# Resilient pastures and sediment: a case study in Hawke's Bay

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## Abstract

For many hill-country farms sediment will be a bigger regulatory issue than nitrates over the next decade. A dense, resilient pasture can reduce the risk of insidious sediment loss. Any ecosystem that relies on a few species is fragile. Sowing a single species leads to repeated re-sowing and increasing bare ground to remove competition, increasing the risk of sediment flows. An important issue during regulatory consultation will be establishing a natural, pre-human baseline for forest cover and documenting more recent changes in sediment flows. Hill country cropping and pasture renewal is incompatible with resilient pasture. This is a farmer's perspective on a diverse and persisting hill country pasture-based system that can make a good return on capital without re-grassing or fodder cropping. Funding of independent research on pasture and fodder systems is essential if farmers are to make good decisions.

**Keywords:** agricultural research, funding, permanent pasture

## Importance of the background rate of sediment

The emotive driver of policies of afforestation is the idea that all New Zealand was covered in bush and that human actions, in particular European farming, have destroyed large tracts of the country's bush, leading to accelerated soil erosion and sediment losses to water. Therefore, there is a need to establish natural, or pre-human baselines for forest cover and sedimentation to inform realistic policy targets and public opinion.

Lake core data provide evidence of a background rate of sedimentation. After removing the effects of air-fall tephra, the long-term rate of sedimentation in Lake Tutira was 3.3 mm/year, comprising 27% from storm surges (five events in the 20$^{th}$ Century were classed as storm surges, Orpin et al. 2010) and a 73% background sedimentation rate, caused by slope wash, active gully erosion and shallow landslides caused by smaller rainfall events. So, although they look dramatic, events such as Cyclone Bola in 1988 are not the major drivers of sediment in the long-term, although these large events do result in the deposition of large amounts of sediment in water courses that are a source of downstream sedimentation for decades following the events. Slope wash makes a significant insidious contribution, even in rain events not big enough to cause visible damage and is hugely magnified if there is bare ground. It must be stressed that these are long-term averages over 7200 years. When looking at time scales of individual centuries or shorter periods, there must be account for the considerable changes in climate and sudden shifts in vegetative cover (Wilmshurst 1995).

## Establishing a natural baseline

After 1350 AD, Tutira and Putere lake cores show an increase in storm-surge sediment, and an associated increase in charcoal. Pollen records from the cores show a transition to vegetation dominated by bracken fern. Although Wilmshurst (1995) notes that fire was common before 1350 AD, she accepts the traditional explanation that the fires producing this charcoal were caused by Polynesian settlers. Modern recalibration of radiocarbon data has moved the probable date of Polynesian settlement to around 1250 or 100-200 years more recent than thought previously (Matisoo-Smith 2017). Assuming a founding party of 250 people (five canoes) and a rapid population growth of 1.5%, by 1350 AD there would have been only 1100 people in the whole of New Zealand. By 1410 AD, when Wilmshurst notes that bracken reached its peak abundance, there would have been 2700 people. It seems unlikely that this small population, settled predominantly in coastal regions, would be responsible for "the loss of about half the native forest cover" (Masters et al. 1957).

Grant (1996) documents several periods of intense gales, resulting in wind-throw in Hawke's Bay forests. After such periods of extensive damage, forests are immediately vulnerable to fire due to dry foliage. After a period of time the sap wood rots, then much later the heart wood. After both these processes, the land becomes vulnerable to fire even if previous fires have occurred, as in the Norsewood fire of 1888 documented by Grant (1996). Fires started in standing dead wood by lightning strike are well documented, especially in the ranges. Driven by hot, dry, NW-winds, they can destroy large areas of wind-damaged forest. Colonising bracken fern is highly combustible and enables subsequent fires to take hold.

The drier climate of the Sporer Minimum (1400-1550 AD), caused by solar activity, would have allowed bracken fern to become a stable climax ecosystem (McGlone et al. 2005). Wilmshurst (1995) states "After deforestation in Hawke's Bay, bracken dominated the landscape for about 500 years, until the time of

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European settlement in the mid-1800s". Although no other natural change of anywhere near this size occurs in the 7000-year Tutira record, the buried kauri forests of Waiharara indicate that large scale forest destruction has occurred more than once and is a feature of New Zealand's landscape history. Although it is probable that Polynesian fires helped to maintain bracken dominance during wetter periods, especially after the Maunder Minimum (1650-1720 AD), it should be acknowledged that natural processes were responsible for a substantial amount of deforestation leading to bracken fern dominance in the east of the country for the 500 years to 1850 AD.

A pre-human baseline should acknowledge that while large areas of bracken fern existed concurrently with Polynesian settlement, they were largely part of a natural cycle of vegetation change. Wilmshurst (1995) notes that this change resulted in increased sediment from heavy rain events. Work conducted by the National Institute of Water and Atmospheric Research (NIWA) shows that annual sediment loads entering Hawke's Bay are now only 45% above pre-human levels (Hicks et al. 2019). It should be noted that NIWA's baseline is the current landscape modelled under a pre-human vegetation cover. It does not consider the 500 years of bracken dominance to be natural as this is usually attributed to human agency.

## Post-European settlement to about 1990

From the above it is almost certain that the effect of European agriculture came on top of a period of 500 years of elevated sedimentation. The period from the early 1800s to World War II was dominated by a pastoral farming regime that resulted in the clearing of native vegetation, sometimes forest, but very often native grasses, fern or manuka, from large tracts of hill country prone to accelerated soil erosion. The Soil Conservation and Rivers Control Act of 1941 was passed to conserve soil resources, prevent downstream damage from erosion and to make better provision for the protection of property from damage by floods. This resulted in the establishment of catchment boards and soil conservation plans that saw the planting of poplar and willow across large tracts of hill country. That activity continues today.

Until the 1950s the chief practice for maintaining pastures on hills was repeated burning (Guthrie-Smith 1921). These pastures were of a poor quality. From the 1950s until mid-1980s, denser pastures were established with the use of aerial topdressing and better animal control using more fencing. A reduction in sediment loss (Marden 2011) should have occurred. Unfortunately, a wave of development and intensification was supported by hugely increased returns from the Korean wool boom in 1951, followed by a series of government support packages, culminating in the Land Development Encouragement loans of 1978. Much of the development was ill-conceived. The old techniques of cut and burn were still used, but even more invasive practices such as giant-discing and root-raking were also common, even on quite steep slopes. All this was combined with a fashion for very high stocking rates. Livestock numbers reached a peak shortly after the Livestock Incentive Scheme of 1977. The result is seen in the Tutira core samples: 90% of the catchment was pasture in 1986 (Wilmshurst 1995) and the background, or non-storm, level of sedimentation over these three decades remained at the same high post-European settlement rate of approximately 10 mm/year (Orpin et al. 2010)

After Cyclone Bola there was a renewed interest in planting poplar and willow poles to reduce storm erosion and some land was totally retired. More importantly, this period coincided with a huge focus on farming efficiently. On hill pastures there was no more wasteful expansion and intensification by the sheep and beef sector. Permanent pastures were enhanced under greatly improved management and stocking rates fell by about 30%, although per hectare production increased due to improved genetics, fecundity and livestock management (Beef + Lamb New Zealand 2020). Unfortunately, the effect of these changes on the Tutira lake core is unable to be assessed because in 1982 the Papakiri (Sandy Creek) was diverted directly into the outfall from Lake Tutira, removing a large portion of its catchment.

## Recent times

A Ministry for the Environment report (2018) states that: "44 percent of the soil that enters our rivers each year comes from exotic grassland." This pasture which includes grazed tussock covers 10.2M ha. The total area of mainland New Zealand is 26.5M ha so 44% of the entering soil comes from 38% of the land area. That means pasture is only 16% worse than the rest of the country in terms of generating sediment. In general, the non-pasture land is either in plantation forestry or is steeper and in higher rainfall zones, but bush-clad. Our bush has been degraded by introduced pests and so almost certainly has a higher rate of soil loss than in pre-human times. Taking these factors into account it seems highly likely that the rate of soil loss from pasture today is well below the 200% above the pre-human base rate calculated from data (Orpin et al. 2010) for European farming prior to 1990.

It is important to ensure that the progress in sediment reduction made since 1988 is not lost. The influence of The Pasture Renewal Charitable Trust with their aim to re-grass 8% of our sheep and beef pastures every year (Hawke's Bay Today 2015), has been very concerning.

This trust saturated farming papers with articles designed to promote the interests of its 14 agribusiness sponsors (Hutching 2015). Physical production indices were emphasised, while financial returns and environmental effects were glossed-over and only best-case scenarios presented.

Of particular concern is the recent rise in hill country fodder cropping. The "spray & pray" approach, with little regard to slope and aspect, has been augmented recently by burning prior to sowing. On the positive side, enormous progress has been made in reducing erosion through soil conservation, but the trend for more regrassing and fodder cropping increases the risk of sediment loss.

## Maintaining a diverse and productive sward

Waiau Station and Allington Farm are in Northern Hawke's Bay on Land Use Capability (LUC) Class 6 and 7 hill country. They are run together as a breeding and finishing operation with an effective area of 1610 ha. The operation has been a contributing farm for the Beef + Lamb New Zealand Economic Service Class 3 North Island Hard Hill Country East Coast Quintile Analysis for 7 years. The land is steep and very varied in aspect and slope with an unpredictable climate, especially in spring and summer. It is estimated that the pasture has 20 species per square metre. The pasture has a mosaic of micro-sites that shift across the landscape with changes in slope and aspect and with climate. For example, after a couple of dry summers there will be a carpet of yellow *Lotus hispidus* over the driest sites. A series of wet summers and this little plant is less visible; a few plants plus a huge reservoir of tiny seeds are all that remain.

This diversity, both of species and cultivars, means that the farm's pasture is truly persistent. It can respond to a wide range of conditions, while maintaining ground cover. However, this is not enough; pasture needs to not only maintain a cover but also to grow, produce and earn money. After reading research from Sir Bruce Levy onwards and with help and support from the current agricultural science community, a management system is being developed that is helping shift pasture composition to favour legumes. Like many Wairoa properties the farm runs a high percentage of breeding cows. These are calved in mid-October and weaned early in February-March. They are then break-grazed on 1- or 2-day shifts until June. On sunny aspects a variety of slightly harder-seeded cultivars of subterranean clover are broadcast and trampled in by these cows to augment the 'Mt. Barker' and 'Woogenellup' that was oversown by previous owners. This policy allows an improvement of about a fifth of the pasture each year without the cost or the environmental risk of "spray & pray" techniques. It is aimed to minimise undesirable species by modifying management.

Lower-performing breeding stock are always identified and ready for sale in case de-stocking is required beyond the trading animals. During dry summers supplementary feed is provided by pollarding the numerous poplars and willows established over a long history of soil conservation plantings to address the risk of accelerated soil erosion and sediment loss from LUC Class 6 and 7 land. All the land is below 350 m and with a high-producing breeding flock there is the ability to winter sufficient stock to utilize spring growth. Over 30 years of farming, the proactive sale of stock means no purchases of urea, hay or grain have been needed during adverse weather events. The farm has been in the top quintile of the Beef + Lamb Economic Farm Service Hard Hill Country East Coast Survey for 5 out of the 7 years that it has been part of the programme. Over these 7 years the farm had an average rate of return of 5.3% compared to an average of 5.0% for the top quintile.

The author believes that in the benign climate that most of the North Island enjoys, fodder crops and re-grassing should not be used unless they are combined with a crop rotation producing cereals or some other human food crop. There is a place for short-term specialist crops in that situation and in areas with harsher winters than those experienced in Wairoa. Good husbandry of permanent pastures with a high legume content is about management, informed by scientific research. It rarely results in the purchase of agricultural machinery, herbicides, pesticides, seeds and urea. For this reason, the author wishes to make a plea for the decoupling of agricultural research funding from industry partners. To inform good environmental decisions there is a need for an independent research community that is fully funded by taxpayer dollars, not supported by partners who wish to sell products.

## Conclusions

In order to maintain a social licence to farm, relevant baselines and good data to inform realistic policies are needed in the wider public arena. Independent agricultural research funding is also essential for unbiased advice to inform management on-farm. There is now the ability to produce less sediment than during the first century of European agriculture. For hill country pastoral farming the key to environmental resilience and reduced sediment flow is scientific management of permanent pasture cover.

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