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A case study outlining the benefits of implementing sustainable cropping practices

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Ian Lea and his wife Prue retired in 2016 after 35 years running a successful mixed farming business in the southern Riverina. This case study outlines how their adoption of sustainable cropping practices benefitted their soil health, soil water availability and yields, and allowed them to continue to improve business profitability and reduce risk.

Key learnings

Ian and Prue knew they needed to keep improving their business. They did so incrementally by adopting practices that reduced their costs and risk, and increased soil water and nutrient availability.

- They *benchmarked* every farm enterprise, so they knew which were profitable and not profitable.
- They *adopted conservation farming practices* to improve soil structure by:
  - *Minimising tillage and direct drilling*. This increased soil water and nutrient availability.
  - *Retaining stubbles*. This decreased raindrop impact and runoff, and increased infiltration.
  - *Controlling traffic* by tramlining in all cropping paddocks. This reduced soil compaction but also increased seed, fertiliser, herbicide, fuel and labour efficiency.
- They *rotated crops* to provide a disease and weed break and to manage risk by:
  - *Extending the rotation* to 5 years, with one year of fallow, and including break crops. This improved profitability and reduced risk over the longer term.
  - *Fallowing* some paddocks each year (Ian fallowed at least 2 paddocks out of 16) using a non-selective herbicide and cultivation. This avoided a build-up in herbicide resistance.
  - *Sowing break crops* to manage disease. To manage financial risk, no more than a third of the total cropping area in any one year was committed to break crops.
- They *actively managed soil health,* so yields were not constrained by nutrition.
  - *Soil tests* were done regularly at the same locations to monitor soil health and nutrition.
  - *Soil nutrition was managed like farm management deposits*: i.e. built up when finances were good and drawn down when finances were tight.
  - *Lime* was spread to manage soil acidity and as a long-term investment in soil fertility.

The result was more water available to crops that were not constrained by nutrition, weeds, or disease. These changes allowed Ian and Prue to double their wheat yields between 1990 and 2016.

Grower profile

In the 35 years of their joint farming career, with an average growing season rainfall of 282mm, Ian and Prue Lea lifted the **water use efficiency** of their wheat by 86%, from 8.6 to 16.0 kg/ha/mm, and their barley by 190%, from 6.0 to 17.4 kg/ha/mm.

Other farmers said he grew better crops because he got more rainfall.

"We didn't", he says, *"we just used what rain that did fall on our crops better by using better farming practices"*.

Ian attributes much of this increase to better crop water use efficiency following his adoption of conservation farming after 1990. This case study documents their journey.

Figure 1. Ian Lea checking a wheat crop. (Photo: Rob Gill)

Farm facts

- The farm was a 1,468 hectare property near Deniliquin in southern NSW. It was planted in a five-year rotation to winter cereals and break crops. Median annual rainfall was 385 mm
- There were 16 main cropping paddocks split into five management blocks. On average, 12 of the 16 paddocks were cropped each year. The cropping area could be extended if labour was available and rotations were not compromised.
- Ian had a five-year rotation: (i) cereal; (ii) field peas, lupins or canola; (iii) cereal; (iv) feed cereal; (v) fallow. This was followed within each of five "blocks" on the property, with flexibility allowed for managing seasonal changes.
- There was a large flock of Merino wethers for opportunity grazing.

Background

Ian started farming at Deniliquin in 1964. From 1967 to 1982, Ian farmed in partnership with his father, mother, and brother, cropping 1,000 ha and joining 1,200 crossbred ewes each year for prime lamb production. In 1982, Ian and his brother Harry dissolved the family partnership to form new partnerships with their spouses, with Ian and Prue farming "Wynlea" until they retired in 2016.

Figure 2. Traditionally preparing stubbles in 1972 prior to changing to stubble retention and direct drilling. Tractors from left are Case 830 towing a Furphy spike roller; Case 930 towing a 21 tine Shearer scarifier; and a Case 970 towing a 25 tine Shearer scarifier. (Photo: Ian Lea)

Prior to 1990, Ian & Prue farmed conventionally. They burnt stubbles around February because their combine (18cm row spacing with cultivating tines in between) could not handle the trash, and they cultivated fallows to control weeds. Cultivation of fallow paddocks generally commenced in early winter after sowing was completed and when the soil was in good condition: i.e. friable, not root-bound, and not over-wet.

Disc ploughs were used for the initial cultivation, then either discs or scarifiers prior to summer, followed by a bar or smudger board to level. This was followed by more passes depending on summer and autumn rain for further weed control and to provide the weed and stubble free fine seedbed required for sowing into with the combine seeder (Figure 2). The result was soil that crusted and reduced crop establishment and water entry, and which had a hard-pan that limited root growth and water and nutrient availability.

The turning point for Ian came in 1988/89 when he purchased a boom sprayer and visited a farm in the Wimmera. The farmer he visited was using an air-seeder with a 30cm tine spacing which allowed him to sow into the previous year's stubble without burning any straw or needing to cultivate. This inspired Ian to change how he was farming, and from 1990 he gradually adopted conservation farming practices.

The operation

There were many challenges to changing their practices, but the Leas found solutions. As Ian says, *"We didn't have to work harder and grow more hectares, we just had to farm smarter"*. The following section outlines the process they went through to change the way they farmed.

Benchmarking

Keeping records and benchmarking every farm enterprise was the key to Ian's success. It allowed him to compare new practices with old and determine the profitability of any change. Adopting conservation farming practices improved the health of Ian's soils, and these changes increased water entry and storage in the soil profile and allowed better root growth to access it. This enabled higher yields from the rain that fell on the farm. However, the changes were made because Ian knew they would reduce costs and risk and were affordable.

Soil testing (1988)

After purchasing another 290 ha in 1985, Ian was keen to understand more about his soils. His first soil tests in 1988 were an eye-opener. They made him realise how depleted the soils were from so many years of over cultivation and low fertiliser rates.

Ian needed proof of the financial benefits of changing his fertiliser practices, so he compared his standard practice (Super at 44kg/ha = 3.9kg/ha P & 0.0kg/ha N) with his agronomist's recommendation (MAP at 53kg/ha = 11.6kg/ha P & 5.3kg/ha N) in 2 paddocks. The results were obvious, with the better fertilised crop jumping out of the ground and looking good all season.

He also started soil testing one or two paddocks each year to get an understanding of the state of his soils. However, the results were difficult to interpret until he began using GPS to re-sample the same locations each time. This removed site variability and allowed year to year variations and responses to management to be seen.

Ian took the same attitude to managing his soils as he did his Farm Management Deposits. He knew that if he kept soil fertility levels up when he could afford it, then he could reduce rates in seasons when finances were limited and not suffer any yield penalty - he had fertility "in the bank" to draw on (Figure 3). Soil testing and keeping good records were key to managing this.

Direct drilling and adoption of minimum till (1990)

The purchase of a boom sprayer in 1988 allowed timely and cost-effective chemical weed control instead of cultivation. This was the key to shifting to *direct drilling* of crops and the adoption of *minimum till* in the first four-years of the rotation. Strategic cultivation in the fifth fallow year prevented the build-up of chemical weed resistance.

After experimenting with minimum till, Ian started converting his 6.1m Connor-Shea™ air-seeder in 1993. He removed every second tine to get a 30cm row spacing; increased break-out pressure; and separated the seed from the fertiliser with a Janke™ 'piggy-back' knife tine.

In 1996 he sold the Connor-Shea™ and bought a 9.6m Janke™ Simplicity air-seeder. This was also progressively modified. Ian removed both front out-riggers and relocated tines by:

- adding a row at the back so wet soil was not thrown in front of the machine wheels, thus preventing soil build up;
- removing the finger harrows and replacing them with a rubber tyre roller;
- adding Janke™ coulters across the front of the machine; and
- increasing break-out pressure by replacing the 180kg assemblies with 227kg assemblies to improve dry sowing into uncultivated soil.

Five-year rotations and legume breaks (1991)

The inclusion of *legume break crops* (mainly field peas and lupins) in the rotation started in 1991. He quickly realised the benefits of the *disease break* and the *residual nitrogen* for the following cereal crops (Figure 4).

His analysis of *gross margins* over a seven year period showed he was on the right track. He found that whilst back-to-back cereal crops may have improved his cash flow in the short term, losses to disease, herbicide resistance, and the shorter time between fallows all reduced his profitability over the longer term.

However, Ian found it hard to keep growing high risk crops (i.e. pulses) after being hit by crop failures and droughts. Splitting the farm into five blocks provided the solution. This allowed him to maintain a five-year rotation whilst ensuring a four-year break between lupins (*Anthracnose*) or field peas (bacterial blight), and three years between canola (blackleg).

Figure 3. Drilling triple super while fallowing using the JankeTM air-seeder. The fertiliser was an "opportunity" purchase at a bargain price. It was drilled into the fallow to put phosphorous in the soil nutrient "bank" at the time it was most affordable. (Photo: Ian Lea)

Figure 4. Ian Lea at a field day on "Wynlea" discussing a 3.97 t/ha crop of Kaspa field peas direct drilled into wheat stubble. Having legumes in the rotation was important for fixing nitrogen and controlling disease. (Photo: Rob Gill)

Figure 5. Canola direct drilled inter-row into retained wheat stubble. (Photo: Ian lea)

Retaining stubbles (1993)

The *elimination of stubble burning* was made possible with the *shift to wider row spacing* and the modifications to the air-seeders.

Harvesting crops at a cutting height no greater than the row spacing (i.e. 30cm) facilitated trash flow at sowing (Figure 5). In heavy cereal crops, Ian slashed stubbles as soon as possible after harvest. Rotating bulky cereal crops with break crops like lupins also helped, as stubbles did not build up from consecutive crops.

Header trash became less of a problem as modern headers developed, with open fronts, straw choppers and chaff spreaders. Harvesting at a 15° to 20° angle to tram lines meant the seeder ran across trash rows, not along them.

Controlling traffic (2003)

Controlled traffic was started in 2003 by physically marking out tramlines in three paddocks with the goal to reduce overlap expenses (seed, fertiliser, chemicals), concentrate compaction, and minimise crop damage from machinery passes after sowing (from top-dressing urea and spraying).

Ian assessed his machinery and worked out how to move everything to the tractor's wheel spacing of 2.2m centres (Figure 6). By doing this, he avoided the costly replacement of equipment. He modified the seeder to only sow 30 tines on a 9m width, and then progressively gridded the whole farm to a tramline spacing of 9m with wheel spacings on 2.2m centres.

Bringing the header into this system was too expensive, so Ian started harvesting at an *offset angle of 15° to 20° to the tramlines*. He used a different direction each year so that, over time, header trash covered the paddock uniformly and was not concentrated in strips centred on the tramlines.

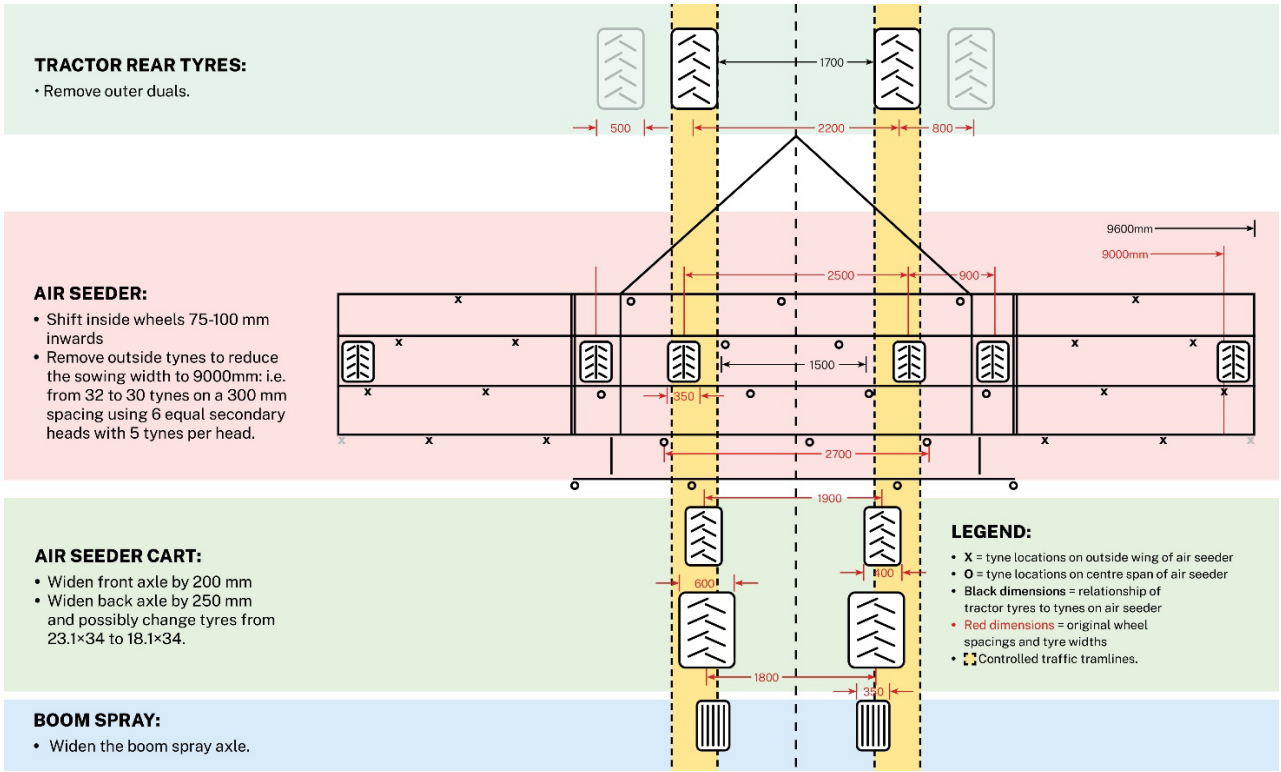

Figure 6. Ian's plan for modifying the wheel layout and spacings of his tactor, air-seeder and boom sprayer to fit his 9m boom spray width and tramlines based on a 2.2m wheel spacing. These simple modifications saved the need to buy new machinery. (Source: Ian lea)

Benefits of the management options chosen

Ian and Prue doubled their wheat yields from an average of 1.5 t/ha between 1958 and 1970 to an average of 3.1 t/ha between 2010 and 2016 (Figure 7).

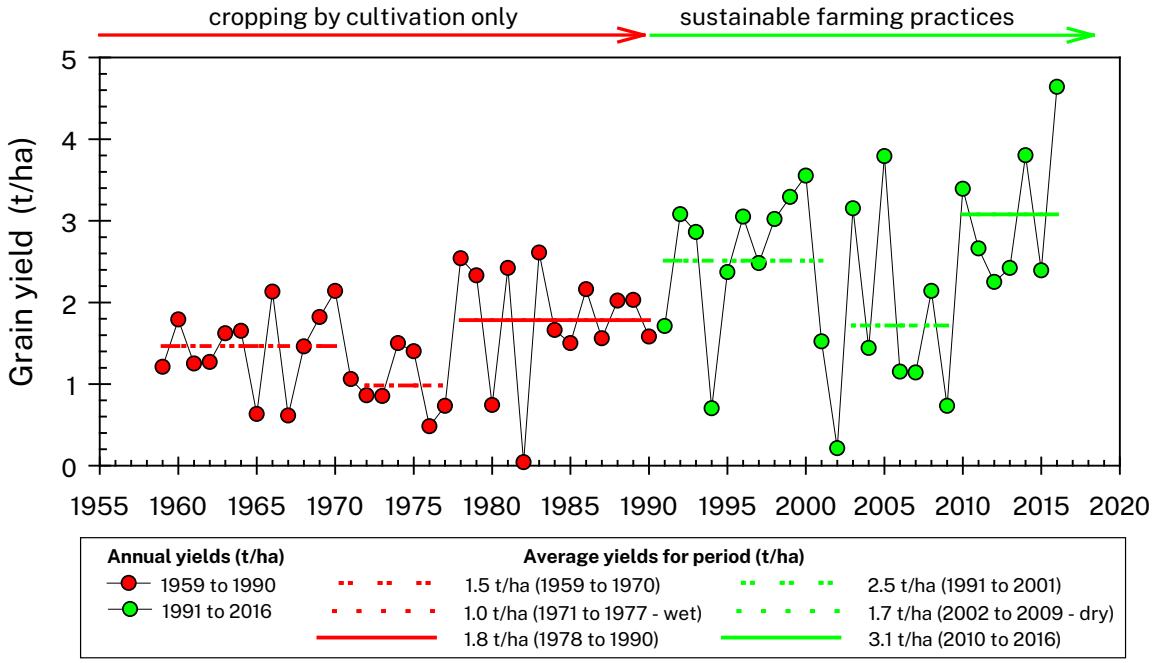

Figure 7. Wheat yields on "Wynlea" from 1959 to 2016 showing the differences in yield before and after the change to conservation farming in 1990. The effect of wet years between 1971 and 1977 and drought between 2002 and 2009 on wheat grain yields is also evident. (Source: Ian Lea)

Ian attributes much of this increase to greater water use efficiency following his adoption of conservation farming in 1990. This resulted in better moisture conservation in dry times and less waterlogging in wet times, with higher yields at all rainfall amounts after 1990 (Figure 8).

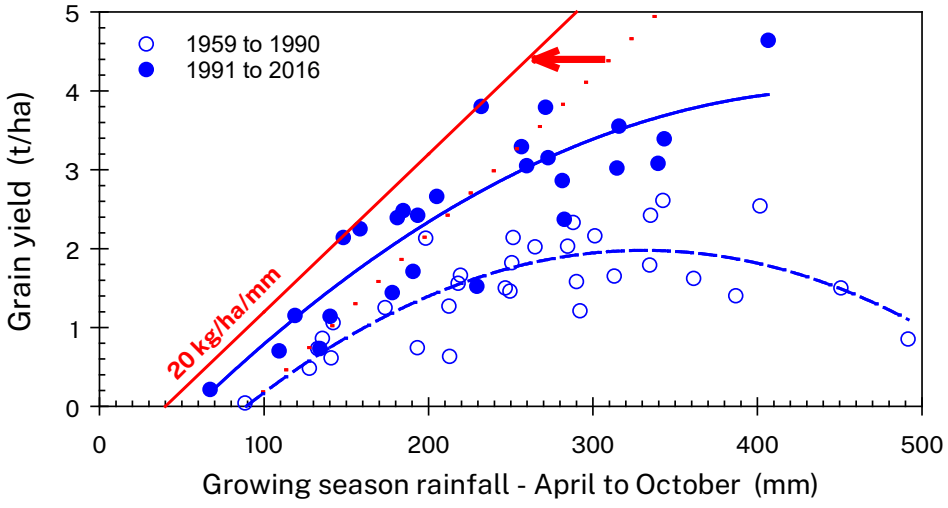

Figure 8. Wheat grain water use efficiency at “Wynlea” between 1959 and 2016 calculated using April to October rainfall at Deniliquin. The improvement in water use efficiency after the adoption of conservation farming is shown by the upward shift in the line fitted to yields before 1990 (blue dashed line) to the one after 1990 (blue solid line). The leftwards shift in potential water use efficiency (red dashed line to red solid line) shows conservation farming reduced water loss through direct soil evaporation by 50mm (red arrow). Higher yields in wetter years indicate that greater soil moisture holding capacity and better profile drainage resulted in less waterlogging after 1990.

The following table shows Ian's estimates of the percentage contributions of each practice to this increase in water use efficiency and yield.

Table 1. Estimated impact of conservation farming practices on farm productivity.

Practice	Impact	Comment on practice benefit
Direct drilling	40%	*Reduced tillage/minimum tillage*: improved soil structure by reducing crusting, compaction and hardpans. This improved crop establishment, water infiltration and soil water holding capacity.
		Stubble retention: stubbles protected soils and seedlings from rain-drop impact, increased organic matter and improved water conservation through greater infiltration and reducing overland water flow.
Boom spray	20%	*Timeliness of spray applications:* the introduction of a boom spray enabled large areas to be sprayed quickly before sowing. This meant more hectares were sown at ideal moisture, soil moisture loss was minimised, and crop establishment improved compared to traditional cultivation.
		Tramlining: helped reduce chemical costs by minimising overlap and was less stressful because it removed the need for foam markers. Modern GPS makes this easier now.
Rotations	10%	*Break crops:* the use of legume break crops improved disease control which reduced risk and led to consistently higher yields.
		Fallowing & strategic cultivation: this was also important to control disease and prevent the build-up of chemical resistance by weeds.
Outsourcing	10%	*Advice:* for rotation crops, soil testing, fertiliser strategies and chemical use. This enabled better-informed decisions.
		Consultants: involving others in the discussion around decisions allowed ideas to be "bounced off" outside advisors and prevented issues being overlooked.
Sowing improvements	20%	*Deep banding of fertiliser at sowing*: placing fertiliser deeper than the seed provided cultivation below the seedbed. This broke up hard pans, assisted in controlling crown rot and Rhizoctonia, and allowed quicker root development.
		Wider row spacing: a 30cm row spacing allowed good trash flow and penetration of knockdown sprays into the standing stubble. It also eliminated "breaking-out" of soil between rows, minimising moisture loss and improving seed placement. *Author's note - Yield potential is related to rainfall and row spacing. The higher the rainfall, the narrower the row spacing needed to achieve your yield potential. Ian's 30cm row spacing suited the 220mm median growing season rainfall at Deniliquin.*

Practice	Impact	Comment on practice benefit
		Rubber tyre rollers: gently firmed the soil around the seed in the row and could be easily detached from the machine when conditions were too wet. Individual press wheels didn't have this flexibility and finger harrows had poor trash flow and disturbed chemical (e.g. Trifluralin), decreasing weed control.
		Sowing speed 9km/hr: the maximum speed with direct drill to avoid soil "throw" covering back rows, and for precision placement of seed and fertiliser.

Soil testing resulted in better fertiliser decisions

Gypsum was applied to selected paddocks between 1990 and 2001 on the expectation it would prevent the crusting that was affecting crop emergence. It was not greatly effective on Ian's predominantly red and brown clay loams, even though they were sodic. Ian attributes the reduction in his crusting problem during this period to his adoption of conservation farming practices.

Ian commenced a program to broadcast single superphosphate (SuPerfect™) in 2002 to build up soil phosphorous levels where soil tests showed they were depleted. Apart from phosphorous (8.8%) and sulphur (11%), SuPerfect™ also contains 19% calcium. Ian's soil test results show a doubling in phosphorous levels and a halving in percent exchangeable sodium following the spreading of SuPerfect™. Yields from following crops vindicated this strategy.

Based on soil test results, which showed pH levels of around 4.5, Ian started to apply lime at 2.5t/ha in 2000. The results were noticeable. After looking at the cost-benefit ratio, Ian found liming affordable and with many flow-on benefits. He continued to spread 2,500 tonnes of lime between 2000 and 2015 at a cost of $124,000 based on year 2000 costs.

Controlling traffic had multiple benefits

Once Ian started tramlining, he realised how many advantages there were to the system:

- Reduced soil compaction in the crop zone which, together with other conservation farming practices, improved soil structure and friability and increased rainfall infiltration.
- Better traction from firmer ground - the dual tyres on the tractor could be removed and there was no need for water ballast. This lowered the horsepower requirement and improved fuel efficiency.
- Quicker commencement of any operation, no matter what the weather
- Better maintenance of sowing depth, as the inside wheels of the air-seeder tracked in the tramlines and the main-frame didn't sink.
- No knocking down of crops when top-dressing or applying fungicides

Summing up

In the 35 years of their farming career, Ian and Prue lifted the water use efficiency of their wheat by 86% and their barley by 190%, from an average growing season rainfall of 282mm.

While Ian still saw room for improvement with their wheat, he feels the barley was getting very close to its potential. With droughts and a changing climate, finding ways to improve their water use efficiency and make the most from their rainfall was one of the key challenges for Ian and Prue. Making the changes necessary to improve their water use efficiency took Ian and Prue many years but, as Ian says, "*We didn't have to work harder and grow more hectares, we just had to farm smarter".*

Ian and Prue Lea retired from farming at the end of 2016, but the lessons they learned show how conservation farming does improve business outcomes.

Further reading

Soil Management PrimeFacts for southern and central NSW croppers can be found at https://www.dpi.nsw.gov.au/agriculture/soils/guides

- Soil sampling - https://bit.ly/soilsamplingsummary
- Soil structure management - https://bit.ly/soilstructuremanagement
- Soil dispersion and sodicity - https://bit.ly/soildispersionandsodicity
- Soil acidity - https://bit.ly/soilacidity

Contact Ian Lea (ian@retiredfarmer.com.au) for a copy of his book: *Farming at Deniliquin: 1958 to 2016*, Deniliquin Newspapers Pty Ltd (2019), ISBN 9780648351238

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