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INTEGRATED FARM PLANS (IFP):

a portal to the future

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Abstract

Integrated Farm Planning involves addressing individual farms and applying landscape planning and farm management modelling to produce bespoke farm plans addressing known environmental issues for the property's next 30+ years.

Spatially, the farm context and multi-factor site data are identified and recorded to provide baseline mapping for a farm plan and we then comprehensively address rural environmental issues whilst allowing for productivity. Landscape context, natural ecosystems, production systems, nutrient management and GHG emissions are addressed. The landscape resource involves natural, cultural and social diversity, with past and present management regimes recognised in looking toward the future. Using internationally certified lifecycle carbon emissions' analyses[1] the IFP team has developed a model and a framework that applies multi-skilled best practice, knowledge and data to produce integrated farm plans.

Plans are developed which spatially identify the land management changes needed to achieve improved environmental management. They provide staging that transitions each farm toward net GHG carbon neutrality, through mitigating and preferentially in-setting[2] emissions within the property or nearby, whilst also transitioning to low nutrient loss, healthy freshwater ecosystems and sustainable lived-in farms.

Using the IFP, the team provides a blueprint for transitioning to environmental and social sustainability through planning and strategic monitoring. Due to the urgent need for guidance in management of GHG, and our IFP-based research and case studies, development is underway for provision of a freely available DIY tool to enable farmers/advisors to develop indicative IFP to show ways to transition individual farms toward net GHG carbon zero.

Background

Aotearoa NZ agriculture has been identified as a significant emitter of GHG primarily through ruminant animal emissions and intensive land-use practises. To address this issue, our team has explored and developed farm planning techniques to provide staged reduction of agricultural

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[1] e.g. Dairy EA™ system

[2] 'In-setting' refers to carbon sequestration actions undertaken within the property or on adjoining lands in the catchment. 'Off-setting' refers to carbon sequestration undertaken elsewhere, spatially unrelated to the farm landscape being addressed.

GHG on individual farms. From early last year we have developed Integrated Farm Plans (IFP) that identify current emissions and spatially identify ways for farms to transition toward net GHG carbon zero typically through changes from management monocultures to mosaics. The IFP have been enthusiastically received and implementation on case study farms has begun.

From our research, analyses, planning and design for IFP, we appreciate the extent of rural land use and management change needed to achieve Climate Change Response (Zero Carbon) Amendment Act 2019 requirements, and the need for farmers to be able to have time to plan for and implement adequate change.

Given the urgency to address climate change, last year the primary sector industry committed to a 5-year program of action to ensure farmers understand their individual emission sources and sinks, be equipped to mitigate and offset their emissions, and, to roll out integrated Farm Environment Plans (FEP), covering emissions reductions, offsets and adaptation, for all farms. The recent Joint Action Plan commits that "*A quarter of farms have a written plan in place to measure and manage their greenhouse gas emissions by 1 January 2022. All farms have a written plan in place to measure and manage their greenhouse gas emissions by 1 January 2025.*" (He Waka Eke Noa, April 2020) And, "*By 2025, 70% of farmers will agree they are managing their GHGs in accordance with their Farm Environment Plans*" (Ministry of Primary Industries, 2019b).

Our team is concerned at the continuing lack of clarity for farmers as to their current emissions profile, the ongoing avoidance of addressing agricultural GHG through most farm planning exercises, and, the lack of adequate information available to farmers as to what changes they will need to make. Given the scale of the issue, the time needed to transition, and the lack of adequate planning tools, in addition to one-off IFP we are now developing a DIY tool to assist farmers work out their likely current emissions and begin to spatially plan how they might address these through mitigation, in-setting and off-setting.

Landscape Context

No farm exists in isolation. No farm involves merely numeric inputs and outputs. Every farm belongs within and is a spatial contributor to a landscape. A landscape that involves underlying natural landforms, overlain with managed soils, vegetation, and, infrastructure. A landscape that contributes to or embraces a water catchment. A landscape whose waters define space and nurture life. A landscape that pulses with the seasons. A landscape with a sense of place from layers of nature and layers of human interaction through centuries - te whakapapa.

Internationally, a landscape approach is increasingly recognised as the way forward from recent over-simplification of agricultural landscapes (Kellermann et al., 2008; Mander, Wiggering, and Helming, 2007; Uthes and Kiesel, 2020). Responding to critical monoculture effects such as the Australian severe water limitations in the early 2000's and ensuing redesign of the monocultured cropping approach, the landscape approach is increasingly seen as a sensible component of agriculture (Landis, 2017). Similarly, the effects of monocultures on water and biodiversity in the United States led to a governmental, academic and applied landscape response with movements emerging such as in regenerative agriculture (Landis 2017; Christopher 2017). Whilst addressed more holistically in Aotearoa NZ (Blaschke and Ngapo, 2003), farm planning has in recent decades largely ignored the landscape and is insular and tabular rather than spatial and connected.

Yet a farm cannot operate in isolation, and, through effects on wider natural systems, farming carries responsibilities (Interim Climate Change Committee, 2019). Commitment to reduce greenhouse gas (GHG) emissions to net zero by 2050 is one such responsibility (Ministry for the Environment, 2019). The IFP process responds directly to the need for significant land management and land use change to meet the GHG emissions targets of 2030 and 2050 (O'Conner and Shaw, 2020; Ministry of Primary Industries, 2019a; Biological Emissions Reference Group, 2018). What will this look like and how will it work within farms and rural landscapes?

Responding to GHG in Aotearoa NZ farm landscapes

At a farm scale, addressing GHG has seen a reviewing of farm modelling and management tools already on hand, with the first question of 'how to calculate emissions' being added to Overseer. Overseer (Williams, 2019), and similar tools, have for some time been used to evaluate and manage Nutrient Cycles on a basis of inputs and outputs. More recently developed into Overseer FM, this tool provides for inclusion of GHG modelling (de Klein and Rollo, 2019; Parliamentary Commissioner for the Environment, 2018; Biological Emissions Reference Group, 2018; Wheeler, Ledgard, and Boyes, 2011). Figure 1 below summarises how Overseer FM works.

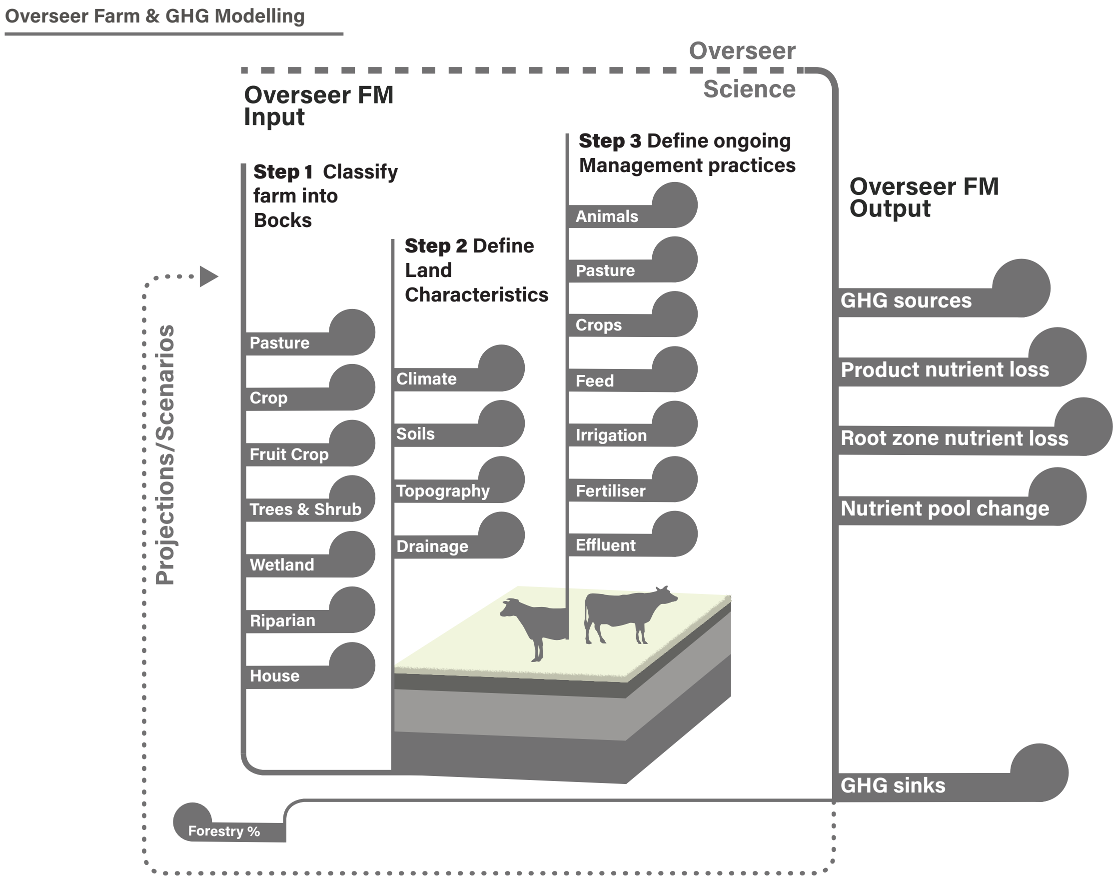

Figure 1 – Model showing how Overseer FM functions

Consultancy guidance around *what will reduce emissions* has focused largely on farm management practices, forestry offsetting, and, land management change in stocking, pastoral and cropping. For example, AgFirst's 2019 '*Mitigation and cost of on-farm Greenhouse Gas Emissions*' guide, provides broad numbers regarding horticulture and native plantings, and more detailed stock and forestry related GHG data. However it is clear that NZ farm management planning research has focused narrowly on only pastoral data, stocking data, or forestry as key players in GHG mitigation (Parliamentary Commissioner for the Environment, 2019; 2018).

With GHG calculated by Overseer, the approach of the Farm Environment Plan (FEP) has emerged as central to '*how to implement emission reduction'* (Interim Climate Change Committee, 2019). In essence, an effective FEP would create a spatial understanding of the existing farm and its underlying landscape, translate this into a series of Land Management Units (LMU) for assessment of GHG through Overseer, then result in a plan for managing and monitoring farm resources including GHG in the future.

In Figure 2 below the process involved in a Beef+Lamb Level 3 FEP is shown diagrammatically, and then aligned with Overseer to show the overall picture of how GHG is currently managed on farms using these tools.

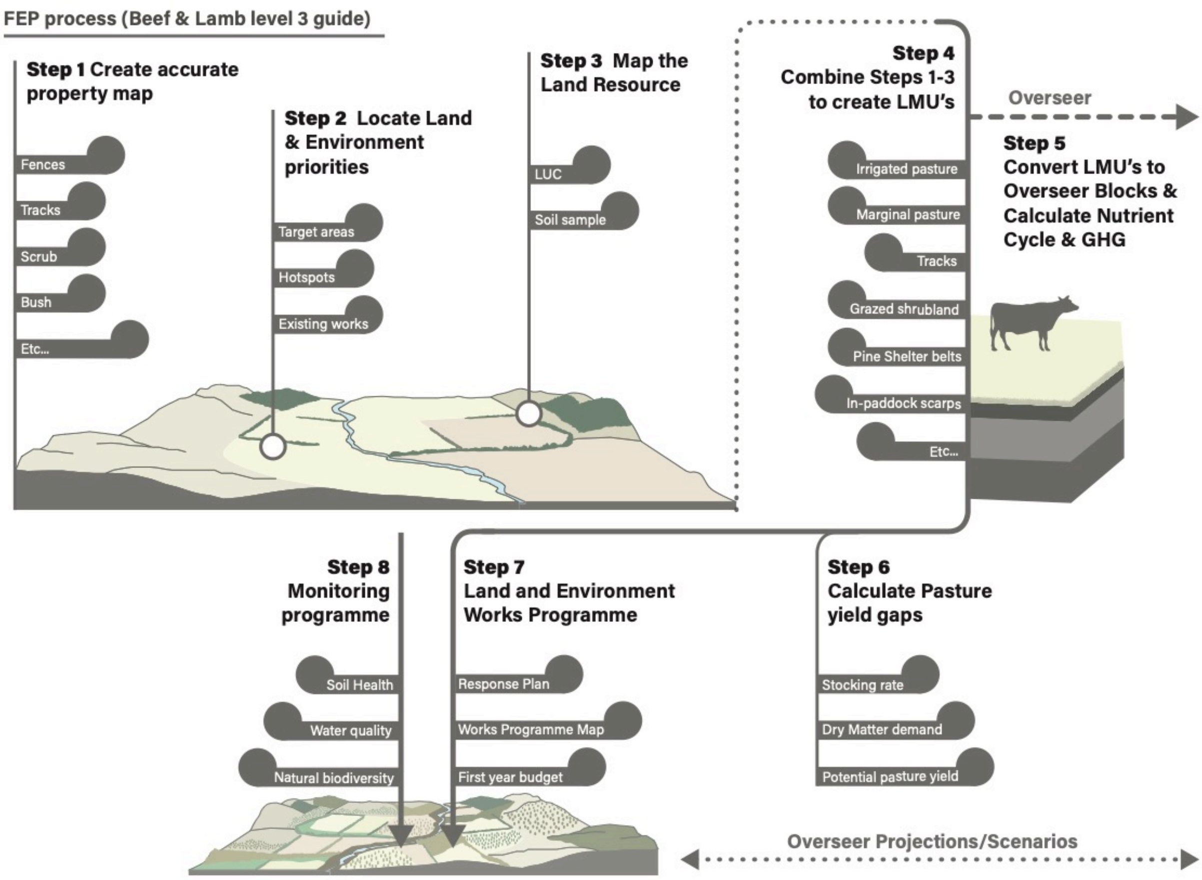

Figure 2 – Model showing the FEP level 3 process (Beef+Lamb New Zealand 2019) & alignment with the Overseer FM tool

Constraints and opportunities in the current approach

The 2018 ‘Report of the Biological Emissions Reference Group (BERG)’ found that while *“widespread adoption of currently available mitigation options (mainly farm management practices) could see a 10% reduction in absolute biological emissions from pasture-based livestock, a greater than 10% reduction in absolute biological emissions will likely require a combination of on-farm mitigation and land-use change*”.

A 2030 target of 11 per cent below 1990 levels, and a 2050 target of net zero emissions of all greenhouse gases other than biogenic methane, point directly to the need for significant landuse change. Using a landscape approach integrates and evaluates multiple land uses for innovative mitigation and in-setting options. So do current tools allow for this?

A landscape approach and spatial explicitness

A landscape approach focuses on the connection, contribution and effects between the many different resources within a specific landscape that address the present, past and future, to create ‘*a more diverse set of land use activities, enhancing the resilience of rural communities to future environmental and economic disruption’* (Parliamentary Commissioner for the Environment 2019).

This process relies on spatial explicitness. Overseer is not spatially explicit, as it is based in seven ‘Block’ types - pasture, crop, fruit crop, etc. While these are based on spatial blocks of the farm, from when they are identified and measured, they then ‘float’ without connection to their neighbouring blocks, or to their landscape context and catchment. They are each addressed alone and apart (Parliamentary Commissioner for the Environment, 2018). In terms of GHG calculation, Overseer builds upon these different blocks exploring a broad range of nutrient, climate, soil, and management inputs. That is, it precludes integrated management.

The current approach of combining the FEP process with Overseer requires a translation of FEP created site-specific LMU’s into the simplified base blocks of Overseer, after which the GHG Overseer output is used to inform the FEP planning step. This FEP planning step involves an active design process with the spatial integration of a wide range of resources to mitigate GHG (Beef + Lamb New Zealand 2019). This involves land use and management changes, but they have significant flow-on effects outside of the individualised Overseer blocks.

As it stands this process of understanding the effects of change is limited within the non-spatial Overseer blocks and their GHG calculations, restricting and further complicating what is already a challenging design process. For example, if a band of marginal pasture is identified as a separate LMU within the FEP, and, is being explored as a future LMU of spaced trees with under-grazing, how does this translate into Overseer, and how could this limit design options? To summarise, Farm Environment Planning is fundamentally a design process relying on an understanding of the farm within its landscape context, therefore to design GHG mitigation while supporting effective and functional farms we cannot work from a basis of simplifying the farm landscape into a limited set of isolated components. It is simply not the full picture.

Detail and nuance of Land Management Units

‘Land Management Units (LMUs) are areas of land that can be farmed or managed in a similar way because of underlying physical similarities’ (Beef + Lamb New Zealand, 2019). These

LMU's need to reflect the detail and nuances of the farm to understand how all the different components of a farm landscape work together.

There appears to be a lack of focus on the significance of spatial detail in current farm modelling. For example if a block of irrigated pasture is calculated to have an effective area of 10ha, but, in reality, 5% of this is shelter belt and 10% is marginal un-irrigated peripheral areas, all detailed input data compiled within the 10ha parcel thus has a 15% discrepancy.

An LMU is not necessarily a paddock, a group of paddocks, or a limited range of land uses. LMU mapping can instead ignore fences and current landuse, to reflect both the existing and the potential in classifying areas with similar underlying land <u>and</u> management qualities. LMU's are the evaluative basis of Farm Environment Planning, and we need to get them right.

Carbon sinks

To address GHG sources and balance out a farm's emissions, GHG sinks need to be provided for storage of carbon. The carbon store, the sink, may be either as an in-set on or near the farm, or elsewhere as an off-set. Permanent woody vegetation is the long-term approach to GHG sinks, thus the emphasis is more appropriately on permanent tree crop and woody native revegetation or natural regeneration. Rotational forestry is less appealing as harvested forest is an inherently short-term approach to 'carbon farming'. At its core, *'every time a forest is harvested, the original area needs to be replanted, plus a further similar area needs to be planted to provide carbon offsets for the next rotation, and so on'* (AgFirst, 2019; Burrows and Lucas, 2019).

Current FEP and guides that encourage farmers to protect waterways through plantings such as of *Carex* and flax to address nutrient and sediment runoff are wasting an opportunity to address multi-factors and include woody plantings that provide sequestration.

Consultancy based

Within the current approach to FEP's there is a clear reliance on consultancy, and the need for a landscape approach does not alleviate these pressures. It's estimated that consultancy for evaluating and planning mitigating GHG on a farm would cost between $16,000 - $61,000 per farm (Biological Emissions Reference Group, 2018). This is a serious barrier when considering the huge number of farms and therefore the quantum of plans required nationwide by 2025 (Ministry of Primary Industries, 2019a).

While consultancy will likely continue to be a critical part of this process, there need to be approaches which directly empower farmers as well as consultants to map and understand the current on-farm biological emissions (Biological Emissions Reference Group, 2018), and enable planning for the landscape management and transformations necessary to address GHG.

The IFP method: from Monoculture to Mosaics – a landscape approach

Figure 3 – the endless knot symbolises the intertwining and interconnectedness of everything

Underlying IFP is the recognition of farms as potential integrated mosaics of different land uses and land management. The nuances of the farm landscape, the underlying landscape, and the landscape context need to be fully engaged when evaluating and planning for GHG reductions. Working with the underlying landscape and catchments as a basis for integrating rural landscapes has a history in New Zealand (Lucas Associates, 2004; Blaschke and Ngapo, 2003; Swaffield and Meurk, 2000; Rosoman and Lucas, 1997; Lucas 1987a and b), which we look to actively draw on when answering the call for this approach to deal with our current need to transition from monoculture to mosaics (Spicer, Swaffield, and Moore, 2019).

As an example of the potential of mosaics, in the 2018 BERG report (Biological Emissions Reference Group), it was found that current and planned plantings such as shelterbelts and small woodlots (not currently recognised by the ETS) could inset up to 2.5% of current gross livestock emissions on intensive lowland sheep and dairy farms, and 5–20% on a hill country sheep and beef farm. That is a start in moving from monoculture to landscape mosaic. More comprehensive mosaics can provide full in-setting as well as plant-based foods.

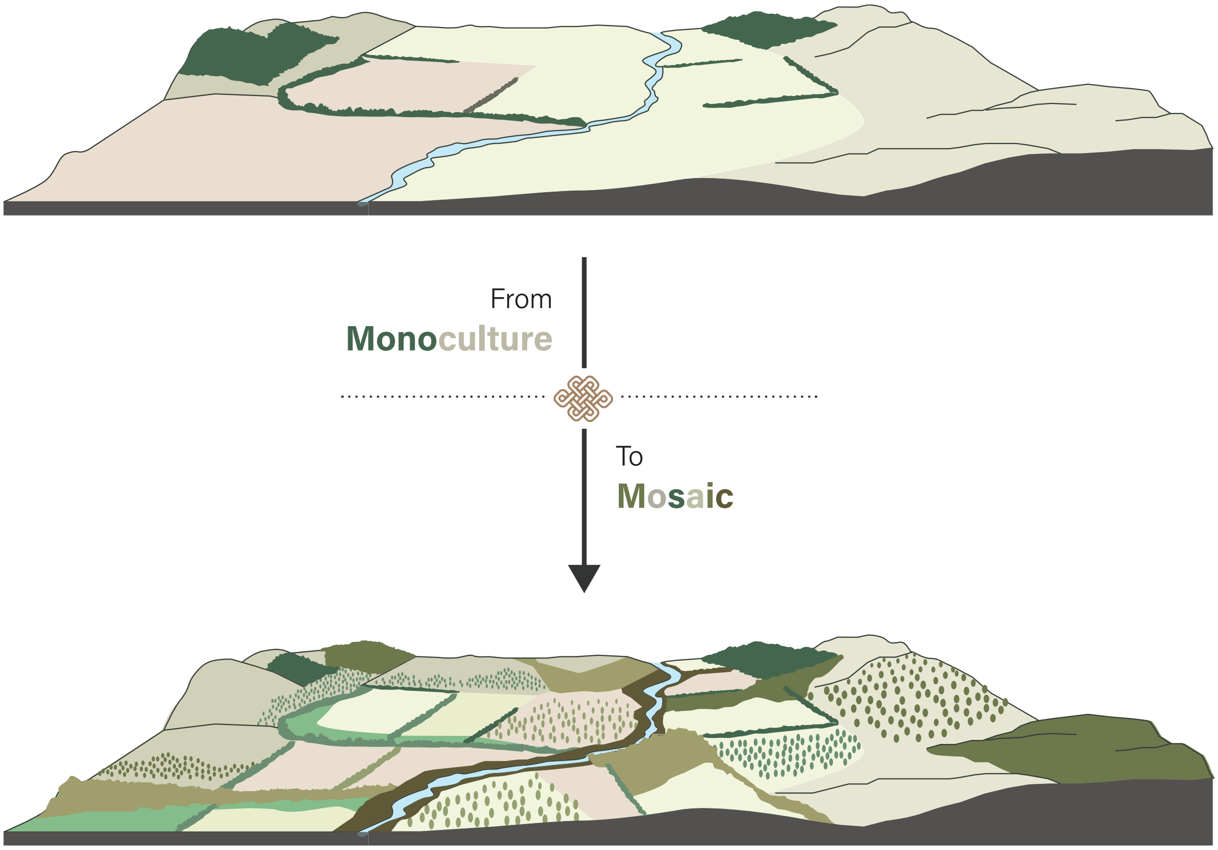

Figure 4 –the underlying IFP principle for a holistic 'Monoculture to Mosaic' approach

The IFP Process

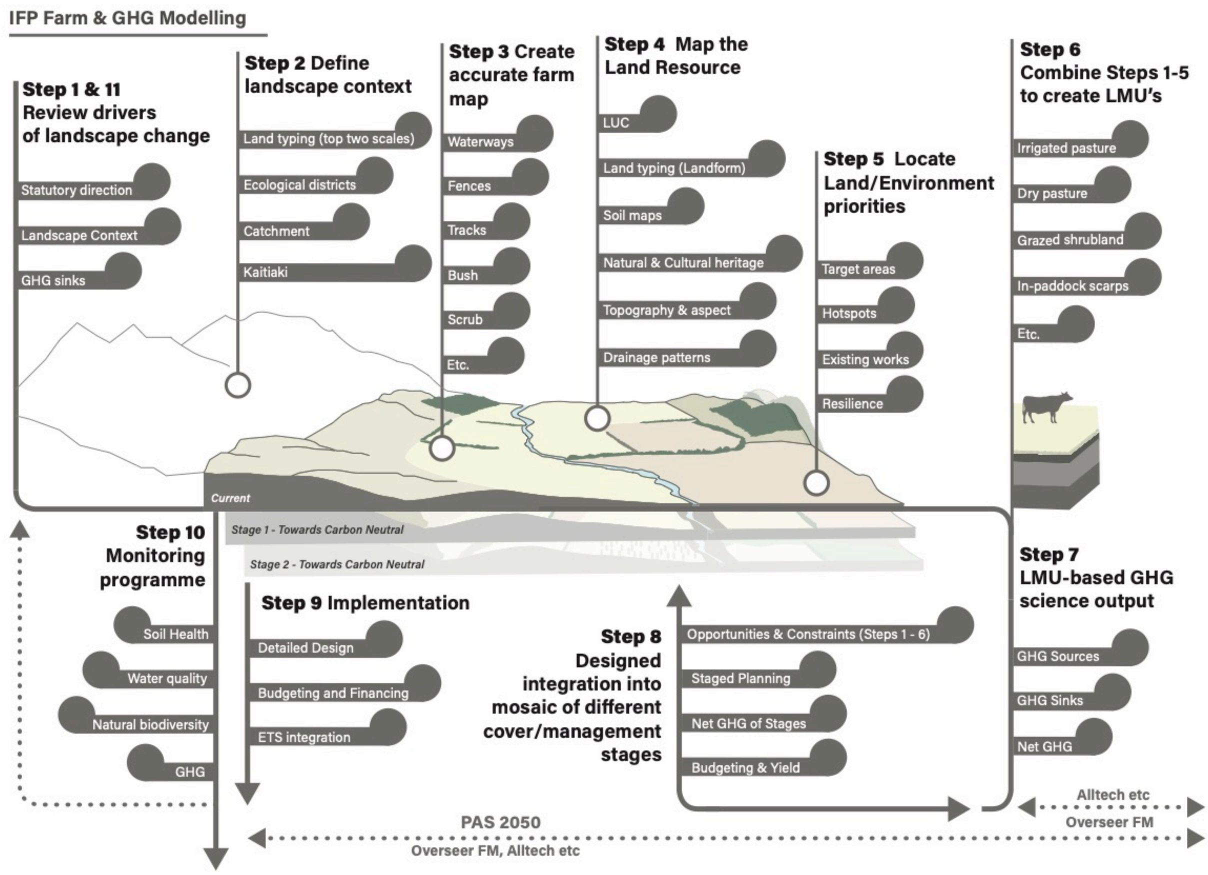

Figure 5 – Model showing the IFP process with its 10 steps

Appreciating that every farm is different, and that management and aspirations are diverse, our team has undertaken landscape-based farm planning exercises with farmers to ascertain what would be involved to transition their farm to net carbon zero. The overall IFP process is summarised in Figure 5 with a cycle of 10 steps.

Steps 1 to 5–Kaupapa and Whakapapa Understanding the landscape and the farm within

We recognise the underlying nature of the place as cued by the Ecological Region and Districts framework which delineates and describes the inherent diversity of Aotearoa NZ (McEwen et al., 1987). Then utilising land typing (Lynn, 1987; Lucas, 1994; Lucas Associates 1997 and Swaffield and Lucas, 1999) to address the geomorphic character at landscape and catchment scales, and windowing in to apply that modelling at the farm scale. Thus landform components are mapped, and the underlying natural biophysical character recognised (refer to Figure 6 overleaf).

Known values and those recorded in public databases are noted, including biota and heritage associated with the farm and its context. As well as terrain, soils, waterways and natural biota, the stocking regime, fuel usage, and farm management infrastructure are mapped and recorded – including fencing, lanes and tracks, sheds and other structures, irrigation, ponds and water reticulation, shelter and woodlot plantings. Farm management issues and opportunities are mapped.

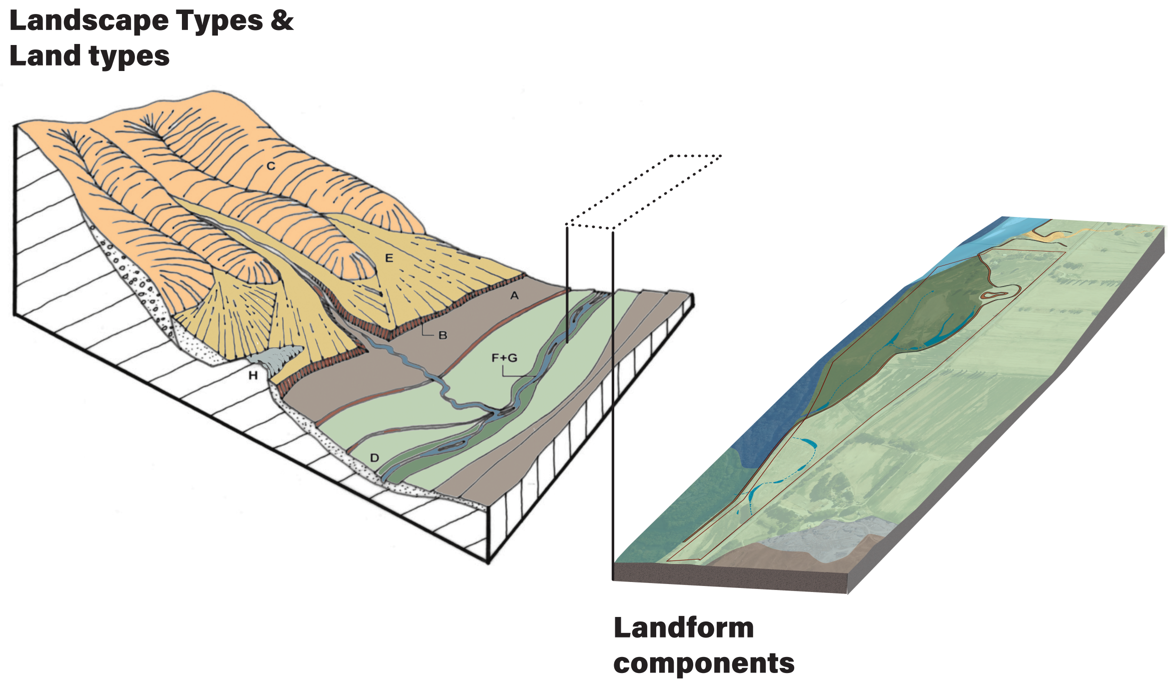

Figure 6 –Land typing applied at the farm scale, with landform components mapped

Steps 6 and 7 - Greenhouse Gases in landscapes, using Land Management Units

The landform component mapping and the farm use overlay form the basis for gaining an understanding of the current emissions profile (GHG). Rather than paddocks or non-spatial blocks, GHG is calculated directly from land management units (LMU), as an indicative yet uniquely spatial and tabular emissions profile for the farm. IFP is concerned specifically with the 'where' of emission sources and sinks as well as the 'what', so that when moving into the planning stage one can better understand 'where' the effects and actions of mitigating GHG might occur.

Division of farmed land into classes for estimating GHG emissions is best if it differentiates the Land Use (LU) classes that have the largest differences in emissions (e.g. irrigated land from non-irrigated) or splits of common LU classes based on intensification (e.g. cultivated/fertilised pasture from unimproved hill country grazing). In general, the more intensively land is managed (higher rates of fertiliser use, more irrigation, more cultivation, fuel use and higher animal numbers) the higher the net GHG emissions. Or the other way round, the less soil disturbance, less animal numbers, less irrigation, less fuel and more permanent woody vegetation the lower the GHG emissions. GHG sinks and sources are normally separated into soil, vegetation and animals. In most cases there will be interactions between them at an ecosystem scale, and we attempt to combine the overall emissions factor (EF) for each LMU type.

To help classify LMU for emissions estimates in IFPs, we use a hierarchy of parameters that progressively separates classes for which we have some information on EFs. Then, at a very detailed level there will be management actions that alter net emissions within a single LU class (e.g. more controlled irrigation, or refined fertiliser use, change to regenerative methods, or seasonal changes in stocking rates). These altered management changes have promise of reduced emissions but there are very few data or studies that quantify such refinements.

Our estimates of GHG have used a combined approach of results from recent research[i] studies for selected LMU classes (Giltrap et. al., 2017, Dynes et. al., 2018), sequestration rates from afforestation (Burrows et. al., 2018), along with direct emissions measurement and monitoring (Alltech[3]). Emissions factors combine soil, vegetation and animals to estimate net emissions or sequestration per hectare, as well as calculated in accordance with PAS 2050 to estimate emissions per hectare (Alltech, 2020).

Steps 8 to 10 – Planning, designing, and monitoring

Addressing the on-farm emissions, the GHG sources, we then explore the opportunities for their reduction and mitigation on the farm. With the farmer we explore potential for in-setting, that is, opportunities to provide carbon sinks within the farm or nearby to balance those being generated on farm. With the landscape approach identifying catchments, 'in-setting' can extend from the farm boundaries out to its associated catchments to address GHG at a landscape-scale.

The planning and design stage within an IFP involves the integration of the many different landscape layers identified in Steps 1-5 alongside addressing GHG. For example fire risk is understood through addressing patterns of fuels, sources and sensitive values within the landscape. Then fire resilience is addressed through spatial design and planning of landuses, landcovers and management (Kraberger, Swaffield, and McWilliam, 2018).

The IFP involves developing staged plans to show where and how emissions could be reduced over time toward net carbon zero. Whether for sheep and beef, cropping, horticulture or for dairy farms, these plans provide a clear way forward that has been received with enthusiasm, and resulted in some rapid farm management change. Two sample IFP, one a 1200 cow dairy farm on the Canterbury Plains, and a 42 ha sheep and beef unit in Central Otago, are profiled as case studies at www.IntegratedFarmPlan.nz

In-setting via woody plantings has been found a necessary tool in IFP done to date. For example, for the small sheep and beef unit, achieving 7 ha of tree crop and woody native plantings, plus blended pasture, could address current freshwater management issues, maintain existing stocking, and offset all the GHG emitted, that is, reach net carbon zero. Woody plantings involve local native and/or non-invasive exotic species.

For the dairy farm, the planned in-setting involves densely planting the less productive areas outside the pivot irrigators as well as introducing woody food forest bands across paddocks underneath the irrigation. An array of fruit and nut trees will be introduced to store carbon, add saleable plant products and animal feed, as well as improve paddock microclimate and provide intervention of groundwater nitrates. Changes in pasture management will improve the soil, waters and feed. The in-setting regime is estimated to enable a 26% reduction in farm emissions.

To further reduce emissions, the dairy farm IFP involves a staged reduction in cow numbers from 1200 to 900, plus introduction of herd shelters (Figure 7). The energy thus generated will power the milking sheds and the cut 'n carry pasture supply to the cows confined through the winter and half the summer, and, the process provide fertiliser. The biodigester will also enable production of other food products, including greenhouse vegetables, fish and algae. The algae will supplement the herd's grass diet to enhance digestion and lower methane emissions. The

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[3] Alltech undertake on-farm monitoring of CO_2, CH_4 and N_2O to identify the carbon footprint of farm production through to farm gate.

biodigester thus enables a closing of the nutrient circle, with a grass-fed diet but no fertiliser or feed needing to be brought in. The various mitigation measures will reduce overall emissions a further 54%, so that overall the dairy IFP results in reductions of 80% of emissions compared with the 2019 regime.

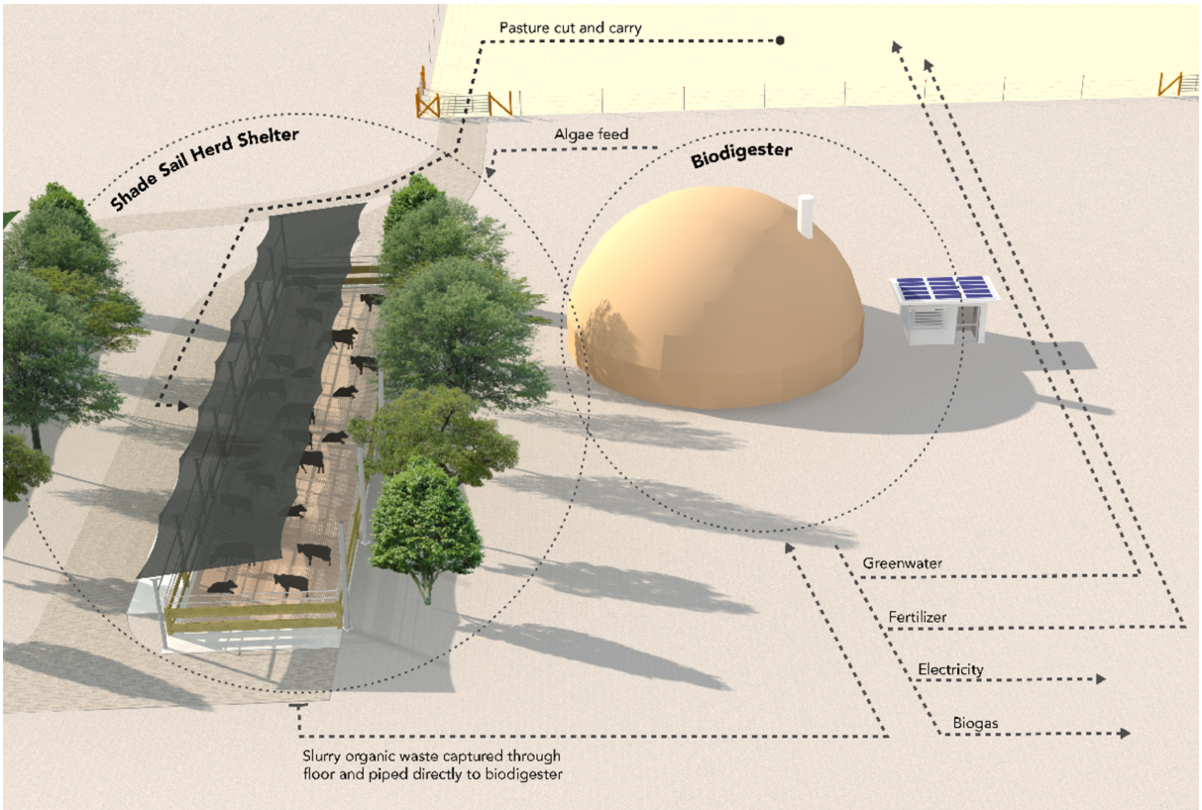

Figure 7 – IFP herd shelter diagram

Our method favours mitigation and in-setting, rather than off-setting involving paying someone remotely to store carbon. Nor does our method rely on ETS. Instead GHG are sought to be balanced within the farm, the catchment and/or that landscape. However we recognise that in some more arid landscapes, and on some high value soils, establishing substantial woody cover may not be appropriate, and off-setting elsewhere may be needed. Thus for a valley floor farm with all high-value arable soils, in-setting might occur through leasing or trading with a neighbour on less productive hill or riparian soils. Through regeneration or other means of permanent canopy forest establishment, the landowners can together reach net carbon zero.

Our team recognise how important and urgent it is for farmers to identify a pathway forward to enable them to revise their management to meet Carbon Zero Act provisions plus community and market expectations. Through positive experiences, we are committed to addressing the nuances of a farm and the farmers to help them find constructive solutions. However we also recognise this country's timeframe precludes the undertaking of farm-by-farm IFP exercises. Whilst ideal for skilled teams led by landscape architects to work with individual farmers to develop the IFP, such one-off planning is not practical if the country's farms are to be adequately prepared and transitioned toward carbon zero.

Locating and furthering the IFP Approach

We have reviewed various farm planning tools currently available to farmers and their advisors and are concerned at inadequacies. With so much advice for farmers very single topic and data focussed, and not providing for integrated spatial management, efforts can be inefficient. For example, streamside plantings to address freshwater and biodiversity issues might need adjusting spatially and utilise more woody species to then also provide GHG in-setting.

However, while IFP is unique in that it is a fundamentally spatial and landscape-based tool, it aligns very closely with the FEP process (see below in Figure 8), while also complementing tools such as Overseer, FarmIQ, and internationally recognised tools such as Dairy EA™ (Alltech) as the detailed monitoring and review processes.

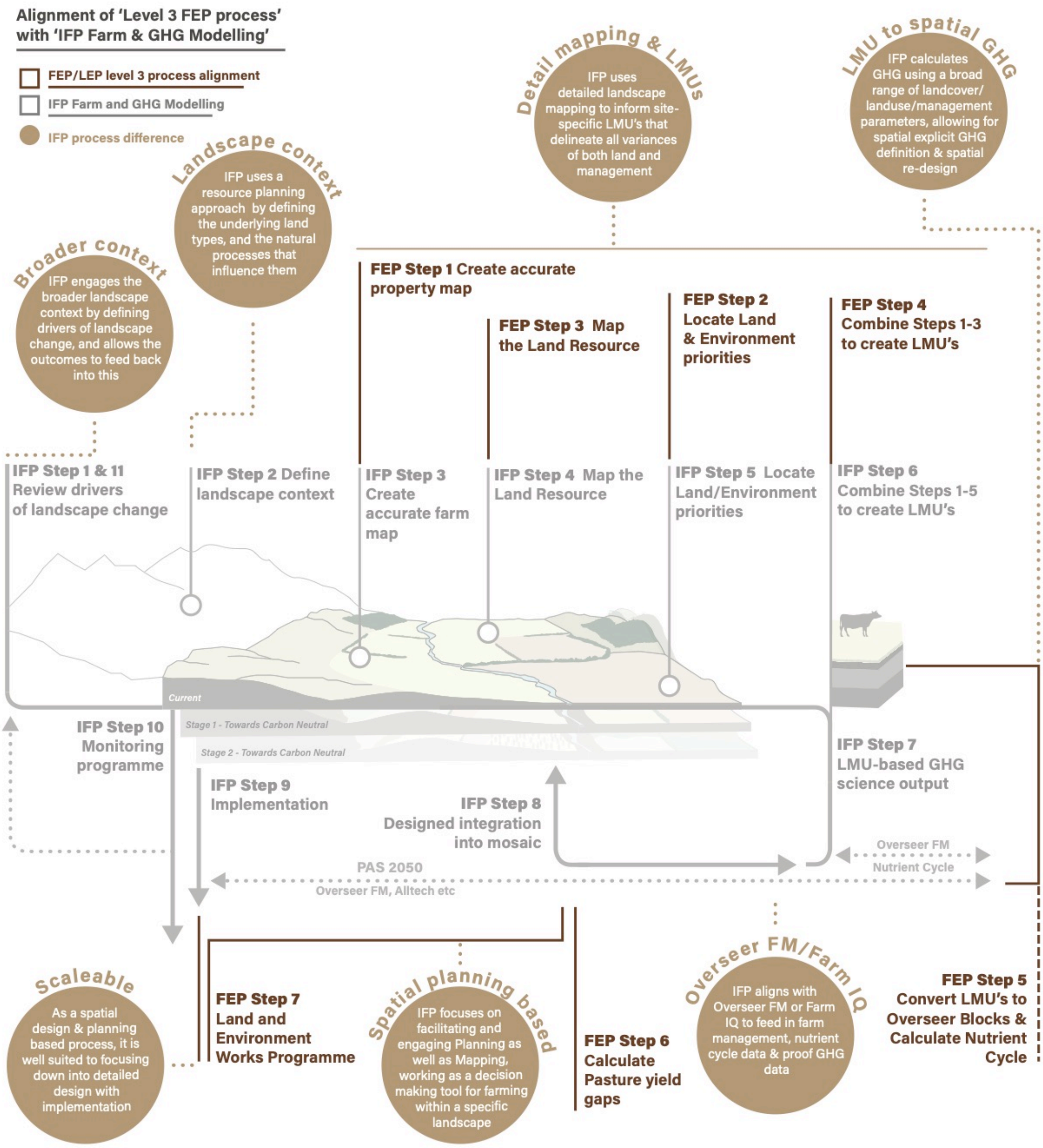

Figure 8 – Model showing the IFP process aligned with FEP process

Further development of the IFP process is focusing on four areas, shown below in Figure 9. The first is the continuation and public accessibility of Land Typing and for all of rural New Zealand, a stand-alone project which feeds into IFP. (some examples are shown at https://www.integratedfarmplan.nz/integrated-farm-plan-land-typing).

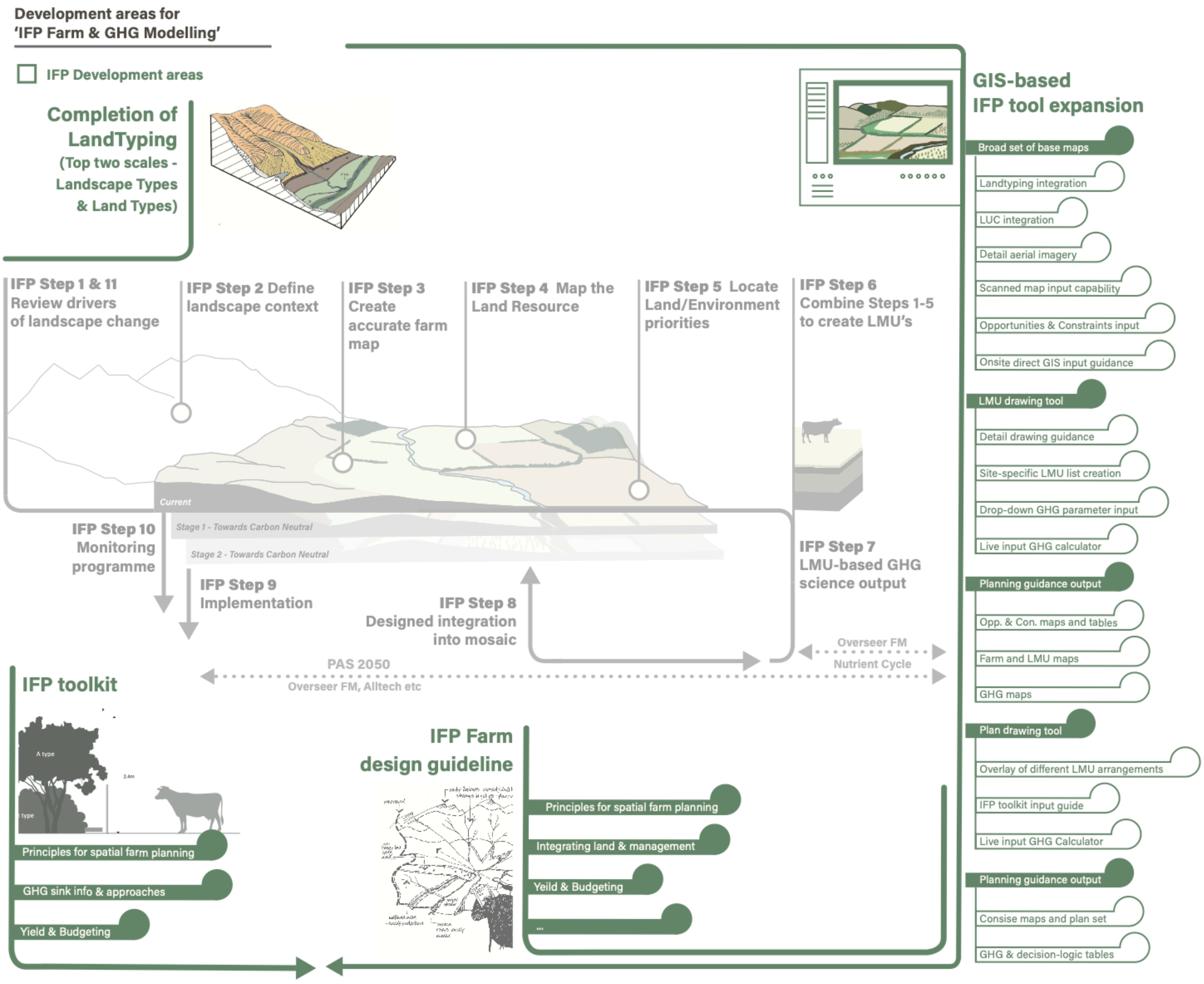

Figure 9 – Model showing the IFP process aligned with FEP process

The remaining three all work together as a freely-accessible DIY tool for creating IFPs. The first a GIS-based mapping tool to facilitate thorough landscape context and farm analysis, the creation of a nuanced site-specific LMU map (including the setting and processing of GHG parameters), and, finally the planning process of alternative future stages and their net emission profile. The science behind emission factors is an area requiring extensive development alongside the IFP process, especially around "non-productive" landscapes, but also following areas of development such as the Regenerative Agriculture movement. The second a design guideline to assist with and direct the IFP planning process, and the third, a toolkit with a range of tools and methods for GHG sinks and how to code these into the IFP LMU GIS layer. Together, we envision these enable an effective DIY tool for creating IFP nationwide.

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