Title	**Full inversion tillage renewal to increase soil carbon: agronomic and environmental benefits and trade-offs**
Project Timeframe	Aug 2017 – Sep 2020
Countries Involved	New Zealand (The New Zealand Institute of Plant and Food Research, Manaaki Whenua-Landcare Research, Massey University) Ireland (Teagasc, Trinity College Dublin) Germany (Thunen Institute)
Aim	To verify the potential to increase soil carbon and to demonstrate the practical applications of full inversion tillage (FIT) pasture renewal, including its effects on the agronomic and environmental performance of pasture systems.
Research Highlights	• Modelling indicated that FIT pasture renewal could sequester 21-36 Mt C across 2.6 Mha of New Zealand high production grassland soils (suitable for ploughing) over 20 years. This is approximately 10-17% of New Zealand's agricultural GHG emissions over the same period (at current emissions rates). • The additional costs of FIT pasture renewal (tillage and fertiliser) were offset by higher dry matter production within the first 12-18 months following pasture renewal (compared with non-renewed pasture), particularly where a forage crop was grown as a break between old and new pasture. • N_2O emissions (winter-spring period) from livestock urine patches on FIT pastures are 30-40% lower than the emissions on continuous (non-renewed) pasture and 50-60% lower than emissions on pasture renewed with no-tillage • FIT pasture renewal also reduced the risk of nitrate leaching compared with no-tillage pasture renewal but under certain circumstances. • Practical guidelines for FIT pasture renewal were developed, covering aspects like suitable soils/sites, tillage, nutrient management, and seasons (autumn vs spring). • International collaborations were made with Ireland, Germany and Ireland.
Future Work	• Further research is required to verify the benefits for GHG mitigation and to support on-farm adoption. • Establish demonstration trials on farms representing a range of suitable soils and climates to test and improve the good management practice guidelines and to monitor the longer-term gains in soil carbon and agronomic performance.

	• Verify the reductions in N_2O emissions during pasture re-establishment and from urea fertiliser and livestock urine applied to different soils. • Identify the biogeochemical mechanisms that are responsible for increasing soil C storage following FIT pasture renewal in order to maximise the benefits across different soils and climates.
Key Research Output(s)	Journal articles Kirschbaum, M.U.F., Don, A., Beare, M.H., Hedley, M.J., Calvelo Pereira, R., Curtin, D., McNally, S., Lawrence-Smith, E. (Under Review). Sequestering soil carbon by burying it deeper within the profile: A theoretical exploration of three possible mechanisms. *Soil Biology & Biochemistry*. Hedley, M.J., Beare, M.H., Calvelo Pereira, R., McNally, S.R., Lawrence Smith, E.J., Tregurtha, C.S., Osborne, M.A., Gillespie, R.N., van der Klei, G., Thomas, S.M. (Under Review) Practise Guidelines for successful introduction of full inversion tillage to increase soil carbon stocks under pasture. *New Zealand Journal of Agricultural Research*. Vos, C., Reinsch, T., Schneider, F., Don, A. (Under Review) Does grassland renovation increase soil organic carbon stocks? – Results of a long-term experiment. *Agriculture, Ecosystem & Environment*. van der Klei, G., Calvelo Pereira, R., McNally, S., Thomas, S., Beare, M.H., Hu, W., Hedley, M. (Under Review) Nitrous oxide emissions from urine and fertiliser addition following pasture renewal with full inversion tillage. *Agriculture, Ecosystems & Environment*. Calvelo Pereira, R., Hedley, M.J., Hanly, J., Beare, M.H., McNally, S.R., Bretherton, M.R. (Under Review) Carbon storage, herbage yield, and nitrate leaching in New Zealand permanent pastures following spring renewal using deep ploughing. *Soil & Tillage Research*. McNally, S.R., Beare, M.H., Tregurtha, C.S, Hunt, J., Calvelo Pereira, R., Hedley, M.J., Lawrence-Smith, E.J. (Under Review) Short term carbon input and C loss from soil following a one-off pasture renewal using full inversion tillage. *Soil Biology and Biochemistry*. Lawrence-Smith, E., Curtin, D., Beare, M., McNally, S., Kelliher, F., Calvelo Pereira, R., Hedley, M. (Under Review) Full inversion tillage during pasture renewal as a one-off management practice to increase soil carbon storage: New Zealand as a case study. *Global Change Biology*. Madigan, A.P., Zimmermann, J., Krol, D.J., Williams, M., Jones, M.B. (Under Review) Full Inversion Tillage as a potential future

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