



LANDCARE RESEARCH
MANAAKI WĒHENUA

Design of New Zealand's 8-km grid-based plot network

Static master data



Design of New Zealand's 8-km grid-based plot network: Static master data

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1 Introduction

National environmental reporting requires robust and consistent sampling of the New Zealand landscape (Allen et al. 2003). National biodiversity and ecosystem function (carbon) reporting currently utilises an 8-km grid-based plot network encompassing public conservation land and other forest and shrubland (Holdaway et al. 2014). This network was initially established by the Ministry for the Environment for the purpose of carbon monitoring (Land Use and Carbon Analysis System [LUCAS] natural and planted forest plot networks). The grid is currently being measured by the Department of Conservation (MacLeod et al. 2012) and the Ministry for the Environment. Recently, Regional Councils have started planning on ways to extend this plot network across the whole New Zealand landscape, to provide New Zealand with robust and representative data on the state and trend of biodiversity across the entire NZ landscape (MacLeod et al. 2012; Thomson 2015; Bellingham et al. 2016).

The integrity of the national plot network, in terms of ability to report both regionally and nationally at any given time, is dependent on consistency of design and methodology among agencies. A formal national-scale master data plot registry is therefore required to facilitate the expansion, by Regional Councils, of the sample network across New Zealand in a way that preserves the integrity of the national sample. Master data fields can be split into static data (that do not change over time) and dynamic data (that need to be updated over time). The scope of this report is limited to the static master data that form the foundation of the proposed plot registry.

Static master data include the following fields:

1. PlotID (e.g. AA138)
2. Ideal grid-based plot locations (NZMG and NZTM and WGS lat/long)
3. Ideal randomised year of measurement (5-year and 10-year cycle)

PlotID and ideal plot location data for the entire national grid have to date been contained within a table in the LUCAS database administered by the Ministry for the Environment (LUCAS table t500). A separate version has been maintained within an independent database administered by the Department of Conservation. The ideal random year of measurement has been calculated at different stages for different subsets of the sampling universe (e.g. LCDB natural forest and shrubland, planted forest, public conservation land, LUM pre-1990 natural forest, and other privately owned land within the Greater Wellington Region). It is important that existing randomisations are integrated nationally, and remaining plots assigned a random year in a way that preserves the integrity of the national sample. It is also important for this process to be formally documented for future reference and the resulting data and report made available to those engaging with the national grid, e.g. for Regional Councils who are beginning to adopt the national 8-km grid for their biodiversity monitoring programmes (MacLeod et al. 2012; Thomson 2015; Bellingham et al. 2016).

The objectives of this report are to:

- provide a brief overview of the design of the national 8-km grid-based plot network and its intended use for monitoring and reporting
- collate and integrate existing agency-specific versions of the static master data (PlotID, ideal grid-based plot locations, ideal randomised year of measurement)
- determine ideal randomised year of measurement for plots not currently sampled, thereby extending the sample design to cover all of New Zealand's terrestrial landscape
- document the randomisation methods used to determine the ideal 5-year and 10-year measurement cycle
- provide recommendations on how stakeholders should interact operationally with this data

1.1 Overview of the design of the national grid-based plot network

The 8-km national plot grid was originally designed as a system for providing an unbiased estimate of the carbon stored in New Zealand's natural forest and shrubland (Coomes et al. 2002; Payton et al. 2004; MfE 2011). Data from this plot network underpin New Zealand's ability to meet its international greenhouse gas reporting requirements under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, and national environmental reporting (Holdaway et al. 2014; Ministry for the Environment & Statistics New Zealand 2015). The Ministry for the Environment is responsible for this reporting. The grid size (8 km) was determined based on the sample size estimated to be required to estimate national carbon stock in natural forest and shrubland to a certain level of precision (i.e. a 95% probability that carbon stock estimates will be within 5% of the mean (+/- 10 Mg ha) (Payton et al. 2004). Only those points that sampled natural forest and shrubland according to the Land Cover Database 1 (LCDB1) were considered in the original sample design, as at the time this was the sampling area of interest for greenhouse gas reporting purposes. Forest and shrubland plots were randomly allocated a sample year based on a theoretical 5-year cycle with no geographical stratification (Payton et al. 2004). These plots were established and measured by the Ministry for the Environment (MfE) for the first time over the period 2002 – 2007, in a programme known as the Indigenous Carbon Monitoring System (CMS). With revisions of the mapped area of forest and shrubland (e.g. the creation of the LUCAS Land Use Map), new plots have been added to the sample universe. These were also allocated an ideal year of measurement using random sampling.

MfE also extended its use of the 8-km grid to monitor carbon stocks in other forest types. The 8-km grid was further subdivided to produce a 4-km and 1-km grids of sample points for higher intensity sampling of planted forest that was directly scalable to the 8-km grid size. The 4-km sampling grid is used by MfE to monitor carbon stocks in both post-1989 and pre-1990 planted forest (Herries et al. 2013). The 4-km grid was also adopted for post-1989 natural forest by MfE in 2012 (Beets et al. 2014). For planted forests, a random subset (1/5) of the plots mapped as planted forest is measured each year (Nigel Searles, MfE, pers. comm.). For post-1989 natural forest, all plots were measured in a single field season (Beets et al. 2014). Note that for the purpose of this report, the 4-km grid is considered out of the scope as the current focus is on expansion of the 8-km plot network for Regional Councils.

Subsequently, the Department of Conservation has adopted the 8-km grid for its Tier 1 biodiversity monitoring (MacLeod et al. 2012). In doing so they have extended the 8-km plot network to sample all points located on public conservation land (PCL). They adopted the same 5-year measurement cycle as for the Ministry for the Environment's CMS (now known as the LUCAS natural forest plot network). New plots were randomly allocated a measurement year, again with no level of geographic or land use stratification.

Most recently, Regional Councils have started to adopt the national grid as a means of providing nationally integrated data for state of environment reporting (Bellingham et al. 2016); although to date Greater Wellington Regional Council are the only council that has measured any of the plots. Greater Wellington also used random sampling to allocate a sample year to each of the unallocated plots in their region. Auckland Council has also adopted a grid-based biodiversity monitoring programme; however, their current sample design (which involves locating the plots in the bush fragment nearest the grid location) is inconsistent with the design of the national 8-km grid (i.e. to provide an objective sample of the landscape, not determined by current land cover).

With the growing demand for an all of government approach to monitoring, DOC, MfE, Regional councils, and Statistics NZ are working with Landcare Research towards a consistent and nationally complete monitoring network for reporting on biodiversity, state of the environment, and greenhouse gases. For this to be successful, a national approach to the design of the sample grid is needed to ensure that its original design properties (i.e. a representative and non-biased national sample) are retained as the grid is implemented by multiple agencies.

2 Methods

2.1 Data sources

Relevant data were requested from DOC, MfE and Regional Councils on 17 December 2015. Data sets provided by these agencies are detailed in Table 1. These datasets were used for subsequent analyses.

Table 1. Data source files obtained from partner agencies

Organisation	Data file	Data description	Provided by
Greater Wellington Regional Council	Plot registry information.xlsx	Plot ID, easting and northing, randomised year of measurement for GW plots	Philippa Crisp 22/12/15
Department of Conservation	COPY_LUCAS Master Plot list_all year additions and randomisation_15.16 version_DOCDM 1100498.xlsx	Plot ID, easting and northing (for entire 8-km grid), randomised year of measurement for DOC-relevant plots	Meredith McKay 5/01/16
Ministry for the Environment	4-km grid points.xlsx	Plot ID, easting and northing for the entire 8-km and 4-km grid	Daniel Lawrence 18/12/15
Ministry for the Environment	Plot cycle workings 12.8.14.xlsx (“P90 natural forest plot cycle” and “private land plots” worksheets)	Randomised year of measurement for pre-1990 natural forest	Andrea Brandon 27/01/16
Ministry for the Environment	Post-1989 natural forest plot list.xlsx	Plot ID, easting and northing, and actual measurement year for post-1989 natural forest plots	Joanna Buswell 2/03/16
Ministry for the Environment	Planted forest plots.xlsx	Plot ID, easting and northing, randomised year of measurement for planted forest plots	Nigel Searles 12/04/16

2.2 Consolidation of existing static master data

The four static data fields (Plot ID, theoretical easting and northing, and randomised year of measurement) were extracted from the data files described in Table 1, merged, and assessed for inconsistencies. Plots mapped as open water had been previously excluded from the data sets provided.

Plot ID

The DOC & MfE plot lists for the entire 8-km grid were identical, except for a single plot (CM41) that was in the DOC database but not the MfE database. This discrepancy is most

likely due to different base layers being used to determine sample universe (e.g. whether the plot falls on land or in the ocean may vary depending on the base layer used). This plot was located in coastal mangrove forest (according to LCDB4.1), and as land with moderate (soil wetness) limitations for arable use but suitable for cultivated crops, pasture or forestry (according to NZLRI). It was therefore deemed relevant to terrestrial biodiversity monitoring and was included in the master plot list.

Note this master plot list includes plots that have been subsequently abandoned in the field or otherwise deemed unsuitable for sampling. A list of abandoned plots is a dynamic data field and is out of the scope of this report.

Plot Location (easting and northing)

All ideal (grid-based) plot locations matched within acceptable rounding error (i.e. all points <0.5 m, mean rounding error 0.002 m; DOC and MfE databases used different levels of rounding for eastings and northings). Original NZMG locations were used as the definitive grid co-ordinates (ending in 51 and 74). These were assessed for typographical errors (none found), and then converted into NZTM and Lat/Long values using the official LINZ data service (<http://www.linz.govt.nz/data/geodetic-services/coordinate-conversion/online-conversions>), keeping all decimal places provided.

Note that these plot locations relate to the ideal grid-based plot location. Actual plot locations are likely to be different due to uncertainty in the exact location during plot establishment, the replacement of grid-plots with existing NVS plots in some cases (Coomes et al. 2002), and the implementation of plot relocation procedures in cases where the exact location is impossible to measure. Actual plot location is a dynamic data field and is out of the scope of this report.

Random year of measurement

Data were provided either as a nominal year (1–5) or actual calendar year. For MfE natural forest, Department of Conservation, and Greater Wellington data, year 2014 (the 2014/2015 field season) was used as year 1 of the 5-year cycle. The 5-year plot cycle for planted forest is offset (year 1 = 2016) so for this dataset the calendar year was used and this was converted to a nominal year based on a 5-year cycle beginning in 2014. The natural forest cycle was used here for reference as it is most applicable to national biodiversity monitoring. A data table was generated containing the random year of measurement for MfE, DOC and GWRC plot cycles. There were a total of 68 plots where the random year of measurement differed among the datasets provided (Table 2). These were circulated to relevant parties for resolution.

The general approach taken to resolving data disagreements was to adopt the ideal measurement cycle obtained from the party that was most likely to be responsible for measuring each plot. This was done using a rule-based approach coupled with specific plot-level verification of land use and land ownership. Specifically, the following 6 corrections were made to resolve conflicts (Table 2):

1. Where the DOC and MfE natural forest cycles agreed with each other, but differed from the GWRC plot cycle, the DOC/MfE cycle was used. This was due to differences between the ideal year of measurement (MfE and DOC data), and the actual year of measurement (GWRC data). This resolved 6 (9%) of the conflicts.
2. Where the MfE natural forest cycle differed from the GWRC plot schedule by one year, the MfE Natural forest cycle was used. As for (1), this was due to differences between the ideal year of measurement (MfE data), and the actual year of measurement (GWRC data), and resolved two (3%) of the conflicts.
3. Where the DOC and the MfE natural or planted forest cycles differed but the DOC cycle was able to be traced back to the original CMS cycle, the DOC cycle was chosen as it was consistent with the original plot network design. This resolved 10 (15%) of the conflicts.
4. Where the land tenure was confirmed as PCL the DOC measurement cycle was applied. DOC has priority in setting the measurement cycle for all plots within public conservation land. This resolved a further 27 (40%) of the conflicts.
5. Where the DOC cycle was different to the MfE planted forest cycle and the land tenure was confirmed as private land (outside of DOC's sample universe), the planted forest cycle was adopted. This resolved 14 (20%) of the conflicts.
6. Where the Greater Wellington cycle was different to the MfE planted forest cycle, the Greater Wellington cycle was adopted. Differences in methodology between planted and natural forest mean that for biodiversity reporting purposes the Greater Wellington cycle takes precedence. Also, altering the Greater Wellington cycle mid-way through implementation was potentially problematical. This resolved 9 (13%) of the conflicts.

Table 2. Identified disagreements in randomised year of measurement* and steps taken to resolve them

PlotID	DOC database	GWRC database	MfE(n) - natural forest database	MfE(p) - planted forest database	Database adopted to resolve conflict [#]	Reason / comments
AC139	Year 1	-	Year 2	-	DOC	Plot on public conservation land
AC164	Year 2	-	Year 3	-	DOC	Plot on public conservation land
AD137	Year 5	-	Year 2	-	DOC	Plot on public conservation land
AF156	Year 3	-	-	Year 1	DOC	DOC year was original from CMS
AK132	Year 2	-	Year 3	-	DOC	Plot on public conservation land
AV139	Year 2	-	-	Year 3	MfE(p)	Planted forest, not PCL
AY115	Year 2	-	Year 4	-	DOC	Plot on public conservation land
BB118	Year 4	-	-	Year 3	MfE(p)	Planted forest, not PCL
BB129	Year 4	-	Year 5	-	DOC	Plot on public conservation land
BG117	Year 4	-	Year 5	-	DOC	Plot on public conservation land
BH113	Year 3	-	Year 1	-	DOC	Plot on public conservation land
BM6	Year 2	-	Year 3	-	DOC	Plot on public conservation land

PlotID	DOC database	GWRC database	MfE(n) - natural forest database	MfE(p) - planted forest database	Database adopted to resolve conflict [#]	Reason / comments
BQ107	Year 5	-	Year 1	-	DOC	Plot on public conservation land
BQ110	Year 1	-	-	Year 5	DOC	Plot on public conservation land
BQ117	Year 3	-	Year 5	-	DOC	Plot on public conservation land
BR14	Year 2	-	Year 3	-	DOC	DOC year was original from CMS
BR18	Year 2	-	Year 3	-	DOC	DOC year was original from CMS
BS17	Year 2	-	Year 3	-	DOC	DOC year was original from CMS
BS19	Year 2	-	Year 3	-	DOC	Plot on public conservation land
BT119	Year 3	-	-	Year 5	DOC	DOC year was original from CMS
BU16	Year 2	-	Year 3	-	DOC	DOC year was original from CMS
BU22	Year 2	-	Year 3	-	DOC	Plot on public conservation land
BY99	Year 2	-	-	Year 4	MfE(p)	Planted forest, not PCL
BZ99	Year 2	-	-	Year 3	MfE(p)	Planted forest, not PCL
CB24	Year 2	-	Year 3	-	DOC	Plot on public conservation land
CB31	Year 4	-	-	Year 3	MfE(p)	Planted forest, not PCL
CD26	Year 2	-	Year 3	-	DOC	DOC year was original from CMS
CG40	Year 2	-	Year 3	-	DOC	DOC year was original from CMS
CK36	Year 2	-	Year 3	-	DOC	Plot on public conservation land
CK96	-	Year 1	-	Year 4	GW	GW measurement most relevant
CL95	-	Year 4	-	Year 3	GW	GW measurement most relevant
CL98	Year 1	Year 2	Year 1	-	DOC/MfE(n)	Interpretation of ideal vs actual year
CM103	-	Year 2	Year 3	-	MfE	Interpretation of ideal vs actual year
CM46	Year 5	-	Year 2	-	DOC	Plot on public conservation land
CM97	Year 1	Year 2	Year 1	-	DOC/MfE(n)	Interpretation of ideal vs actual year
CM98	Year 1	Year 2	Year 1	-	DOC/MfE(n)	Interpretation of ideal vs actual year
CN40	Year 2	-	Year 3	-	DOC	DOC year was original from CMS
CN97	Year 1	Year 2	Year 1	-	DOC/MfE(n)	Interpretation of ideal vs actual year
CO103	Year 3	-	-	Year 5	MfE(p)	Planted forest, not PCL
CO104	-	Year 4	Year 5	-	MfE	Interpretation of ideal vs actual year
CP96	Year 1	Year 2	Year 1	-	DOC/MfE(n)	Interpretation of ideal vs actual year
CQ101	-	Year 5	-	Year 1	GW	GW measurement most relevant
CQ31	Year 2	-	Year 3	-	DOC	Plot on public conservation land
CS101	Year 1	Year 2	Year 1	-	DOC/MfE(n)	Interpretation of ideal vs actual year
CT97	-	Year 2	-	Year 5	GW	GW measurement most relevant
CT98	-	Year 2	-	Year 1	GW	GW measurement most relevant
CU34	Year 1	-	Year 4	-	DOC	Plot on public conservation land

PlotID	DOC database	GWRC database	MfE(n) - natural forest database	MfE(p) - planted forest database	Database adopted to resolve conflict [#]	Reason / comments
CU97	-	Year 3	-	Year 4	GW	GW measurement most relevant
CU98	-	Year 3	-	Year 5	GW	GW measurement most relevant
CW54	Year 5	-	-	Year 4	MfE(p)	Planted forest, not PCL
CW96	-	Year 1	-	Year 3	GW	GW measurement most relevant
CX53	Year 3	-	-	Year 5	DOC	Plot on public conservation land
CX56	Year 4	-	-	Year 2	MfE(p)	Planted forest, not PCL
CX89	Year 1	-	-	Year 2	MfE(p)	Planted forest, not PCL
CX93	-	Year 3	-	Year 4	GW	GW measurement most relevant
CZ55	Year 3	-	-	Year 5	DOC	DOC year was original from CMS
DC59	Year 5	-	-	Year 3	MfE(p)	Planted forest, not PCL
DC60	Year 2	-	-	Year 4	DOC	Plot on public conservation land
DE64	Year 5	-	Year 5	Year 1	DOC/MfE(n)	Plot on public conservation land
DM68	Year 3	-	-	Year 4	MfE(p)	Planted forest, not PCL
DS62	Year 4	-	-	Year 5	MfE(p)	Planted forest, not PCL
G171	Year 2	-	Year 3	-	DOC	Plot on public conservation land
I168	Year 1	-	Year 3	-	DOC	Plot on public conservation land
I169	Year 3	-	Year 4	-	DOC	Plot on public conservation land
L154	Year 5	-	Year 4	-	DOC	Plot on public conservation land
O161	Year 2	-	Year 1	-	DOC	Plot on public conservation land
R157	Year 3	-	-	Year 4	MfE(p)	Planted forest, not PCL
U167	Year 5	-	-	Year 3	MfE(p)	Planted forest, not PCL

Notes:

[#] The database value adopted for the theoretical measurement cycle of the national 8-km grid. The ideal measurement cycle is independent of the organisation responsible for the measurement of any particular plot (both currently and in the future).

* Randomised year of measurement (1-5) for a 5 year measurement cycle. Current cycle year 1 = 2014/2015 field season, year 2 = 2015/2016 field season, year 3 = 2016/2017 field season, year 4 = 2017/2018 field season and year 5 = 2018/2019 field season.

2.3 Randomisation of unallocated plots

To date, all methods used to allocate an ideal year of measurement to plots within the 8-km national grid were based on a random sample of candidate plots across the 5-year measurement cycle, with no stratification to guarantee an even number of plots or certain level of geographic spread each year (Payton et al. 2004). This approach is statistically sound, particularly for large sample sizes, but can result in a randomly uneven spread of plots across years. This creates a potential operational issue for Regional Councils who have a restricted budget for each year and limited flexibility between years. A practical constraint

was therefore employed to randomise unallocated plots to ensure variation in the number of plots among years within each region was constrained to within $\pm 5\%$ of the mean. This was done within each region using a four stage randomisation procedure for all unallocated plots:

1. The pool of unallocated plots within each region was identified
2. Each plot from that pool was randomly assigned a measurement year (1–5)
3. If the total number of previously unallocated plots assigned to that year was greater than the maximum threshold (maximum = average*1.05) that year was rejected and another year randomly assigned
4. Once all plots were allocated a random year, years in which the total number of plots was below the minimum threshold (minimum = average*0.95) were identified. Additional plots were sampled at random from the pool of plots in all other years and moved to the target year until the minimum threshold was met.

Regional boundaries were based on the New Zealand 2016 12-mile high-definition spatial layer, downloaded from Statistics New Zealand on 14 April 2016.

http://www.stats.govt.nz/browse_for_stats/Maps_and_geography/Geographic_areas/digital-boundary-files.aspx

The above randomisation procedure was completely independent of plot land use, location within regions, or vegetation type, and is done in a way that is consistent with previously allocated plots (i.e. is totally random). It therefore preserves the ability to report state and trend based on a representative random sample at both regional and national scales within any particular year.

The 10-year measurement cycle was derived from the complete 5-year cycle as follows:

1. The existing 10-year measurement cycle data were used for MfE private land plots, except for four Northland/Auckland plots (BR14, BR18, BS17, BU16, CD26, CG40 and CN40). The 5-year measurement cycle data for these four plots differed between DOC and MfE (Table 2), and these differences had been propagated into the MfE 10-year measurement cycle. For those four plots, the 10-year cycle was calculated based on the resolved 5-year (DOC) cycle following the approach described in (2) below.
2. For remaining plots, each year of the 5-year cycle was randomly split into 2 years. This was done so that year 1 in the 5-year cycle = years 1 and 2 of the 10-year cycle, and so on sequentially until year 5 of the 5-year cycle = years 9 and 10 of the 10-year cycle.

An alternative method for generating a 10 year cycle from the 5year cycle was considered. This alternative method involved year 1 from the 5 year cycle being split in half and one half being assigned year 1 and the other half year 6 of the 10 year cycle, and so on. Both this approach, and the one adopted here, generated a 10 year cycle in which a statistically non-biased representative sample (10%) of plots is measured nationally each year, and both are equally valid statistically.

The only difference in the approaches is in the realised measurement interval during the transition phase. The model employed by MfE and adopted here results in the plots being split evenly across measurement intervals of 5,6,7,8,9 and 10 years, with the transition from 5 to 10 year period happening gradually over the first measurement round. The alternative approach has half the plots being measured on a 5 year cycle, and half on a 10 year cycle for the first 'transitioning' measurement round. This difference would not affect the subsequent statistical analyses in any way, as variation in measurement interval is easily accounted for as standard practice.

As both approaches are equally valid, the method for generating the 10 year measurement cycle that had previously been employed by MfE for natural forest on private land was adopted here for consistency.

3 Results

The 8-km national grid contains 4179 potential plots. In total, 2254 plots (54%) had been allocated a theoretical measurement year by MfE, DOC or GWRC. The remainder were allocated a random year according to methods described above. The unique plot identification code, theoretical (grid-based) location, and randomised year of measurement (5-year and 10-year cycles) for all 4179 plots are provided in Appendix 1. The spread of plots by year is given in Table 3, by region in table 4, and summarised geographically in Figure 1. The ideal location of the plots can be visualised using the appended graphical widget (Appendix 2; plot_location_widget_v6.html). The number of previously unallocated plots varied considerably by region, reflecting variation in regional land area and land cover and the level of existing monitoring in each region (Table 5).

Table 3. Summary of plots by ideal randomised year of measurement

Cycle year	Calendar year	Number of plots [#]
1	2014	826
2	2015	835
3	2016	848
4	2017	835
5	2018	835

Note:

[#] These values are for the ideal randomised measurement year. The actual number of plots in each measurement year is likely to differ for a number of reasons (e.g. logistical, access and budget considerations).

Table 4. Total number[#] of plots by region and ideal randomised year of measurement

Region*	Year 1 (2014)	Year 2 (2015)	Year 3 (2016)	Year 4 (2017)	Year 5 (2018)	Total
Auckland	14	19	16	12	15	76
Bay of Plenty	40	33	45	39	41	198
Canterbury	136	140	132	161	142	711
Gisborne	27	27	28	24	24	130
Hawke's Bay	42	41	43	44	48	218
Manawatū-Whanganui	69	66	70	78	66	349
Marlborough	31	27	36	29	35	158
Nelson	2	0	3	1	1	7
Northland	39	41	42	37	43	202
Otago	88	106	113	92	98	497
Southland	104	108	98	106	79	495
Taranaki	22	26	24	23	20	115

Tasman	34	33	24	30	33	154
Waikato	74	84	75	69	83	385
Wellington	28	22	27	21	29	127
West Coast	76	62	72	69	78	357

Notes:

Total number of plots includes plots currently measured (or scheduled to be measured) by MfE and DOC as well as currently non-established/unallocated plots, and is based on theoretical grid location. The actual location of some plots may differ from their theoretical grid location and result in changes to the numbers presented here.

* Regional boundaries based on the New Zealand 2016 12-mile high-definition spatial layer, downloaded from Statistics New Zealand on 14 April 2016.

Table 5. Number of previously unallocated[#] plots by region and ideal randomised year of measurement

Region*	Year 1 (2014)	Year 2 (2015)	Year 3 (2016)	Year 4 (2017)	Year 5 (2018)	Total
Auckland	9	9	9	10	10	47
Bay of Plenty	10	9	10	10	8	47
Canterbury	91	87	86	90	77	431
Gisborne	12	13	12	13	13	63
Hawke's Bay	23	25	25	24	26	123
Manawatū-Whanganui	45	43	45	47	46	226
Marlborough	10	11	11	11	10	53
Nelson	1	0	0	0	0	1
Northland	18	20	19	18	20	95
Otago	67	67	73	66	73	346
Southland	34	34	31	34	30	163
Taranaki	14	14	14	14	11	67
Tasman	4	4	4	4	4	20
Waikato	43	46	45	47	44	225
Wellington	0	0	0	0	0	0
West Coast	3	3	4	4	4	18

Notes:

Numbers approximate the number of plots each Regional Council (except Greater Wellington) would be required to measure to complete the national 8-km grid. Exact plot numbers for Regional Councils are likely to be different as not all plots with a previously allocated ideal year of measurement are likely to be measured by other parties, and not all methods are employed at all previously allocated plots.

* Regional boundaries based on the New Zealand 2016 12-mile high-definition spatial layer, downloaded from Statistics New Zealand on 14 April 2016.

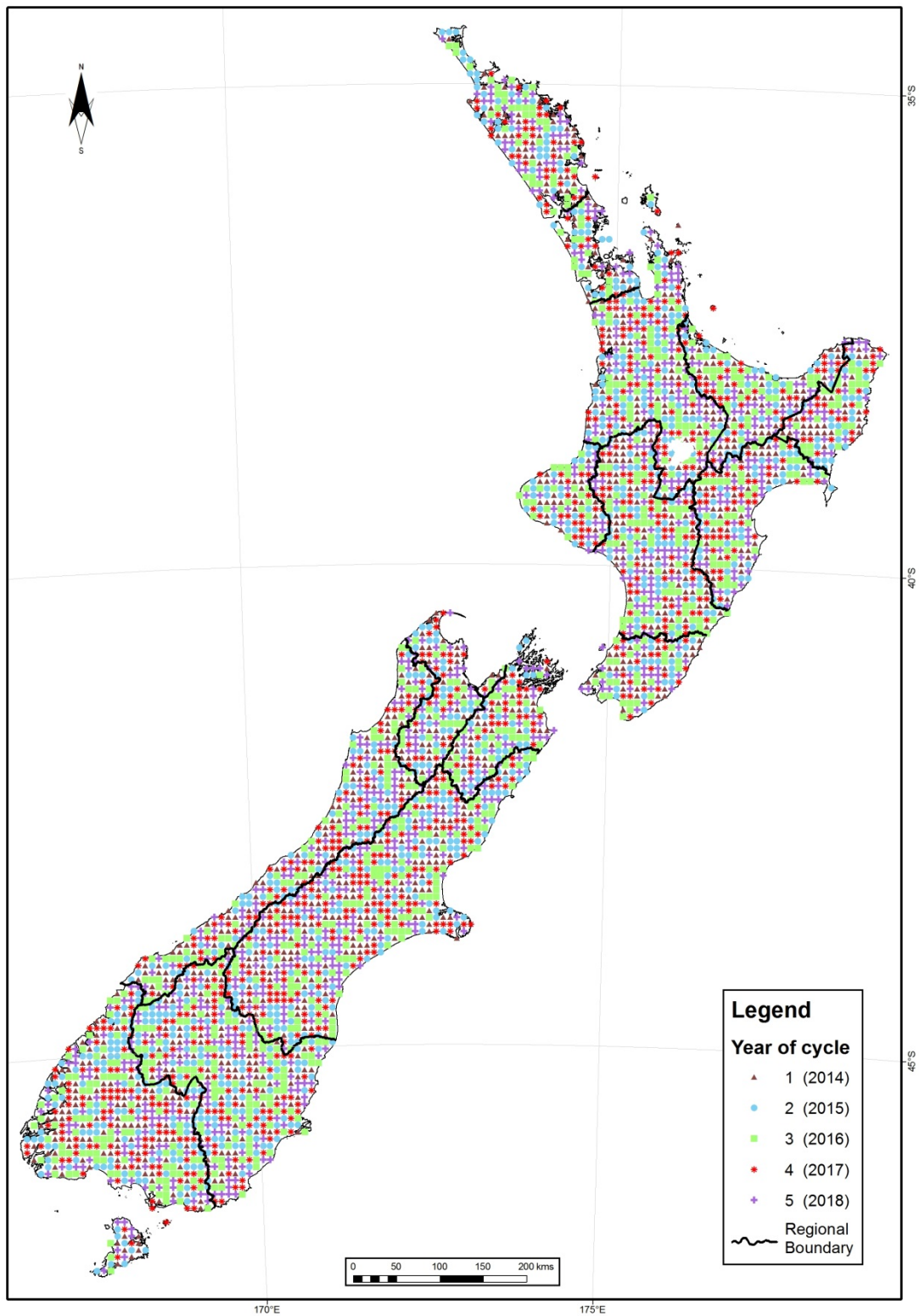


Figure 1. Map of New Zealand showing geographical distribution of the 8-km grid plots and their randomised year of measurement.

4 Discussion

This report documents a nationally integrated and geographically complete version of the static master data (plot ID, grid location, and ideal randomised year of measurement) for the national 8-km plot network. These data provide users (Regional Councils, DOC, MfE) with a nationally representative sampling design, resolving existing organisational-based data conflicts. Use of this national design will prevent the occurrence of future design conflicts as more plots are measured by Regional Councils. The static master data also form the basis of developing a more detailed plot registry that contains dynamic information such as actual measurement year, actual plot location, measurement organisation, and methods employed.

It is important to note the difference between ideal year of measurement and actual year of measurement. Confusion between these two data fields was evident in the existing database conflicts (Table 1). While the ideal year of measurement should be adopted where possible, some plots will be (and have been) measured outside of this period due to issues such as budget management, inclement weather, and delays in obtaining access. This does not compromise the validity of the sample design as long as such plots are selected at random from the pool of potential plots to be dropped/picked up without consideration of the land use, location or vegetation type. Actual measurement year is a dynamic data field and is out of the scope of this report.

Actual plot location may also differ from the grid-based ideal location. This could be due to random geolocation noise when initially locating and re-locating the plots (typically ± 20 m), plots that were shifted to another random location within the nearby landscape (± 200 , 400 or 600 m, Department of Conservation 2013), or points that were replaced with nearby NVS plots (± 4000 m, Payton et al. 2004). Shifting new plots from the grid-location to other locations should be avoided wherever possible to preserve the integrity of the random sample design and avoid the introduction of sample bias.

4.1 Scenarios for applying the static master data

Regional Councils

- Data on the number and location of plots within each region can be used as an initial planning guide for the development of regional monitoring strategies. Note that detailed planning requires further information on actual plot location and actual measurement history (including methods used) for each plot
- Data on the ideal random year of measurement detail which plots should be measured in any specific field season.

Department of Conservation

- As boundaries of PCL change, the static master data should be used to assign plots previously located outside PCL with a random measurement year. If those plots had previously been part of a Regional Council sample, the allocated ideal measurement year will be consistent between DOC and the Regional Council

- If there is a shift to a 10-year measurement cycle for selected aspects of the Tier 1 programme, the 10-year cycle data presented here should be adopted.

Ministry for the Environment

- The existing LUCAS database should be updated to incorporate the static master data presented here. Maintain and make available details of the national 8-km plot network to key stakeholders (e.g. Regional Councils)
- When the LUCAS sample universe changes (e.g. new areas mapped as forest and shrubland), the static master data should be used to assign plots previously located outside the LUCAS sample universe an ideal random year of measurement. If those plots had previously been part of a Regional Council or DOC sample, the allocated ideal measurement year will be consistent across all parties
- The 5-year (or 10-year) cycle should be considered for post-1989 natural forest, rather than measuring all plots within a single field season, to allow non-biased inter-cycle reporting by multiple agencies.

4.2 Recommendations for future work

- The next stage of this research should seek to develop and implement ways to incorporate dynamic data fields and links to data repositories and data providers. This will ultimately create a rich national data resource for use in environmental reporting at both regional and national scales.
- Dynamic data fields to consider include: whether it has been established or not to date; actual plot location; measurement history (by whom and when); methods employed; and links to the associated data.
- Suitable mechanisms (e.g. web-based tools) should be developed to allow stakeholders to regularly update the dynamic data fields, and to explore the data resource.

5 References

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Appendix 1 – Data file ([Appendix_1_static_master_data_July2016.xlsx](#))

Containing static master data for both 5- and 10-year measurement cycles for all 4179 plots from the 8km grid.

**Appendix 2 – Plot visualisation widget
([Appendix_2_plot_location_widget_July2016.html](#))**

For exploring theoretical plot locations and measurement cycles.