 indicates that if cover was high along the trunk stream links, loads would fall significantly at the end of valley.

3. CONCLUSION

The paper highlights advancements in spatial data, parameters, validation and community engagement for the Fitzroy SedNet model. However community scenario analysis displays concerns over global grazing cover values, high resolution gully mapping, and a lack of data on stream bank erosion. Although the results are encouraging discrepancies still exist that require further development of the SedNet model to greater assist with water quality target setting. The application of the SedNet model has benchmarked a number of knowledge gaps which the community can now use to direct funding and improve data for future model applications.

4. ACKNOWLEDGMENTS

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