Peat - Part 2 Version 1.9 24 August 2012

Drainage

The first thing with peat is to get the drainage right, but check with the authorities regarding your responsibilities before doing anything. I put in 17 km of new 60 cm deep drains on our first farm without any permission. Today's regulations require bookwork and charges. Also see Soils > Draining.

Regulations regarding drains & waterways

Without drainage boards and councils controlling drains to rivers and then to the sea, most peat could not be developed, so peat owners should combine with authorities and neighbours to achieve the best for all concerned.

Before doing any draining, find out what the local laws are, and will be in the future, if possible. Waterways may have to be fenced to prevent animals walking in them. A waterway is usually one that has water in it all year. Having even slopes in drains can eliminate ponding and change the classification. See below for fencing and removing drain banks.

If you ensure that all internal drains (called ditches in some countries) are shallow, and have a gentle slope for water to flow to the bigger ones, so they have no puddles, and stop running within a few weeks of rain stopping, then they should not have to be fenced by law.

If the banks are pulled off a drain to create a slope, animals will keep away from them except when grazing, and females will not calve next to these drains, as they sometimes do next to vertical sided drains because it is the driest place. See Soils > Draining.

In New Zealand new or deeper drains may not be installed without resource consent from your local body. High fines are imposed on those breaking this law.

Local body drains are usually along property boundaries, but can run through properties. In all cases they must not have anything done to them, such as installing culverts or bridges, or even cleaning them, by other than the council, without the appropriate council permission in writing - for your safety against penalties. Over the years there have been conflicts between landowners and councils, so applications to clean, or requests for the board to clean them, should be submitted in writing in ample time for a decision to be made by the appropriate people.

Sometimes councils have let a contract for contractors to clean or spray drains, and the contractors have arrived to find that landowners have already done so. Where landowners arrange with the council to maintain the council drains on their properties, it saves councils money and allows landowners to control the depth and keep drains weed-free to their own satisfaction. Noxious weeds are required to be controlled by land owners in all drains at all times to prevent seeds flowing downstream and infesting other land. Animals should be prevented from damaging council drains, and no pollutants should be allowed to enter them directly or via other drains. Pollutants include animal effluent of any kind, wash water, waste milk, dead animals, branches or weeds that can block culverts or jam drains, and all toxic substances.

Drainage authorities should install main drains over the deepest peat so they don't have to be moved or dug deeper into clay after peat upstream shrinks. They should be V shaped to carry more volume without relying on depth, and to reduce maintenance costs.

When large drains are being cleaned with an excavator, be there with trailers, with neighbours helping, to have the spoil loaded straight on to trailers or trucks and carted to low places needing filling, around water troughs, or to gateways and the area around them. Some might think that peat around troughs and in gateways will not last, but it does if put thick enough. Once dry, it compacts well and doesn't pug or stick to hooves and wheels like wet clay does.

Drainage is Important

This neighbour tried a Ford County, but heavy tractors and bald tyres don't go far in wet peat.

These and some other photos are courtesy of Yvonne Ball, John's wife. They developed hundreds of hectares on Woodland Road, Gordonton, near Hamilton.

Without drainage, peat is useless, with correct drainage it can be superb, while with over drainage it becomes costly, much less productive, and causes many problems. To convert peat into soil, bacteria must be given a chance to start and continue the decomposition process. This is impossible if the peat is water logged or even if too wet. However, bacterial action will not take place if the peat is completely dry. When dry, the peat gets waxy and won't absorb water. Over-drained peat is as bad as water-logged peat.

Black field crickets (*Teleogryllus commodus*) can multiply alarmingly when peat is over-drained. They live in the cracks that form, and eat up to 80% of what is grown in adjacent areas. They usually start along the banks of deep drains or in heaps of cleanings and work into dry areas, breeding in dry knobs. If not controlled, they can turn a green paddock into a brown one. Grass grubs that eat pasture roots also thrive in dry peats. All these add to the loss of production caused by deep drains.

Dry peats don't absorb rain, so runoff is greater. Pour water on to dry wheat flour and see what happens. Over-drained peats can become hydrophobic and take months to wet and absorb rain. In all that time pasture growth is less than it could be.

Drain banks, especially under fence lines, can become higher and prevent water entering the drains. Push the tractor grader blade under the fence and pull the raised parts away. See GrazingInfo > Soils > Drainage to see how to change hand cleaned drains into shaped banks growing pasture to the bottom of the drain as long as it doesn't have water lowing all year. If both sides of the drain have the banks pulled off, one fence down the middle of the drain with one or two electrified wire reduces capital costs and eliminates spraying to kill weed growth. If there is water flow, put offset insulators, on the posts in the drain.

The solutions to over-draining include -

- Level and shape the paddocks before adequate liming and deep chisel ploughing.
- Change over-deep straight-sided drains into wide-angle drains with about a 30 degree slope, by pushing the banks into the drain, or pulling them off, and carting the spoil to low places or around troughs or gateways.
- Before growing forage crops and resowing pastures is the time to pull drain banks off drains that are the correct depth, shape paddocks to have no knobs or hollows, and fill hollows. Once deeply cultivated and levelled, or with slight slopes to the drains, they stay level for longer. Uneven paddocks get more uneven as the dry knobs stop decomposing, so get relatively higher than the hollows, and hollows decompose faster, so get lower.
- Multiwire fences along drains can be changed to one or two wire electric fences that are easily moved to allow the sloping of banks and grazing to the bottom.
- Lime and chisel plough down the sloping banks right to the drain bottom if possible. If you don't, the sloping drain banks won't grow good pasture and will pug and be pushed towards the bottom of the drain, which will then need cleaning.
- Drain cleanings should not be left in heaps to breed crickets, grass grubs and weeds. The spoil should be spread in gateways and leading up to them, around water troughs and in hollows.

In the past burning over-drained peat was a way of fixing the problem, but today this is unacceptable, and the time out of production, and the cost of regrassing, make it too expensive. There is seldom justification for over-draining today, but it is still occurring.

Peats vary in their ability to carry heavy animals. Large animals can do considerable damage to pastures that are not correctly drained. If farming on a new, soft, unconsolidated wet peat, smaller breeds, crossbreds or younger stock can reduce pasture damage and costs until it is consolidated.

Dome peat, where the centre is higher than the edges, can sink, after which the water can run the other way, which takes a bit of re-planning.

Optimum Drainage

It is very rewarding to get drainage right over the whole of a peat farm. It is not easy, but optimum drainage should be aimed for, with water levels at between **approximately** half and one metre below the surface, provided the peat is reasonably consolidated, fertile and subdivided into at least 20 paddocks per grazing mob, to allow controlled grazing, without animals remaining in paddocks for too long and pugging it. Optimum drainage requires spinner drains about 20 metres apart in very soft wet peat, about 50 metres apart in drier peat and at least around every paddock in consolidated peat.

This is a belt driven offset spinner drain digger I made. It pivots back for transport.

Narrow deep drains have to be cleaned or sprayed sometimes just to kill the grass growing on the banks. Wide V drains don't - once firm they can be grazed to the water's edge. One electrified wire at the height for the animals concerned can stop animals damaging the drain and crossing it. If the drain is big enough to be classified as a waterway animals have to be kept out.

There should be no hollows to accumulate water, drain banks should be spun or pulled off, and the spoil used to fill hollows, and to raise the area at the gate and four or five metres around the troughs. Peat can still be pugged if the stocking rate is excessive for a long period in wet conditions, even if drainage is optimum.

Optimum drainage on peat gives excellent pasture and forage crop yields and easier management, because there is less pugging in wet weather and less drying out in dry weather. Don't tolerate anything but perfect drainage.

Designs of Drains & Equipment

Shallow spinner drains and wide V drains are by far the best. It doesn't matter how many you have, drains that are less than a metre deep can't over-drain peat.

Rear mounted spinner drainers can be operated by most three point linkage tractors of more than 40 hp with a power take off, which, through a drive shaft and clutch, drives the blades which cut and spread the soil, leaving a neat drain up to two feet deep, depending on the tractor pto height, the number of passes and how much veeing of the drain is done. Several companies now make rear mounted ones. Ask your tractor supplier. Some hire centres and contractors hire them.

They need be only about 60 cm (24") wide and 50 cm (20") deep, so you can drive across them on an angle and harvest and fertilise paddocks in long strips, instead of round and round. Weeds which thrive in wet soils decrease, paddocks remain smooth because of less pugging, water-flows don't develop (they are the boggy areas which develop at right angles to drains on peat - see below), earthworms and soil microbes don't get flooded out. Best of all, more pasture grows. Do a trial on your farm by putting drains in at about 30 metre spacings in one paddock and none in a similar size and type paddock as a control, and measure the pasture growth in both.

The deeper drains that the spinner drains lead to usually cause the peat to sink each side of them. The spinner drains need be only 20 cm deep when on the slope where water will run towards the deep drain.

No one likes drains and the associated maintenance, but, if they are needed, then the sooner they are put in the better.

Main drains and council ones need not be deep (water flows faster in wide drains), and their width should be determined by the catchment area.

Flooding and Ponding

It is physically impossible to instantly remove all the water that falls on flat land in heavy downpours, and, if those up-stream do so, those down-stream can be flooded. If all land owners hold back their share of floodwater, flooding problems will be less. Flooding now seldom occurs in the lower Waikato River area for more than a day or two, thanks to control by hydro dams, local councils, and extensive planning of water flows to the sea. However, all should do their share in limiting flows off their properties, and must respect the necessity of having ponding areas which drainage authorities should organise.

Flooding of peat with clean water for four or five days in winter has almost no ill effects on pastures and soils, but two days flooding in summer can kill pasture because it is growing, so breathing, and the warm water has an adverse effect on pastures. Luckily our heavy rain occurs mostly in winter, and fortunately earthworms can survive underground during floods, and earthworm cocoons can hatch after flooding to restock if deaths do occur.

Peat landowners should be neighbourly and not over-drain their farms, and not keep asking the council for deeper drains, that can then over-drain adjoining farms. This has happened in the past with unfortunate results.

Over-draining

Removing water from peat doesn't only decompose it, it makes it shrink. Deep drains can overdrain and dry out peat dreadfully during dry periods, and make it no better than under-drained peat.

A lot of farmed peat becomes over-drained, so care must be taken to avoid this. Reasons for peat becoming over-drained include -

- Draining peat with today's machinery is comparatively easy, so some contractors working for councils in particular dig deeper than necessary.
- Councils use contractors - many paid by the hour!
- To carry a greater flow, some farmers are inclined to go deeper rather than wider.
- The correctly drained areas decompose and settle faster than the dry drain banks and dry knobs, which then become relatively higher, so over-drained.
- Under heavy stocking, low areas, gateways, lanes, etc., can become bog holes and some farmers then deepen drains rather than drag peat from the knobs and edges of drains to fill the low places. Water moves very slowly through peat, especially after it has been pugged or compacted, over-cultivated or just heavily stocked, especially if it has little earthworm activity. The solution is not to allow hollows to develop, but, if they do, fill them with peat from drain banks, from the edges of the road or by taking dry peat from knobs or over drained areas. If there is no such fill available (I've never seen such a case), ask neighbours, local carriers and councils about its availability. Some may want places to dump surplus spoil from development and roading sites. We made a 2.5 metre wide grader blade with 90 cm extensions, making it 3.3 m (11 ft) wide. This, with a four-wheel drive 50 kW tractor, moved a lot of soil, so it didn't take long to level and fill hollows.
- Many drain banks are higher than the main part of the paddock because the dry peat on the banks and under fence lines doesn't decompose as fast. The centre of the paddock then becomes wet, so drains are sometimes deepened to try to fix the problem instead of getting rid of the cause, that is the high drain banks, which should be pulled off and used to fill the low places.
- Drains can be blocked in summer or have the water level raised in various ways. One way is to place plastic bags of sand or soil in the drains. These can be removed before winter. If council drains are to be blocked you should get their permission.
- Main drains should not be much deeper than a metre, but should be wider to take the flow from the many shallow drains. These depths and systems apply in all types of peat, however, areas around buildings should have a lower water table.
- With prolonged heavy rain, water levels will rise above the optimum, and in droughts levels will drop below the optimum, even under perfect drainage management.
- A few old-fashioned farmers still think that raw deep peat should have drains two and three metres deep. Some farmers who have bought farms with two metre and deeper drains have made no

money until they filled them in to about one metre depth.

Over-drained dry fluffy peat can take up to six months of rain to become moist again, during which time soil and plant growth are reduced, but dryland weeds thrive.

There have been cases where local body drains have been deepened through some properties to remove water from others up stream where deeper peat has sunk. The benefit gained by the draining has been more than lost by the over-draining of other areas. Sometimes it would have been better to pump the water out. Farmers in low areas should farm their peat to reduce shrinkage, which means shallow drains, less cropping and less regrassing.

If peat does become over-drained, dry and fluffy, remember that adequate lime chisel ploughed in thoroughly helps hold moisture, and can change dry powdery peat to a moist productive soil. The amount of lime needed can be up to 20,000 kg/ha chisel ploughed in to 30 or 40 cm if possible. Surface liming on pasture should not exceed 1,000 kg/ha per year or 3,000 kg/ha every three years. Do a few trials and you'll see the excellent response obtainable from liming dry powdery peats, but it must be chisel ploughed in. Don't base lime requirements on the soil pH figure, because dry peat has a fictitiously high pH. Take samples of wet and dry peat from the same paddock and you'll see. The term pH stands for potential hydrogen, not calcium content. Pastures (especially legumes), soils, earthworms and animals all need calcium.

Control Gates

If deep drains can't be filled and reshaped to shallower V drains, it may be necessary to install water level control gates. Many types have been made and consist of boards that are slid down between four verticals (two in each bank) that hold the boards in position. The wider the drain, the stronger (thicker) the boards should be. Allow plenty of clearance between the boards and the uprights to cope with swelling. They should be installed well before dry weather starts and removed before wet weather comes again. Local council approval for them and their design will be necessary.

An automatic one can be made by having a sheet of steel instead of boards, and sliding between steel uprights. They can be welded in the shape of a U. The steel gate should have a V cut in the top and a short funnel to have the overflow run into a drum that should be attached by rope over a pulley above the steel frame of uprights and base. The drum should have a hole in the bottom to let the overflow run out. When the flow is so fast that the bucket fills it should go down and lift the gate. The hole should be adjustable (a piece of flat steel swivel-bolted on next to the hole), to allow changes to be made on site.

If there is slope in a long drain, it may be necessary to have more than one control gate. If the drain is a wide V drain (as it should be), then bags of soil or heavy logs can be laid in place and pulled out by tractor as required. Bags and logs should have nylon cords to ease lifting out and logs should be anchored down.

Underground Water-Flows

Raw peat has natural underground water-flows or water movement routes through it. When developing peat these are seen as wetter and felt as softer areas where tractors can suddenly sink. After developing peat, these "water-flow" areas either continue, or dry up, depending on where drains are placed.

If too few drains are installed, water will continue moving along these water-flows to the main drains. They will be the first areas to pug. If sufficient shallow drains are installed, water-flows are usually tapped and drained and no new ones, or only very small ones, develop. If sufficient shallow drains are not installed, old water-flows will continue and new ones will develop and become a real problem, because animals and vehicles pug them. Animals' hooves and tractor wheels cart the pugged mud out of them so they get lower and become wetter and wider. They can be seen on many peat farms where insufficient drains have been installed.

Deep drains in deep peat shrink the peat by several metres each side of them, and if there is no drain within 30 or 40 metres of the deep drain, underground slow water-flows can develop. Farmers who don't understand peat can then deepen the deep drain. Instead of solving the problem, it aggravates it, as more water is drawn towards the drain. The solution is to put in a drain behind the bog area to cut off the flow, or to put a drain right in the water-flow.

In this new pasture an underground water flow caused this low soft sinking area right next to a 1.8 metre deep drain, because there was no drain for a hundred metres behind it. The new pasture needs nitrogen until clovers produce it.

Large V Drains -

As main drains these are best because -

- They can be grassed and eventually grazed right to the bottom. This can't be done in raw peats and won't work where the bank is so steep that animals push it in. It is not recommended to graze council drains because they don't really belong to the landowner, and damage by animals could cause problems. It is best to get permission and pull the bank off and erect one low (about 60 cm high) electrified wire on short posts close to the drain. Cleaning equipment can then reach over it and animals won't jump over it into the drain.
- Pulling the bank off discourages animals from going too close except to graze. They also avoid calving on the slope, so calf losses in drains are reduced.
- Grazing the sloping banks keeps them freer of weeds. If all farmers did this, weed spread along drains and their control costs would decrease.
- Wide V drains are not death traps.
- They can be visually checked over longer distances for animals and obstructions.
- There are no banks to collapse or be pushed in by animals.
- Water moves much faster on the surface than at the bottom or against the sides of drains, so the wide top of a V drain allows rapid movement of water without there having to be an over-large drain. If required, with the use of restrictive culvert pipes, they can act as ponding areas.
- Despite having a greater flow capacity than the same cross-section of a deeper narrower drain, being shallower they do not over-drain the peat.

Surface Drainage

As well as paddocks being shaped to eliminate puddles, shallow spinner drains should be put in as required and along each fence, so that the water can't run from one paddock to the next. Surface drains gradually become shallow depressions that don't affect the mowing or working of paddocks. Where drains have to cross long narrow paddocks and lead water to side drains, dig them on an angle to the side drain so that tractors cross them on an angle which is easier than going bump, bump.

Having shallow drains along every fence line and from all hollows (that can't be filled and levelled) to the main drains, allows excessive precipitation to run off without -

- Leaching fertiliser and lime.
- Drowning earthworms.
- Waterlogging soils.
- Encouraging pugging.
- Encouraging weeds.
- Lowering the nitrogen content, which makes the areas yellow and slow growing.
- Encouraging shallow rooting, which then affects pastures adversely when dry weather comes.
- Allowing the weight of water in low areas to push them even lower.
- Increasing run-off from the high areas and adjacent paddocks to low areas, so that the puddles become much bigger, and stay longer.

Try to have the fall in these shallow drains so that there are as few low places and puddles in the drains as possible.

Main drains should stop running within two weeks of rain stopping, unless they tap springs from surrounding hills. Spinner drains should stop flowing within a few days of rain stopping, so don't overdrain the peat in any way, but encourage deeper rooting, which will keep pastures greener and growing longer into dry periods.

Where there are hills in the peat, position a shallow drain around the base, otherwise the runoff will cause the peat there to be always wet. If this drain is put at the exact base of the hill, it will have to be moved after the peat sinks, so place it several metres out.

Decomposing and Consolidating

Decomposing and consolidating of some peat can create problems, if drainage is limited by insufficient fall without over-draining other areas, or where drainage water has to be pumped. Shrinkage can't be stopped, but farming practices can slow it.

Things that speed up shrinkage include -

- Over-draining, which is a bad practice.
- Cultivating lime in deeply. Depending on the rawness of peat, moisture, earthworms and grazing, 25 cm (10 inches) of peat will shrink to 10 cm (4 inches) in 3-5 years, but the lime will remain in the 4 inches. Deep chisel ploughing is a good and profitable practice, because pasture and crop yields are much higher and pastures last much longer.
- Applying minerally balanced fertilisers. This is also a good practice - essential for high profits.

After three years, shallowly and poorly cultivated peat with insufficient lime can settle unevenly to only 10 cm in depth, be bumpy and dry with low pasture yields, while that chisel ploughed to 30 cm or more, and with adequate lime and fertiliser, can produce well for two to three times longer.

On some farms rushes swamped out pastures on raw peats, even after several cultivations and resowings, even in the 1980s, but we never had this problem after 1958.

Unfortunately some consultants and tutors who didn't attend the many field days I ran, or who didn't visit successful peat farmers, were still saying in the late 1990s that rushes took over, and it was difficult for tractors to pull mouldboard and disc ploughs through very soft peat. I had developed a peat chisel plough in 1958 which allowed all tractor wheels to be on the same level, increasing the pulling power because there were no wheels in the plough furrow. 25 cm (10 inches) of rain over a few days in February (usually a dry month) 1958 made things so wet that I had time to think, and develop a low cost chisel plough suitable for cultivating peat thoroughly and deeply.

There can be times when it is necessary to hasten shrinkage, for example to decrease the ill effects of over-draining that can't be corrected by decreasing the depth of drains. Examples are when there are high dry knobs in paddocks, where low areas in the same paddock need three quarter metre deep drains. These high areas can be used for filling low areas, around troughs and gateways. Another way of lowering the high areas is by cropping.

Practices that reduce shrinkage and consolidation include -

- Optimum shallow three quarter metre deep drains rather than deeper ones, except some very soft raw peat that will need deeper drains until consolidated.
- Levelling paddocks and shaping them to remove high knobs that dry out and speed the requirement to cultivate and regrass the whole paddock.
- Filling depressions that would otherwise pug and sink, and then require drains to be deepened.
- Capital dressings of lime and correct fertilisers, then adequate annual amounts to maintain good pastures for longer periods. This reduces the costly necessity of frequent cultivating and regrassing. See Ian McDonald's Testimonial near the beginning.
- Avoiding over-grazing in summer that kills pastures which then need cultivating to resow them.
- Avoiding pugging that kills pasture and encourages one to deepen drains, to stop pugging.
- Sowing the best pasture species for peat so that they last longer. Consultants can help with this, as long as they are told what your requirements are, such as no hybrid perennial ryegrasses which last for only two or three years. Peat, not yet in its prime, is like flat hill country (low fertility and dries out), so needs the species that hill country farmers sow. See Pastures and Management. Fescues may help.
- If drains are further apart than 30 metres in wet, raw or soft peat, they will draw water towards them through the more porous parts of peat (peat is not consistently even in its make up), and create water flows which become wetter and create boggy areas across paddocks and even next to drains. These become deeper as animals and machinery cross them. See the photograph above.

Low Wet Areas

Low wet areas in paddocks should be filled or drained because they -

Reduce pasture production.

Encourage the breeding of liver fluke, an internal parasite.

Increase in area as stock carry mud out of them and pollute the surrounding pasture.

Decompose at a faster rate than dry areas, so keep sinking, getting deeper and larger, increasing the problem each year.

Kill earthworms.

Discourage clovers and good grasses.

Animals camp on the high areas, transferring fertility from the low areas.

When heavy rain falls, or after prolonged dry periods, the water runs off the high areas into the low areas, causing the high areas to become drier and slow down their decomposition, and causing the wet areas to become wetter.

Encourage moss, Weewee Toad rush (*Juncus bufonius*), Willow weed (*Polygonum persicaria*), Pennyroyal (*Mentha pulegium*) and the worst Buttercups (*Ranuculus spp*) including creeping Buttercup (*Ranunculus repens*).

Encourage the growth of Couch grass (*Elytrigia repens*), one of peat's worst worries - much worse than Ragwort (*Senecio jacobea*) was.

The solution is to fill low areas with drain cleanings, peat from knobs and from drain banks, and/or drain them as soon as they are noticed.

Private Wetlands

If draining or filling a low wet area is going to be costly and will need repeating, consider using the area as a wetlands sanctuary. However, one should be aware that doing so will encourage ducks and

other birds, which, if too many, will eat and foul a percentage of the adjacent pasture. Reserves sometimes encourage drug growers to use the area, and that can cause other problems, such as being attacked and/or burning the scrub after a feud with other drug growers. This is unlikely in remote distant areas, but was a problem on a small peat reserve in Hamilton in the past.

Once a wetland has been established and recorded, it can't be drained without RMA resource consent, so think of all possible consequences before creating one.

Removing Animals from Drains

Vertical sided two metre deep council drains are animal traps. If an animal has to be pulled out, place the chain around the neck of ruminants and around the body of horses. It is a two-person job, one on the tractor and one attaching the chain to the animal, and then, when the animal is out, undoing it quickly and running to the tractor, because while a dairy cow is unlikely to, a stressed beef animal or bull can charge one.

Water

Before purchasing a farm check the water supply and its quality. Obtaining good water on peat can be very difficult, but, with today's treatment knowledge, water can be made acceptable. Bad water can cause milk grades and bad animal health, and reduce the amount that animals drink, which in turn reduces how much they eat, and produce. One 400 cow dairy farmer, after fixing bad water, gained $8,000 a year from increased animal production and reduced vet costs.

Waterways and Peat Lakes

Animals drinking from main drains have caused damage to banks and polluted the water, both before animals drink and to what flows on to others. Boggy drinking areas breed and spread liver fluke and leptospirosis. Local bodies have requirements which should be checked and obeyed, but in the long term all are likely to require waterways to be fenced off.

Trials in Italy found that poplar trees around waterways were deep rooted and reduced nitrates entering the underground water.

In USA and Australia it was found that from adjacent wooded areas (open bush) with livestock excluded, nitrates in surface runoff were nearly twice as high as from pasture. USA figures showed that 25% of the rainfall in the wooded area ran off, while only 17% ran off that in grass, so it looks as if trees with a grass base are likely to do the best job in reducing nitrates entering water. Applying this could help reduce the pollution of lakes in peat and other areas.

A dairy farm lane should be at least 5 metres wide, plus about one metre for every 50 cows in the mob. There could be several mobs (groups) in one herd on a farm. Dividing herds into two or more reduces the necessity for wide lanes. The lane should be wider close to the dairy, because cows usually slow down there, more so in very large herds.

Starting milking the moment the first cows enter the yard speeds their entry. If on your own, have a good dog, and have the radio and machines running as cows enter the yard. Cows associate the machines running with milking, so will enter more quickly. If they don't, you might have a faulty milking machine, shocks in the parlour or an animal management problem. Cows like to be milked quickly, and get out of the parlour and back to a fresh paddock or break of new pasture.

Before applying surface material, consolidate the peat under the lane with adequate drainage, ample deep chisel ploughing, and grading it up to at least a 35 cm (1 foot) mound, because it will sink to a gradual slope. One that is too steep twists hooves so should be avoided. Peat is the cheapest fill (it just takes more), before spreading metal or gravel or lime chips.

On our farm in 1955 we did this, and then just applied a few centimetres of metal (stone) dust on the surface, with excellent results at a very low cost, but it had to be maintained with any holes fixed promptly. The larger the herd, the better the lane and its maintenance have to be.

Quite often the very end of lanes need not be metalled and can remain in pasture as long as it is mounded and well drained.

Avoid Right Angles

Avoid having any right angle bends in the lanes, because large animals don't like walking around tight bends, and, when they do, they twist their hooves and damage the lane surface.

Keep Lanes Short

Cows walk at up to 3.5 km/hour on good lanes and as slow as 1.5 km on boggy or rough ones. Milk production can drop about 7% for 1.6 km walked one way (3.2 km return) for that milking, and somatic cell counts increase with walking. Keeping lanes as short as possible saves a lot of time and milk over the years.

Culverts

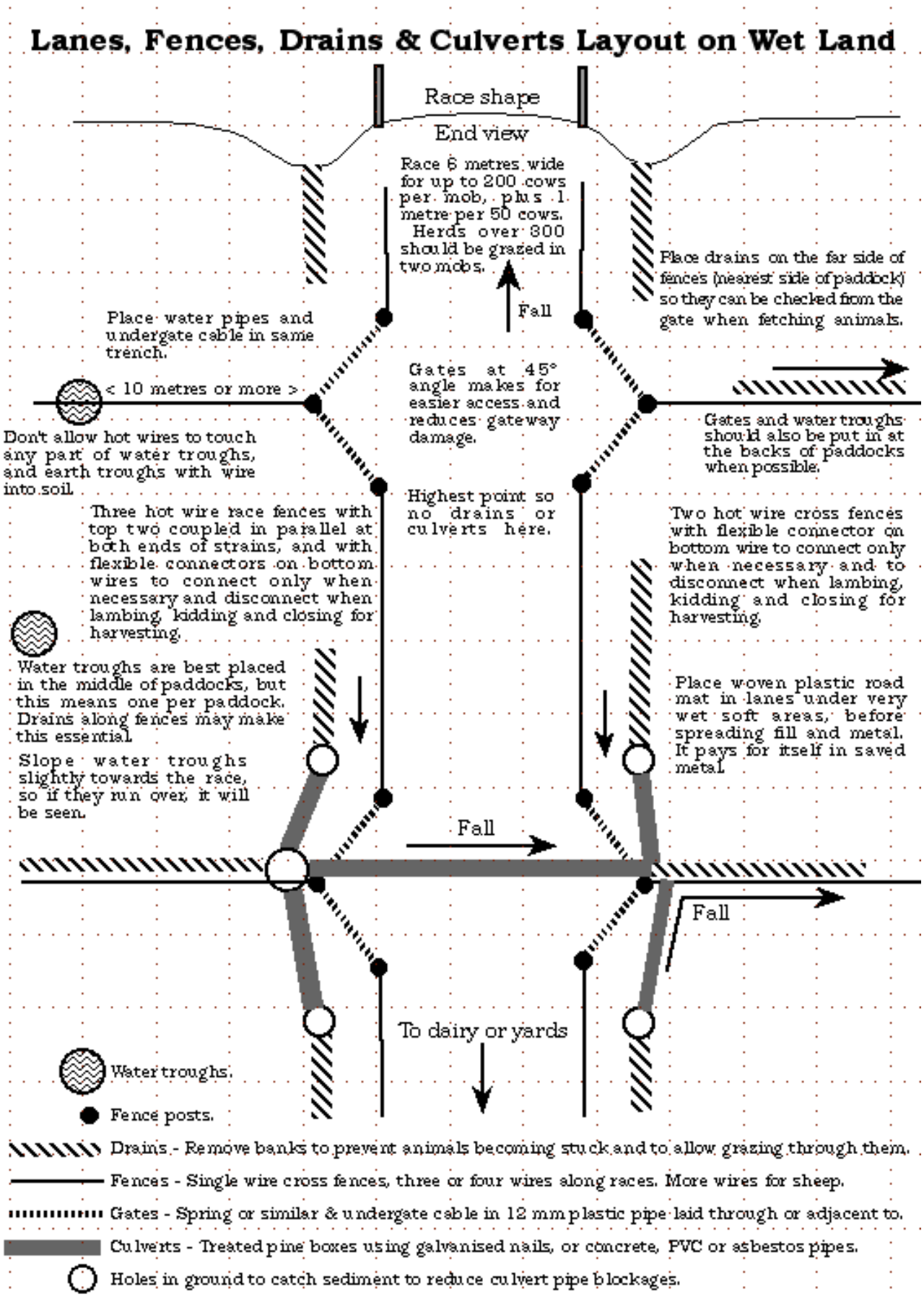
Culverts should be placed about half a metre deeper than the current requirements, to allow for sinking of the paddocks. One doesn't want to be deepening them too often. A hole should be dug and kept clean at the entrance to catch sediment to reduce silting the pipes. Laying the pipes on a slight slope also reduces silting. Ground treated pine box culverts with galvanised nails can be used and are easier to lift and deepen. Turn them over before relaying them. Any sediment will then gradually wash out.

Our Piako Road farm in the centre in June 1982 showing the better quality pastures compared with neighbours' who are no longer there. Our close to square paddocks with shallow drains on every fence line helped. The neighbours had no cross drains - just our boundary drains. Long paddocks encouraged animals to walk back and forth and create paths as shown. The other neighbours large paddocks at the top, without back fencing allowed animals to pug some areas as shown. The few animals on the right of our farm are calves being fully fed.

Roading on peat can be expensive if the peat is not first consolidated by frequent chisel ploughing and crowning. If this is not done, the metal poured straight on to flat raw peat can sink down to four metres in soft peat, as happened on Woodlands Road, Gordonton, in 1963.

I pointed this out to the local body building the road, and after I crowned the peat and consolidated it by chisel ploughing it every month for a year, less than half the metal was needed. I was contracting

at the time. Previously the weight of the metal and trucks carting it in pressed it down and sideways into the drains on each side of the road.



Another mistake they made was to have a drain on one side much deeper than on the other side. This is asking for the road to lean over. A road or farm lane on soft deep peat is a floating structure, so it

must be even on both sides.

Shallow drains (about 60 cm in consolidated peat, deeper in raw peat) should be dug on BOTH sides of lanes to keep them dry, to prevent water flowing over them and to stop water moving under them to another drain.

If making a new lane, chisel plough the whole area, grade the spoil from the drains into the centre and chisel plough it all until it is well broken down, then grade it up to a good crown. Raw peat above deep peat will sink considerably, so should be given more crown than on consolidated shallow peat. In soft, wet, bog areas a plastic roading mat may be necessary to support the material. It will save considerable amounts of metal and end up costing nothing, and also give a smoother lane less subject to sinking unevenly.

There must be a crown on the lane, but it should be only just sufficient to shed the water. Too much slope can damage the animals' hooves by twisting them and causing cracks between the two separate claws of the hoof, allowing footrot infection to enter.

The more timid stock are forced to the sides and then have the tiring and stressful job of straining to prevent being pushed into the fence as they walk to milking. Add stones (instead of chips) to this and timid cows can be really stressed and can suffer hoof problems, especially if jammed up so much by a person behind that they can't see where to place their feet.

Surface Material

A well-shaped firm peat lane with shallow ditches on both sides needs very little metal or gravel on top. I believe that the best product to use for the base is crushed brown 40 mm all-in (soft brown rock with a little clay from the top of quarries). It spreads well, can be graded and it packs down. Metal dust is also good for surfaces and cheap per square metre spread. Sand, because it doesn't bind, can wash away. Dirty sand (contains clay) is a better material than clean sand, to form a free draining but strong surface. Then use crushed coarse agricultural lime on top of whatever base material is used, and for repairs. Keep a small amount on hand to fill holes when they are small, not after they have become large.

Lime chips from 20 mm down to 5 mm make an aggregate that packs tightly and the best surface, but if distant transport is a major cost it may not be economical. Lime chips pack down almost like concrete, but are softer than concrete and stones, and seem to have a sterilising effect, reducing hoof problems. If all are one size they don't pack tightly. Footrot germs don't like the high pH of lime. Farms with footrot problems see it decline rapidly after applying lime to lanes. Lime chips are also dust-free. Cows walking down a hot lane is bad enough without being in a cloud of dust.

Another reason that the lane slope should not be too steep is because the lime can wash off it before it packs down. If your peat has soft areas, it may be necessary to lay road mat (synthetic mesh) to hold the metal or coarse lime in a layer. It is cheaper in the long run because it saves buying so much metal and makes it last longer.

The worst to use is coarse rock or anything with stones larger than 40 mm diameter like this on the left, and below left. The left photo was on corner so cows had to twist their hooves and suffer the large stones, so they were nervous and dunged as can be seen Coarse rock may be about half the price of crushed 10 mm at the quarry, but may be twice the price per square metre delivered and spread more

thickly, because of its large size. It is also hard to grade or move in the future if necessary to grade

into a hole. It splits hooves and cuts tyres. The large stones also find their way into paddocks at the expense of machinery. Getting prices will show that the spread prices are only 40% higher per cubic metre delivered, but less than half is needed per square metre spread.

Avoid using any type of coal ash or other ash. They are concentrated toxins. Many animals have died from eating them. Animals seem to love eating anything different, especially, but not necessarily, if deficient in some minerals and a good soluble nine mineral mix (SMM) is not being fed in the drinking water.

Shocks in Lanes

If animals stop at a particular place in the lane each time, check for shorts there crossing the surface. Another sign of this is when they suddenly change from walking several abreast to single file, for no apparent reason. On dry peat this can occur after the first autumn rain, which causes electrons to flow across the surface of the surface-moist peat, because current flow from shorts and leakage from vegetation touching live wires can't go down though the dry peat, which is a bad conductor to the wet peat a metre or more down.

A client phoned me one autumn after the first rain because he couldn't get his cows out of a paddock through a gateway because of this. He thought that lightning which had occurred with the rain, had scared them. See Grazinginfo > Fencing and Shocks in farm dairies.

Meanwhile, if there is a problem, turn the electric fence unit off when moving animals and during milking.

Keeping Records

With all farming one should keep records and plan daily, weekly, monthly and annually. Keep records of pasture growth rates and pasture cover, so that you know when your leanest period is and can correct it in future years. Many farmers don't realise that with consolidation, increased fertility, improved pasture species, optimum drainage and controlled grazing, more pasture can be grown each day in winter even on peat, when cows are dry, than in summer when cows are milking. In the northern areas of New Zealand, autumn calving with the higher winter milk payment should be considered on well drained peats.

Farm Statistics should be kept on a spreadsheet, diary or book. I still have my diaries back to 1955 with the paddock grazed, milk production from it, fertilisers applied, seeds sown, etc. Spreadsheets are easy to make or you can buy the Farm Statistics one from www.grazinginfo.com

If you are not good at record keeping then at least write on the paddock post with a permanent felt pen what varieties were sown, when the paddock was limed, etc. Frequently farmers have high producing paddocks, but can't remember in which year they were sown and with which variety, or when they were last limed.

Fertilisers for Peat Farms

In this Peat chapter details of the elements used for soils and animals are brief. In Fertilisers and Elements there are about a hundred pages on the twenty elements needed by soils, pastures, crops and animals.

Lime (Ca).

Aim for 0.8% Ca in 75% perennial ryegrass and 25% clover tissue.

Agricultural lime is the main source of calcium and contains from 50% to 97% calcium carbonate (20 to 39% calcium). The higher the calcium carbonate content, the better the lime. Before buying lime ask the supplier for an accurate percentage of calcium carbonate and other elements.

Some limes are very hard. All have to be ground finely to be of use. With today's interest rates (8%), the hard coarse part of lime which doesn't become available for 5 to 20 years will end up costing twice as much as finely-ground readily-available lime.

Calcium in lime is a fertiliser and the most important one with which to start on all soil types. Peats have been criticised for not lasting long in good pasture after cultivating. The length of time peat remains in good pasture relates more to the amount of lime mixed in to the maximum depth than to anything, although drainage, adequate fertilising and liming are essential.

Calcium carbonate, as well as raising the pH, is a soil conditioner and increases the availability of other nutrients including nitrogen, when it provides suitable conditions for soil rhizobia and nitrogen fixation. It is an earthworm and plant nutrient, especially for clovers. Most soils have small amounts of calcium, but peat doesn't.

Peat and high organic soils need more lime than mineral and low organic matter sandy soils.

All references to lime apply to agricultural lime, not any other forms of lime such as hydrated lime.

It is known that, because of peat's organic content, and because there is little aluminium in peat to depress P and root movement down, it doesn't have to have as high a pH as mineral soils for optimum pasture growth. However, because of its low Ca levels and need for Ca to feed clovers, earthworms and cows and decompose the raw peat, regular applications are needed.

The swing to using reactive phosphates, with their 33% calcium carbonate, rather than Single Superphosphate, that has only 22%, helps a little, but won't eliminate the need for lime and the need to cultivate it (and the reactive phosphate) in when cropping and renewing pastures.

The natural pH of dead vegetation (organic matter lying on the surface of soils) is under 5. Because the volume of this organic matter is small it takes only 1,000 to 2,000 kg of lime per hectare to correct it, whereas to raise the pH of a peat (98% organic matter) from 4.8 to pH 5.8, when cultivating peat deeply to about 35 cm, takes at least 17,000 kg/ha of 95% calcium carbonate lime.

There are two pumice layers in deep peats from two Taupo eruptions nearly 2,000 years ago. When some farmers have problems with their peat drying out they look for reasons other than spending $500/ha for 17,000 kg of lime. Some see the pumice layer and blame it, when often it is simply over-draining and a lack of lime. Plant nurseries use peat and pumice as a potting mix. Sand or pumice mixed into the peat improves it. Try a small area by applying 14,000 kg of lime per ha (6.3 US tons/a) and chisel ploughing it in thoroughly, and then roller cultivate 3,000 kg/ha on the surface. Chisel plough deep enough to bring up some of the fibrous raw peat from below to mix with the dry peat that is on top.

It is important to have the top few cm of all soils sweeter (higher pH) than the lower layers. If earthworms are inactive for any reason, an organic layer of thatch will build up under pastures. Thatch encourages acidity in the top layer, reduces germination of self sown and over-sown pasture seeds and is the start of the route to a 'dead' soil. Lime, and especially earthworms, reduce it. Pastures with thatch make good sacrifice paddocks on which to winter animals and feed them, or as on/off paddocks, when the thatch will be trampled into the soil. Apply lime first to help decomposition and sweetening and to encourage earthworms to achieve a 'live' soil.

Dead soils can be caused by a lack of any one or more of the following - drainage, lime, other fertilisers and even trace elements. Over-draining peat can also kill it. Even the best reactive phosphate

will not work on 'dead' peats. It will have to be started with correcting the above, and then using small amounts of water soluble fertilisers.

A sour soil (lacking lime), when pugged will smell dreadful, but if adequately limed it will not. One can see this on a small scale with garden compost of lawn clippings. A heap which gets lime added every 10 cm or so will not smell and not attract flies, while one without lime will smell and attract flies. Limed compost will attract earthworms which will make it into compost without your having to turn it.

Raising the pH

To raise the pH of raw peat from 4.8 to about 5.8 when cultivating to about 40 cm (16 inches), takes about 17,000 kg/ha.

3,000 kg/ha of lime on peat containing earthworms can raise the pH from 5.5 to about 6.0 in the top 8 cm (3 inches). It then drops back over the next three years.

3,000 kg/ha of lime on mineral loams can raise the pH from 5.5 to 6 in the top 8 cm (less on fine clays, more on coarse sands). It then drops back over the next five years, but much more slowly than in peat.

2,500 kg/ha (2,240 lb/acre), on established peat pastures needing it, has given excellent results. No more than this should be applied within about three years, because it will be wasted and can raise molybdenum levels excessively on the surface. Peat in good pasture with adequate earthworms will have them to take it down. They thrive where Ca is adequate and the pH is about 6.

When cultivating, chisel ploughing or spade hoeing lime in are much better then mouldboard or disc ploughing, because they go deeper and mix it. Mouldboard and disc ploughing leave large lumps of peat with no lime. A client who would not change did so quickly when I dug down in a mouldboard ploughed paddock. The lime was still in a layer under the inverted turf and up the cut side a bit. Clover roots and nodules were thick where the lime was, as were earthworms, but the bulk of the sod was still dead. In time the earthworms would mix the lime through the soil, but the cultivation depth was not as deep as with chisel ploughing, which doesn't leave a hard pan.

Clovers, essential for profitable pasture production, growing animals and milking cows, have a high requirement for calcium. Correctly fertilised clover has about 1.3% Ca, while correctly fertilised grasses have only about half this level.

Bare patches that develop in summer on lime and/or fertiliser deficient peat become very hot and dry, and then crack. Autumn rain then runs down these cracks to depths below the root zone, washing water soluble fertilisers with it. Reactive phosphates don't wash away. Surface liming and oversowing reduce this problem, but not if left too late before applying.

Mixing in Lime

It is well known that agricultural lime is best thoroughly mixed into peat, but unfortunately, some advisers say that lime applied to the top of peat pastures is not effective. I repeat that this is completely wrong in theory and practice, and the lack of knowledge of people who say this is sad, because following it costs farmers money. The only time when it is of little benefit when applied on the surface of pastures is when the peat is "dead", one cause of which is a lack of lime. I repeat, dead peats occur where insufficient lime has been applied regularly over the years or the lime was too coarse, drainage was excessive or inadequate, and/or other elements were lacking. Up until about the mid 90s some lime was quite coarse so was much less effective on 'dead' paddocks.

Symptoms of lacking lime are tightness, dandelions, rushes, Weewee (toad) rush, moss, thatch, no earthworms, waterlogged, small leaves on very few clovers, gaps in pasture that grows slowly, little depth of cultivated peat left, and/or bone dry over-drained peat. Yes, both over-wet and over-dry peats become dead. Soil microbes and earthworms can't tolerate either for long. 3,000 kg/ha of lime could sit on top for ages, so apply only 1,000 kg/ha and more again when necessary, unless the problem can only be solved by cultivating, which is usually what has to be done. Pennyroyal and buttercup are also more inclined to thrive when soils lack lime, but, if established, liming won't get rid of them. Drainage will help.

The old recommendation was 3,000 kg/ha every five years, but the typical peat pasture deteriorates if without lime for five years. 1,200 kg/ha every second year is, however, more practical, gives good results and is more profitable. It feeds the earthworms and reduces the problem of "dead" peat.

Some farmers complain that liming softens mineral soils and makes them more prone to pugging. Compared with a dead hard soil covered in thatch, they are right, but dead soils are unproductive and deteriorating, so have to be fixed.

As soils under grazing, including peat, become more fertile, they build up a humus content near the surface, so can become more vulnerable to pugging. Lime encourages earthworms to mix the humus to a greater depth and aerate the soil. The large deep working earthworms (L terrestris, Longa and Caliginosa) are essential for this to happen. The smaller red coloured varieties (*L.rubellus and foetida*), while excellent at breaking down animal manure, don't go deep.

Pugging reduces the build up of dead matter on the surface, but is not the recommended way of correcting the problem unless there is a thick thatch mat, caused by inadequate grazing over a long period, and low Ca. In these cases, liming and heavy grazing with trampling can improve the paddock. Pugging releases carbon that is frowned on by environmentalists, which is most of us these days, so don't overdo it. It is best done quickly, followed by oversowing and perhaps harrowing, if at a time when pasture seeds will germinate.

To check your paddocks, get a spade and see what is happening. There should be very little dead material on the surface, no moss or only little at the end of winter, humus for the first 10 cm, and the peat should be friable down to 20 cm or more. Where Ca is needed, but molybdenum is above 5 ppm, apply it in small frequent amounts rather than fewer large amounts. Keep copper levels higher than normal, say at 14 ppm, and sulphur levels up at 0.4%.

Adequate lime applied when cultivating makes paddocks last longer before having to regrass, provided it is cultivated in thoroughly and deeply. Too much lime can increase the molybdenum to reach toxic levels and cause other imbalances, especially if too much is spread on the surface at any one time. The amount to apply depends on current levels, the recent liming history and how deep it will be chisel ploughed in.

Another benefit of reactive phosphates with their 33% calcium carbonate, is that it reduces the amount of lime required, but only slightly.

Evidence

By mistake, a year before this photo the 2 m deep peat paddock on the right got twice as much lime (about 10,000 kg/ha instead of 5,000) chisel ploughed in to 40 cm on Rukuhia swamp peat on the Gallagher Demonstration farm in Hamilton in autumn. It had 15,000 kg/ha when sown out of scrub and weeds 10 years before, and 7,000 kg/ha when cropped in spring. It showed that the extra lime kept it moist in February and grew nearly twice the pasture and fewer weeds than on the adjacent, previously identical, paddock. Both were pH 5.7 measured in a dry February. Digging showed that peat getting the extra lime was moist, crumbly and full of life, while that getting less lime was dry.

A year before that, it was all one paddock so there was no other difference. Note the poorer pasture and selective grazing and weeds on the left, and the lush pasture with clover and more even grazing on the right. Animals eat weeds with lush pasture to get roughage. Calcium and salt make grasses softer, so grazing is more even, while excess potassium makes grasses harder, so selective grazing occurs.

If unsure whether to apply lime or not, get a pasture analysis, and, if still unsure, put down whole paddock trials at 2,000 and 4,000 kg/ha (1,784 and 3,568 lb/a) and measure pasture dry matter levels before and after each grazing. Add up the total yield per annum, and compare them with a control paddock. Observe animal behaviour when grazing the limed and control paddocks. They are likely to graze the limed ones shorter, eat more and be more contented. Animal growth is faster on adequately limed pasture, so cows' milk production could increase on the limed paddocks. If needed, higher rates can be applied when chisel ploughing to grow a crop or re-grass. Prior to cultivation is the best time by far to apply lime, because it works much better when mixed with the soil.

3,000 kg/ha should always be spread on the final surface and roller cultivated in to 4 to 8 cm. See Cultivation.

If magnesium (Mg) is low, and on peat it is, a lime and serpentine (Mg) mix called LimeMag is available from Rorisons RMD. Use a Lime Nutrient Planner spreadsheet in GrazingInfo to see how much to apply. Enter your information and email it to a GrazingInfo consultant Evan McIntyre , Garth Taylor or support@grazinginfo.com

from Rorison's RMD, Mt Maunganui, phone 0800-401-040. Their mine is at Aria. It is 75% lime and 25% serpentine, with an analysis of 73% calcium carbonate and 7% Mg. Peat being acid makes the Serpentine Mg become available. A trial on a mineral soil needing Ca and Mg, LimeMag gave 30% more pasture growth than the same dollar value of dolomite, and increased Ca to 0.84% and Mg to 0.31%. The dolomite increased Ca to 0.64 and the Mg to 0.28% eight months after application. Where a dolomite source is closer, so cheaper, the figures will be different. See Calcium and Magnesium.

Time of Application

If lime has not been applied for five or more years, or deficiency symptoms are showing, then apply lime as soon as possible at about 3,000 kg/ha, but -

- Not two months before or after applying reactive phosphate or Superphosphate fertilisers, because the former needs acid conditions to be made available and the latter can become like slow release 'Reverted Super'.
- Not on pasture that will be grazed during the three month pre-calving period, because liming increases pasture Ca levels that decrease the efficiency of cows' absorption of Ca, which is a cause of milk fever.
- Not within a month of making silage, because lime can remain on leaves and cause high pH's in the silage, when it should be acid for preservation.
- Not if animals have to graze pastures with lime on leaves, because it can reduce intake and cause scouring.

Surface Liming

To benefit from lime applied on the surface, as opposed to being cultivated in, the lime must be ground extremely finely. When tipped off the truck it should spread out like cement or like an inverted bowl. If it comes in spreader, feel it, and/or tip a 20 litre (4 US gallon) bucket full in a small heap to see. If it sits in a pointed heap it is too coarse - or it could be damp.

One peat client who applied 600 kg of lime /ha pa to the surface on a regular basis, had pastures that showed the benefits of this, in that there were vigorous clovers and grasses with very few bare soil patches, minimum rust on grasses and very little dead pasture on the surface of the soil. There were more earthworms than in adjacent seldom peat farms.

Some farmers, seeing the improvements from applying lime to the surface of peat needing it, are tempted to apply too much. Avoid this and save it for when cultivating.

Excessive surface liming of more than 3,000 kg/ha at a time, or that amount more frequently than

every three years, even in acid peat, can create problems (lower zinc and cobalt, higher molybdenum and lower phosphorus uptake, if the pH gets above about 6.4), and the extra lime is of no advantage.

Two New Zealand scientists wrote in the late 1990's that Ca is not lacking in pumice or Bay of Plenty soils - I presume they based it on the pH levels. Why they wrote this is a mystery, when most New Zealand soils are deficient, and are needing more to replace the increased production/ha of animal products leaving farms, and the recent increased use of artificial N.

Pasture responses to lime on many soils, including peat, pumice, ash and clays in many areas, have been excellent. The lime industry doesn't pay researchers to prove how necessary lime is, and maybe the fertiliser industry pays so much that researchers subconsciously rubbish lime, so that the farmers' discretionary dollars are spent more on fertiliser. Perhaps the lime industry should sue scientists who make statements that are known to be wrong or are easily proved wrong. In Germany farmers have sued their Department of Agriculture after wrong advice was given. Unfortunately, in NZ today more than ever, if there is no money in it, it is not researched, and lime is in this category.

I am not being tough on researchers and so-called scientists, but it is the wrong statements by some that cost peat farmers in particular dearly. Wrong advice cost my wife and me a lot in the mid 50's, until we saw it was wrong, and it is still costing many peat and pumice farmers a lot.

Since 1958 I have been requesting that researchers carry their research right through to the animals and to profits, but it is only in early 2000 that some have done this. The Fieldays started the budget program Economic Farm Surplus (EFS) as a basis for judging the Farms of the Year winners in 1970, but it is only recently (after 25 years) being used by scientists and some consultants, and only after 31 years by Dexcel now DairyNZ. No business person would buy a business without seeing the previous two years finance figures, or survive without budgeting. Download the Free Budget/Profit, Economic Farm Surplus (EFS) and duplicate it to use each year.

For full details on Lime see Elements > Calcium.

Please go to Part 3 after it is added.