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Appraisal and Analysis of Available Data Regarding Distribution and Incidence of Armillaria Root Disease in the Nelson Forest Region

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Executive Summary

The Armillaria root disease (DRA) problem analysis of the Armillaria Research Working Group was initiated because of perceived significant tree mortality in southern British Columbia. One of the first objectives of the problem analysis was to determine the distribution and incidence of DRA in Nelson Forest Region. This report attempts to determine the state of DRA by statistically analysing existing data. To supplement the analysis, a review and comparison of other documents was conducted.

The initial step in the study was to compile and appraise three sets of data for their characteristics and usefulness. Unfortunately, the Comprehensive Pest Inventory data set was dropped from the study because it was not appropriate for statistical analysis. The ISIS (Integrated Silviculture Information System) data set was the most useful but was found to be non-random, inconsistent, and had important real (not derived) data missing. The pixel survey was subject to similar constraints. The pixel survey data was less comprehensive than ISIS, in both the type of information and the geographic extent, and was subsequently used on a more general level.

During the data analysis, ISIS and pixel survey data sets were found to have large standard errors. The pixel survey data had incomplete records which excluded the data set from analysis for certain parameters. The results of the analyses are presented in forty graphs indicating the mean and median percent incidence of DRA by biogeoclimatic zone and subzone, inventory (or growth) type group, tree density, and tree age.

Some general interpretations of the results have been generated while keeping in mind the inherent problems in each data set. An average incidence of DRA of 24.5% was found in 20.5% of the survey area (or 19.2% of the surveys) in ISIS. An average incidence of DRA of 13.85% was found in 49% of the survey area (or 46.5% of the surveys) in the pixel survey data. DRA was found in all of the biogeoclimatic zones and subzones surveyed.

As a result of the problems encountered during the data appraisal and analyses, numerous important recommendations were made for future forest health data collection and storage. The main requirements for the data sets are to record real data instead of derived data, and for the random, proportional selection of surveys.

The results of this report will be interpreted by a statistician in the near future, however, this is expected to be limited due to the problems identified with the data sets. Therefore, a major finding of this report is that the available data does not allow for sound statistical analysis or projections. The quality of the future interpretation of the results presented in this report may attest to these deficiencies. Any Forest Region analysing data from the sources used in this report may encounter the same problems. Any reliable interpretations derived from the results of this report may be useful in determining treatments and for designing Forest Renewal British Columbia proposals.

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Shirley Turcotte, Secretary, Forest Health Section, assisted in editing.

Ken White and Adriane Pollard, hired as auxiliary staff by Forest Renewal B.C. funding, performed the analyses and evaluations.

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1.0 Introduction

The terms of reference for the Armillaria problem analysis were determined on May 25, 1994, by the Armillaria problem analysis subcommittee of the Armillaria Research Working Group (ARWG). One objective was to "identify the distribution and intensity of Armillaria at the stand and landscape level and its impacts on forest growth and mortality (AAC) in southern British Columbia" which was assigned to J. Beale. The objective was further divided into phases of assessment, the first of which was "What is the distribution and incidence (occurrence) of Armillaria root disease across the biogeoclimatic and forest cover landscape?". At this stage, the question was limited to Comprehensive Pest Inventory and pixel survey data for the Nelson Forest Region. It is the first phase of the problem analysis that is the subject of this report.

A number of species of *Armillaria* fungi occur throughout the world. Most of these act as secondary pathogens in deciduous forests. However, *Armillaria ostoyae* (Romagn.) Herink, the causal agent of Armillaria root disease (DRA), is a primary root pathogen of coniferous trees. This disease reduces timber productivity and causes tree mortality over a large area of southern British Columbia (Morrison *et al.*, 1991).

The purpose of this study was to summarize available data on the distribution and incidence of DRA in the Nelson Forest Region and to statistically analyse recent data where appropriate. A review and comparison of documents mainly from the Nelson Forest Region was compiled to compare this analysis to others.

Three data sets were compiled and appraised: Integrated Silviculture Information System (ISIS), Comprehensive Pest Inventory (CPI), and regional pixel surveys. Each data set was unique in characteristics and varied in usefulness.

The analysis produced forty graphs indicating the mean and median percent incidence of DRA using ISIS and pixel survey data. DRA incidence was based on above-ground symptoms of Armillaria root disease. The parameters for analysis were biogeoclimatic zones and subzones, Inventory (or Growth) Type Groups (ITGs, GTGs), tree density (total stems per hectare), and average age. During the analysis, many problems were encountered with the data sets.

As a result of the problems met during the data appraisal and analysis, an emphasis is placed on the recommendations made for future data collection and storage.

The results of this report will be interpreted by a statistician in the near future, therefore, interpretation of the results was limited in this report.

2.0 Appraisal of Data Sets

Three data sets that were available to compile information about Armillaria root disease (DRA) incidence and distribution in the Nelson Forest Region included:
1) Integrated Silviculture Information System (ISIS), 2) Comprehensive Pest Inventory (CPI), and 3) pixel survey data collected by contractors and forest health staff (hereafter referred to as pixel survey data). Some duplication of records occurred between ISIS and the pixel survey data, primarily in the Arrow District, where 73 of the pixel surveys were also found in ISIS. Some of the important criteria of the three data sets are compared in Table 1.

The data sets were chosen for several reasons. First, they were assumed to contain accurate DRA incidence information. The latest records in the data sets were chosen in order to include the increased accuracy in detection of DRA in the last five years. Secondly, the data sets covered a wide variety of Biogeoclimatic Ecological Classification (BEC) units, as well as forest cover groups. Finally, the data sets contained different aged stands covering a large geographic area. Each data set was believed to contribute to the overall picture of DRA incidence in the Nelson Forest Region and were appraised in the following sections.

2.1 Integrated Silviculture Information System

The Integrated Silviculture Information System (ISIS), as its name states, is primarily a silvicultural database. ISIS allows entry and updating of Silviculture Prescriptions, and the recording of treatments to Activity Treatment Units (ATUs). Records in ISIS are entered for all new openings. These openings occur through fire or, more commonly, logging of the area. This means that nearly all of the records in ISIS are of immature stands. This had to be taken into consideration when ISIS data were examined.

ISIS contains forest health observations, but these are not a primary concern of most ISIS users. Currently, there are problems with the forest health data in ISIS, primarily because of inconsistencies in recording pest incidence (in percent) and incidence area. Most of the data recorded for forest health in ISIS is not real data, but is a summary of survey information. A typical forest health observation screen in ISIS is shown in Appendix A. This particular forest health observation screen lists a pest incidence percentage, but no corresponding incidence area. The incidence area is normally recorded by multiplying the pest incidence by the total area of the opening. This calculation does not take into account the variation of DRA occurrence within an opening.

The forest health portion of the new silviculture survey forms allows the entry of detailed information on pest incidence. The new FS 759 forms allow determination of pest incidence down to the host tree level. When the corresponding changes are made to ISIS, it will greatly increase the accuracy and usefulness of the information which can be retrieved. Unfortunately, this information will only be of use in future work, and was not available for the current analysis.

Table 1: Data Sets Considered for use in Armillaria Root Disease Problem Analysis

Data Set	Dates of surveys of interest in analysis	Number of unique records[1]	Survey method	DRA Suspect	Districts surveyed in Nelson Forest Region	Current status of data set	Tree age in survey area	Unit area
Integrated Silviculture Information System (ISIS)	1990-1994	369-12,843 (depending on information required)	Line, plot and pixel	No	All	In use	Immature	Opening
Comprehensive Pest Inventory (CPI)	1987-1992	3462	Plot	Yes	All	Incorporated into Forest Level Multi Pest Survey	Mature	Forest cover polygon
Pixelsurveys	1988-1994 (most records are from 1992 to 1994)	344	Pixel	Yes	Cranbrook, Invermere, and Arrow	Continuing as a part of forest health surveys, or free growing surveys	Mature and immature	Opening or forest cover polygon

[1]Total records in data set minus overlap with other data sets

2.2 Comprehensive Pest Inventory

The Comprehensive Pest Inventory (CPI) data set records pest incidence within forest cover polygons. It was intended as a way of storing pest information, which could then be used in conjunction with the corresponding Inventory Branch data to supply operational data to forest health managers. However, it was never designed to be used for projection of losses due to DRA over large areas.

One advantage of the CPI data set is that it included polygons with trees of older age classes than those found in the ISIS data set. Specific criteria used to select the polygons to be surveyed were listed in the Ministry of Forests report *Augmenting the AAC Through Pest Treatment* (Mackenzie, 1991). These criteria were based on previous experience with DRA in the Nelson Forest Region, as outlined in the report mentioned above. The contractors involved in the collection of the data for CPI were supposed to survey 10% non-suspect polygons in addition to the suspect polygons. Apparently, less than a dozen non-suspect polygons were surveyed (Don Norris, pers. comm.). These shortcomings produced a highly biased data set.

A second serious problem frequently encountered in the CPI data set was incomplete data. This is due to the inclusion of records which were not originally designed for entry into the CPI database. These included surveys completed before the CPI database was set up and incidence reports gathered on a casual basis. Though there was always a pest recorded, there was often no corresponding pest incidence, BEC information, tree species, etc. This lack of information limited the use of the CPI data set in correlating pest incidence to BEC unit, Inventory Type Group, or other parameters. Of the total CPI data set, less than 10 percent contained complete records. Unfortunately, this large amount of missing data rendered this data set of no use for our analysis.

2.3 Pixel Surveys

Information in the pixel survey data set was important because, like the CPI data set, it contained stands of various ages. However, pixel survey sites were not chosen randomly, but were picked because they were believed to contain DRA. These suspect polygons were then surveyed to establish levels of DRA with greater accuracy. One problem with these surveys was that the information was limited to three forest districts: Arrow, Cranbrook, and Invermere. There was some overlap with ISIS information, especially in Arrow Forest District, but this overlap was eliminated in the analysis. There were also many data which were not recorded, but which were required for our analysis. This was probably due to the lack of a standard data sheet for the recording of this survey information. Therefore, each district's data were in a slightly different form. This meant that considerable manipulation of the data was required to standardize the format for analysis.

2.4 Problems Common to All Data Sets

One primary concern which emerged from the examination of all three data sets was the inability to accurately determine the incidence of DRA. The reason behind this inability lies partly with the survey methods used. The ISIS data set contains surveys of three types (see Table 1). If a line survey was used, actual tree numbers were preserved in the percent pest incidence. If a pixel survey was used, actual tree numbers were obliterated, and only the presence or absence of disease was recorded. The procedure of determining pest incidence area in ISIS by multiplying the percent pest incidence by the area of the survey obscured any spatial information gathered by the field observer. This was the main reason why we chose to use incidence percentage as a measure of the intensity of DRA, rather than incidence area.

One variable that was originally planned for inclusion in the data analysis was the silviculture treatment of an area. While the treatment was not recorded in either CPI or pixel survey data, there was a lot of detailed information recorded in the ATU schedule screen of ISIS. One problem with these data is that for each opening, there can be many ATUs, and it is difficult to discern how the ATU relates spatially to the polygons within the opening. This would require going back to the maps on which the openings were marked, and this information is not directly available through ISIS. A second problem with these data were the timing of the treatments in comparison to the surveys which recorded pest incidence. In order to draw any conclusions between treatment and DRA incidence, it would be necessary to go through all the records for each opening under consideration, and only look at ATUs where the survey occurred after the treatment. This action was considered impossible, primarily due to time constraints. It was also likely that the number of ATUs where all the above requirements could be met would be very low.

A problem which has been brought up in a previous report (MacKenzie, 1991) is the lack of proportional representation of the different biogeoclimatic subzones in root rot surveys. As can be seen in Table 2, there is a large disparity between the proportional area of some biogeoclimatic subzones and the proportion of these subzones sampled in both ISIS and pixel survey data. The same problem can be seen with the proportion of ITGs surveyed (Table 3).

There was no information in any of the data sets as to which tree species within the given sample area shows symptoms of the disease. This may help explain some of the seemingly incongruous data. For example, ISIS data showed a high mean percent incidence of DRA in stands with over 80% ponderosa pine forest cover. These data seem strange, as ponderosa pine is considered to be one of the least susceptible conifers to DRA. This might be explained if the remaining 20% of the survey area was Douglas-fir with all stems showing DRA symptoms. Depending on the type of survey, these Douglas-fir could account for the high incidence recorded for that area.

Table 2: The Proportion of Biogeoclimatic Subzones in the Nelson Forest Region (RNE) in Comparison to the Proportion in ISIS and Pixel Survey Data.

BEC unit	Percentage of total area in RNE (from Inventory Branch)[1]	Percentage of total area of pixel surveys	Percentage of total area of ISIS surveys (1990-1994)
ESSFdc	0.00	0.00	0.45
ESSFdk	19.91	25.18	16.80
ESSFvc	4.87	0.00	0.61
ESSFwc	10.62	0.07	6.59
ESSFwm	11.47	2.75	5.29
ESSFwk	0.00	0.00	0.03
ICHdw	4.32	0.00	2.83
ICHmk	1.57	3.23	7.06
ICHmw	15.02	25.63	23.01
ICHvk	1.89	0.00	0.60
ICHwk	4.47	0.00	1.85
ICHxw	0.35	0.00	0.02
IDFdm	5.16	10.35	11.78
MSdk	7.38	32.8	20.69
MSdm	0.00	0.00	0.92
PPdh	1.44	0.00	1.45

[1]This proportion is based on total area of Crown land (Crown 62), all age and site classes.

Table 3: The Proportion of each ITG in the Nelson Forest Region (RNE) in Comparison to the Proportion in ISIS and Pixel Survey Data.

ITG	Percentage of total area in RNE (from Inventory Branch)[1]	Percentage of total area of pixel surveys	Percentage of total area of ISIS surveys (1990-1994)
1	5.62	0.37	4.57
2	0.60	0.36	1.11
3	0.86	0.15	1.25
4	1.66	0.94	2.51
5	3.83	8.75	5.22
6	0.92	6.66	2.05
7	5.54	1.17	2.71
8	0.75	0.06	2.41
9	0.48	0.00	0.10
10	0.23	0.00	0.61
11	2.27	0.00	1.94
12	1.43	0.00	0.04
13	0.51	0.00	0.45
14	2.73	1.81	1.91
15	0.51	1.89	0.29
16	0.72	0.00	0.21
17	0.03	0.00	0.02
18	3.42	6.72	1.05
19	0.40	0.00	0.62
20	8.65	13.92	11.64
21	2.59	1.05	3.05
22	1.18	2.52	2.82
23	1.15	0.32	2.06
24	10.16	5.41	6.40
25	1.35	6.22	2.46
26	0.18	0.00	1.09
27	1.02	0.00	0.33
28	14.54	7.87	11.29
29	9.13	17.40	9.27
30	4.43	1.26	8.84
31	0.70	3.19	2.62
32	0.70	1.92	0.74
33	3.36	1.24	0.89
34	6.09	3.21	2.99
35	0.10	0.00	0.10
36	0.08	0.00	0.02
37	0.00	0.00	0.00
38	0.00	0.00	0.00
39	0.00	0.00	0.00
40	0.45	0.00	0.97
41	0.87	3.29	2.83
42	0.76	3.29	0.52

[1]This proportion is based on total area of Crown land (Crown 62), all age and site classes.

3.0 Methods

3.1 Creation of Databases

When this analysis was initiated, the problems associated with the different data sets were not known. This meant that all possible information from these data sets was considered in the hope that it could be used.

ISIS was the largest data set, so it was necessary to reduce the amount of information available to a reasonable size. The most recent data were used, to increase the chance that DRA had been correctly identified. The procedure for getting the required information from ISIS was developed in consultation with several people.

The fields of information desired for the analysis were originally decided upon by Jeff Beale and Rob Scagel. These fields were further clarified, and Mei Ching Tsoi, Silviculture Information Analyst, extracted the information required, and produced Microsoft Access® databases using this information. The two different databases that we received consisted of openings with DRA, and openings without DRA. The DRA database was restricted to openings listed after 1990, while the non-DRA database contained records from all openings. The non-DRA database was required for the calculation of the proportion of openings affected by DRA, as well as the proportion of biogeoclimatic subzones and ITGs surveyed. A complete listing of the tables and fields available in these ISIS databases is presented in Appendix B.

The pixel survey data were gathered by contractors and district forest health staff in three districts of the Nelson Forest Region: Arrow, Cranbrook, and Invermere. District staff were given an outline of the information that would be required for the data analysis, and were asked to compile their pixel survey data into a Microsoft Excel® spreadsheet. Unfortunately, no standard form was prescribed, and each district produced a slightly different spreadsheet. The information contained in these three spreadsheets was compiled into a single Microsoft Access® database. This was a tedious process which involved cutting and pasting portions of the Microsoft Excel® spreadsheets into Microsoft Access®, as well as trying to fill in as many of the blank fields as possible. This often required examining the original opening information in ISIS, and extracting any pertinent information.

The next step was the addition of Inventory Type Group (ITG) codes to the various databases, except for Cranbrook's pixel survey data. ITGs are groupings of similar forest cover types, according to the leading species found in inventory surveys. All data were sorted by tree species and percent cover of these species, and an ITG was assigned according to the formula outlined in the *Relational Data Dictionary 2.0* obtained from Inventory Branch. If there was only one tree species listed in the ISIS database forest cover data, it was assumed to be over 80% of the cover. The completion of the problem analysis to this point required approximately 12 person-weeks of work, not including work by Mei Ching Tsoi, and preliminary work by J. Beale and R. Scagel.

During the course of this analysis, Compupro Systems Ltd. developed a program to assign ITG codes to any FIP (Forest Inventory Planning) files or silviculture extract files, and this program could be used in the future with data that are downloaded from ISIS. Unfortunately, this program was not completed until after all the ITG codes had been entered by hand.

Once the Microsoft Access® databases were completed, the task of analysis was started. This generally involved producing several queries, and exporting the resulting data into Microsoft Excel® for statistical analyses. Details of these data manipulations can be found in Appendix C. In general, if there were duplications of records (i.e. more than one forest health survey done on an opening), the most recent record was used.

3.2 Data Analyses

Statistical analyses of the databases were performed in Microsoft Excel®. Statistics produced included: mean pest incidence percentage, standard deviation, and standard error; median pest incidence percentage and quartiles; number of surveys with and without DRA; and survey areas with and without DRA. Medians were used to give a better representation of the central tendency of the data, due to the wide variation in pest incidence percentage within some groups (biogeoclimatic zones, ITGs). Two proportion statistics—percentage of surveys with DRA and percentage of survey area with DRA—were obtained from the data. The percentage of surveys with DRA was calculated by dividing the number of survey units (openings, polygons, subpolygons) infected with DRA by the total number of surveys. The percentage of survey area infected was calculated by dividing the survey area infected with DRA by the total area surveyed. All of the data sets and analyses results are available on computer disk from G. Krumlik, Research Branch.

Another important part of the overall problem analysis was a review of many of the previous reports written on the DRA root rot problem, primarily in the Nelson Forest Region. This material was to be examined for possible inclusion in this problem analysis, and for comparison to results from the present study. The complete annotated bibliography can be found in Appendix D and the comparison is in section 5.2. All of the reviewed reports are available from G. Krumlik.

4.0 Results

Mean and median pest incidence percentages were compared within four main parameters: biogeoclimatic zone and subzone; Inventory (or Growth) Type Groups; tree density (total stems per hectare); and average tree age. When possible, both ISIS and pixel survey data were used to produce two sets of statistics.

Based on the tabular data presented in Appendix E, the data were graphed (Figures 1 to 40) in two formats. The first plots the mean percent incidence of DRA against the percent of survey area infected by DRA (all odd numbered figures). The second plots the median percent incidence of DRA with the percent of surveys infected by DRA (all even numbered figures).

The graphs have a one-to-one ratio line that does not imply any statistical attributes. It is simply a reference line which allows easier comparison of the position of the data points between graphs. All of the graphs were given the same standard axis lengths for the same reason.

There were four biogeoclimatic zones consistently surveyed in the Nelson Forest Region: ESSF (Englemann Spruce-Subalpine Fir); ICH (Interior Cedar-Hemlock); IDF (Interior Douglas-fir); and MS (Montane Spruce). The PP (Ponderosa Pine) zone was not often graphed because there were usually not enough data to provide sound statistics.

The pixel survey data did not contain enough data records to be analysed at all levels. For example, there is no figure depicting tree density to the subzone level using pixel survey data, whereas the ISIS data were extensive enough to allow this analysis.

Many records utilized old biogeoclimatic classification units that had to be updated. Table 4 indicates how these changes were made based on *A Field Guide for Site Identification and Interpretation for the Nelson Forest Region.*

Table 4: Old and New Biogeoclimatic Classifications

Old Biogeoclimatic Classification	New Biogeoclimatic Classification
ESSFa	ESSFdk
ESSFb	ESSFvc
ESSFc	ESSFwc
ESSFe2	ESSFdc
ICHa1	ICHdw
ICHa2	ICHmw
ICHb	ICHwk
ICHc	ICHmk
ICHd	ICHxw
IDFf	IDFdm
IDFg1	IDF
IDFg2	PPdh
IDFg3	IDFdm
MSa	MSdk
MSb2	MSdm
PPBGc	PPdh

Finally, it should be noted, and due caution taken, that *all graphs are subject to the biases and inconsistencies of the individual data sets as described in Section 2 of this report.*

4.1 DRA Incidence by Biogeoclimatic Zone and Subzone

The average percent of DRA incidence, and all other relevant statistics, were calculated and graphed by each biogeoclimatic zone and subzone. ISIS (Figures 1 and 2) and pixel survey data (Figures 3 and 4) were graphed separately both by mean and median .

In the graphs of pest incidence by biogeoclimatic zone and subzone, an "all" category is sometimes used in a zone. This category was used when records had no subzone value given, or when subzones had too few records to analyse. The "all" category, therefore, contains more records than the sum of those analysed in each subzone.

Data collected for the ponderosa pine (PP) zone was not graphed because there was only one record with DRA.

The data records that occur both in the ISIS and pixel data sets were removed from pixel survey data prior to analysis, however, the entire data set was used to calculate proportions.

Figure 1: Mean DRA Incidence by Biogeoclimatic Zone and Subzone in the Nelson Forest Region (ISIS Data)

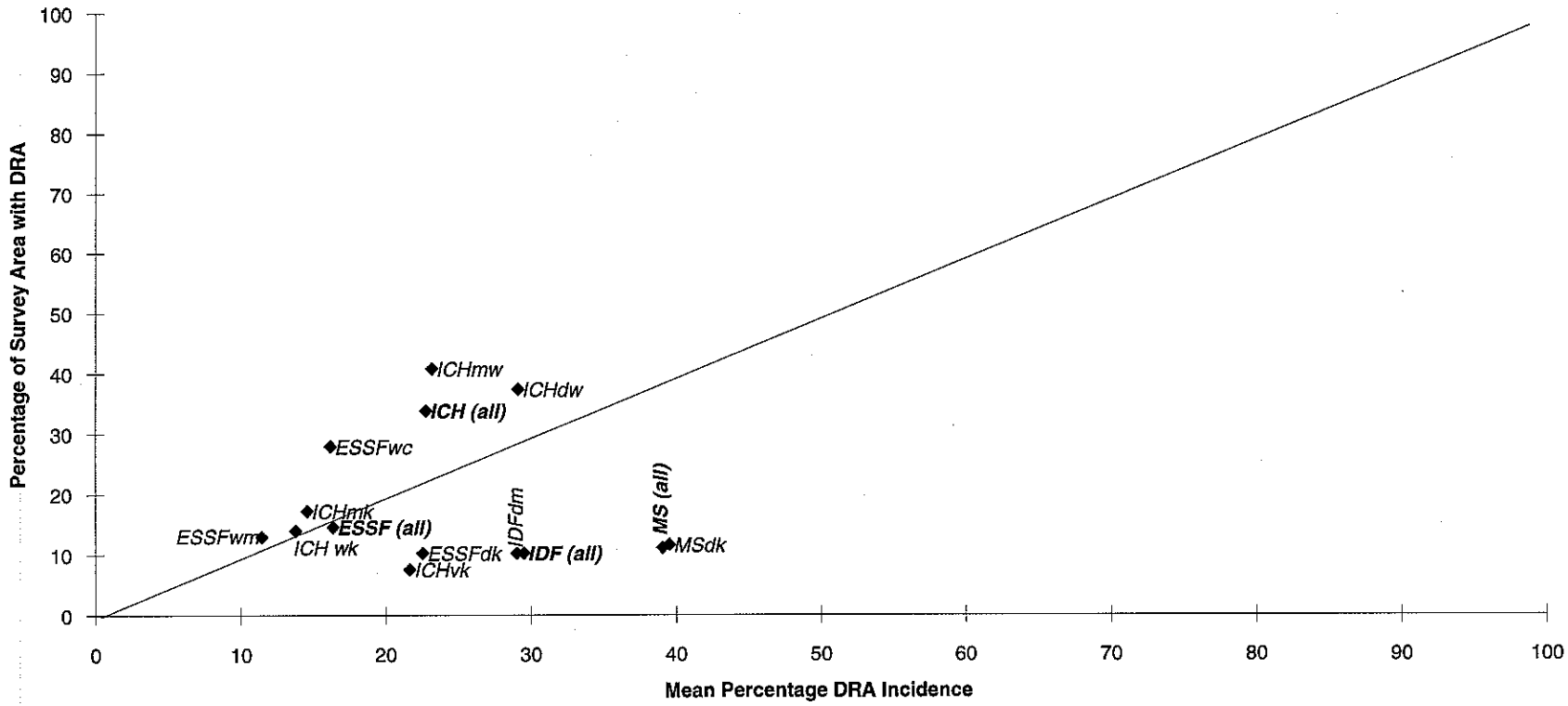


Figure 2: Median DRA Incidence by Biogeoclimatic Zone and Subzone in the Nelson Forest Region (ISIS Data)

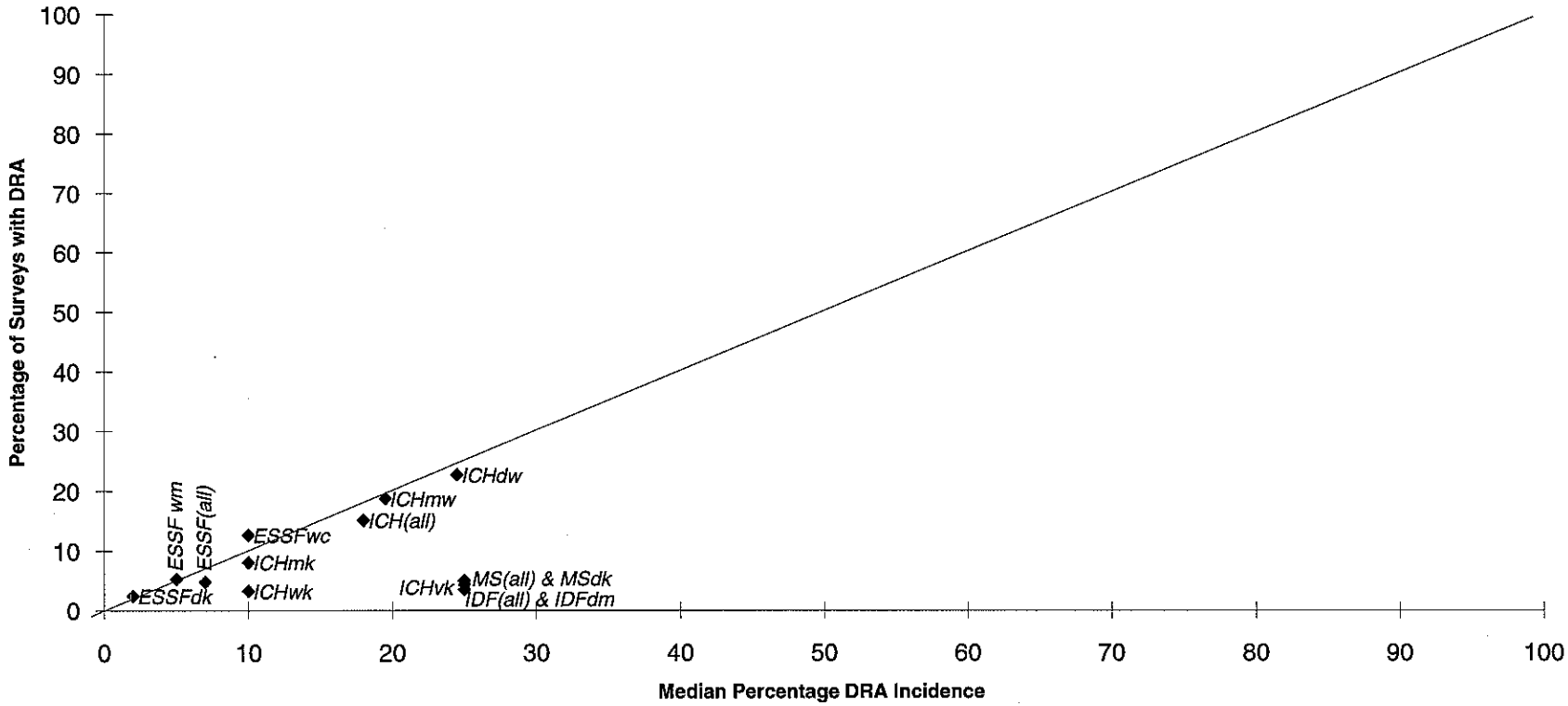


Figure 3: Mean DRA Incidence by Biogeoclimatic Zone and Subzone in the Nelson Forest Region (Pixel Survey Data)

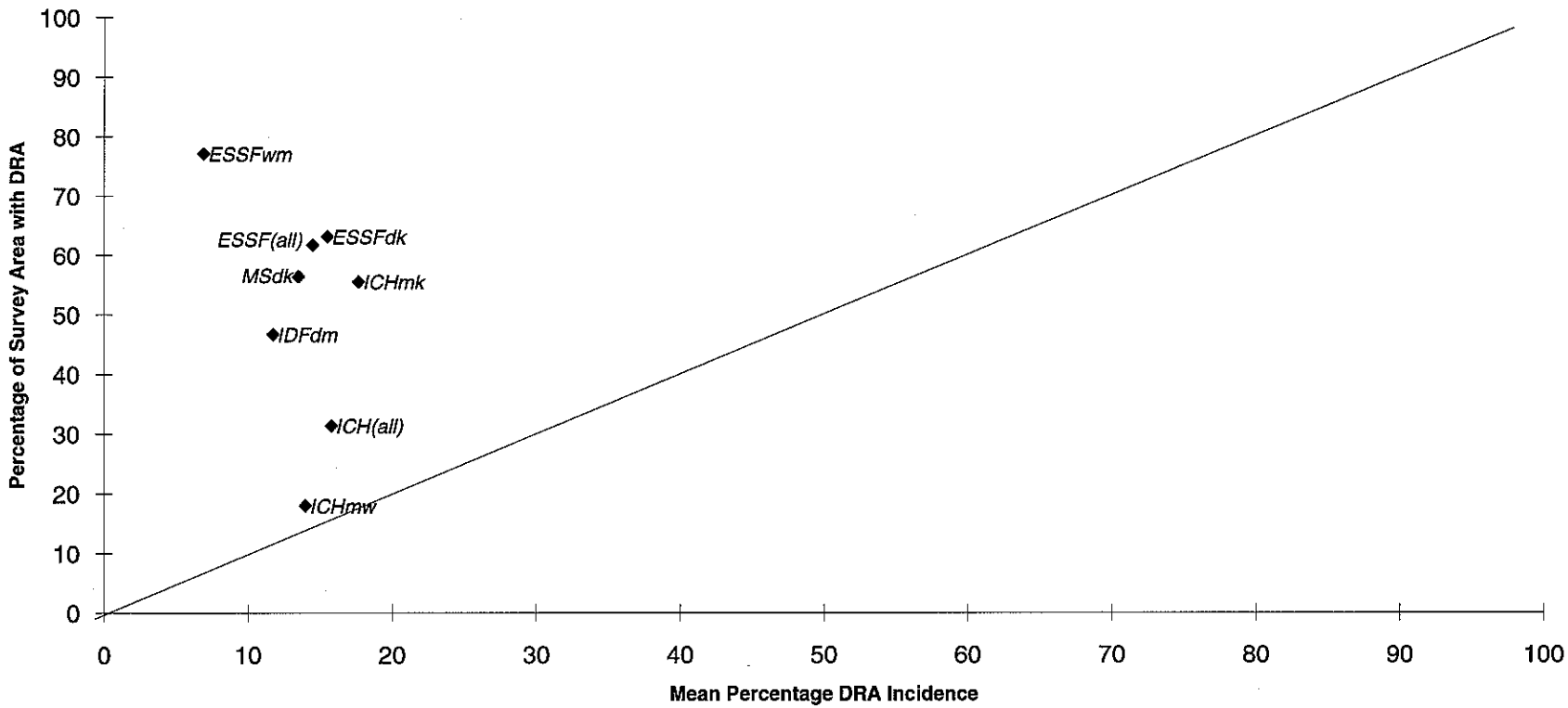
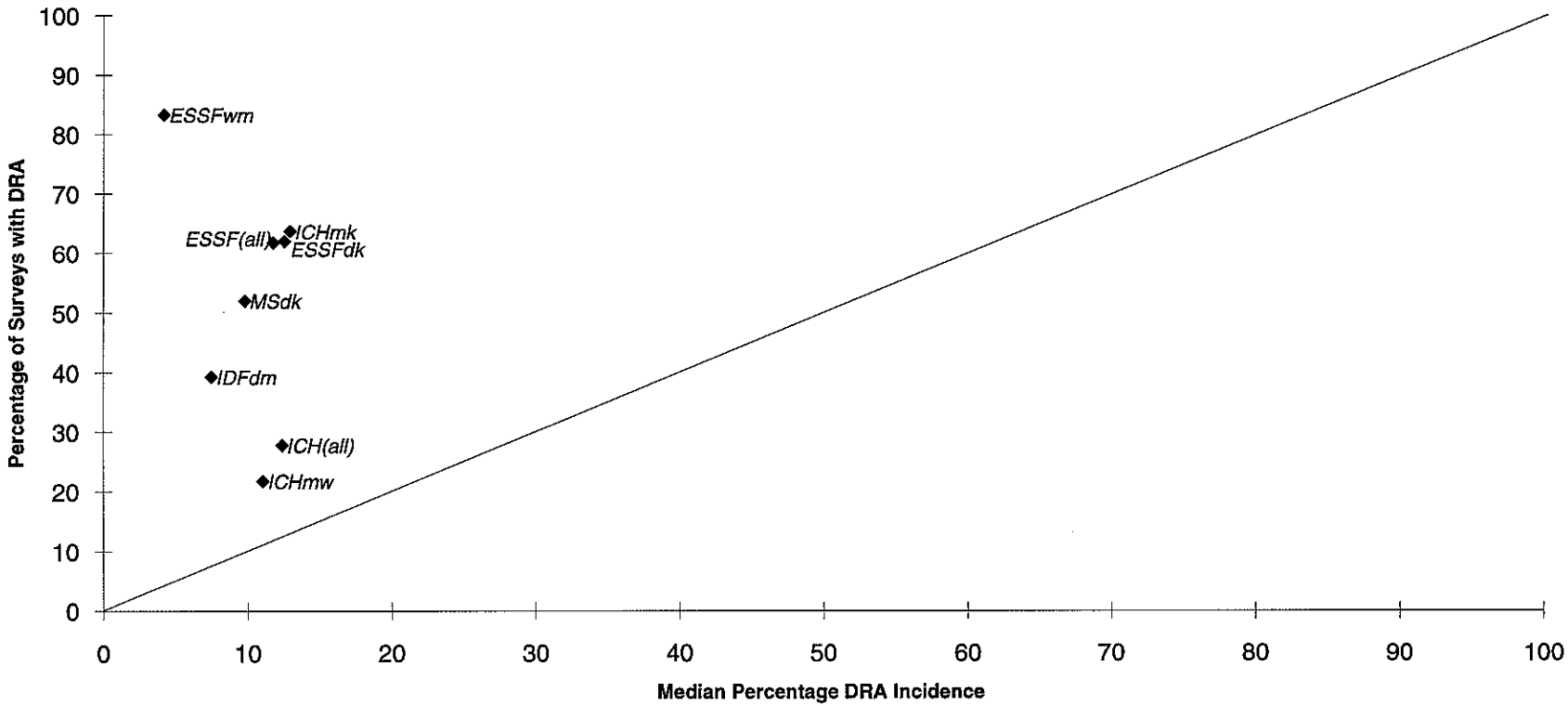


Figure 4: Median DRA Incidence by Biogeoclimatic Zone and Subzone in the Nelson Forest Region (Pixel Survey Data)



4.2 DRA Incidence by Inventory Type Group

Figures 5 and 6 were based on ISIS data, while Figures 7 and 8 were based on pixel survey data. The number beside each data point on the graph represents the ITG number. The leading tree species in these ITGs can be found in Table 5. The ITGs grouped in each GTG can also be found in Table 5. Any missing ITG numbers on Figures 5 to 8 was due to lack of data, or the fact that all of the ITGs are not found in the Nelson Forest Region.

Table 5: Reference List of ITGs and GTGs

ITG number	Leading tree species
1	Fd
2	Fd, Cw
3	Fd, H
4	Fd, S
5	Fd, Pl
6	Fd, Py
7	Fd, L
8	Fd, Deciduous
9	Cw
10	Cw, Fd
11	Cw, H
12	H
13	H, Fd
14	H, Cw
15	H, B
16	H, S
17	H, Deciduous
18	B
19	B, H
20	B, S
21	S
22	S, Fd
23	S, H
24	S, B
25	S, Pl
26	S, Deciduous
27	Pw
28	Pl
29	Pl, Fd
30	Pl, S
31	Pl, Deciduous
32	Py
33	L, Fd
34	L
35	Ac, Coniferous
36	Ac, Deciduous
37	Dr, Coniferous
38	Dr, Deciduous
39	Mb
40	E
41	At, Coniferous
42	At, Deciduous

GTG number	ITGs included
1	1, 5, 8, 27
2	2, 3, 4
3	5, 6, 8, 32
4	7, 27, 33, 34
5	9, 10, 11
6	12, 17
7	13, 14, 15, 16
8	18, 19, 20
9	21
10	22, 23, 24
11	25, 26
12	28
13	29, 30
14	31
15	37, 41
16	38, 39, 40, 42
17	35, 36

Figure 5: Mean DRA Incidence by ITG in the Nelson Forest Region (ISIS data)

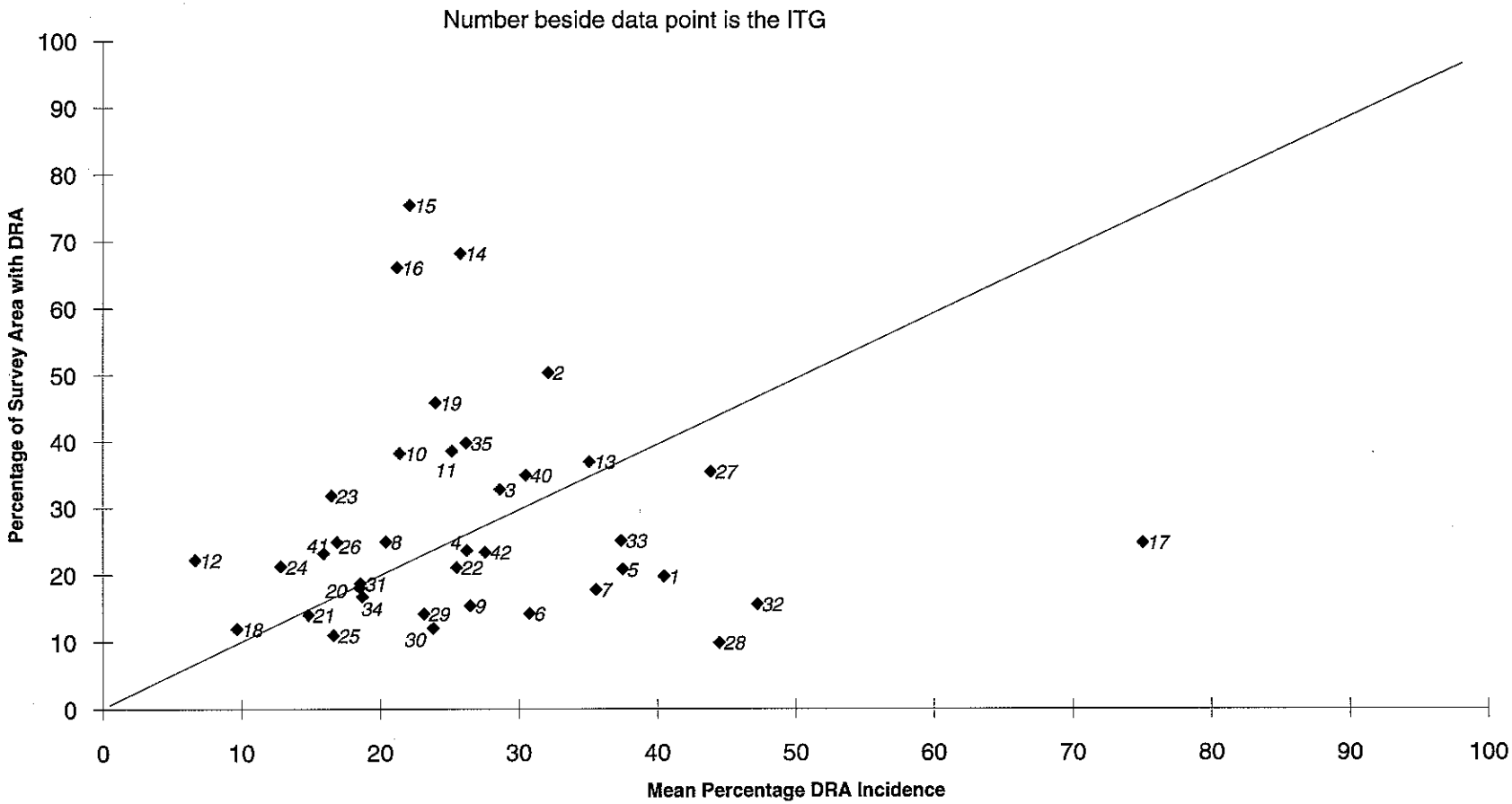


Figure 6: Median DRA Incidence by ITG in the Nelson Forest Region (ISIS data)

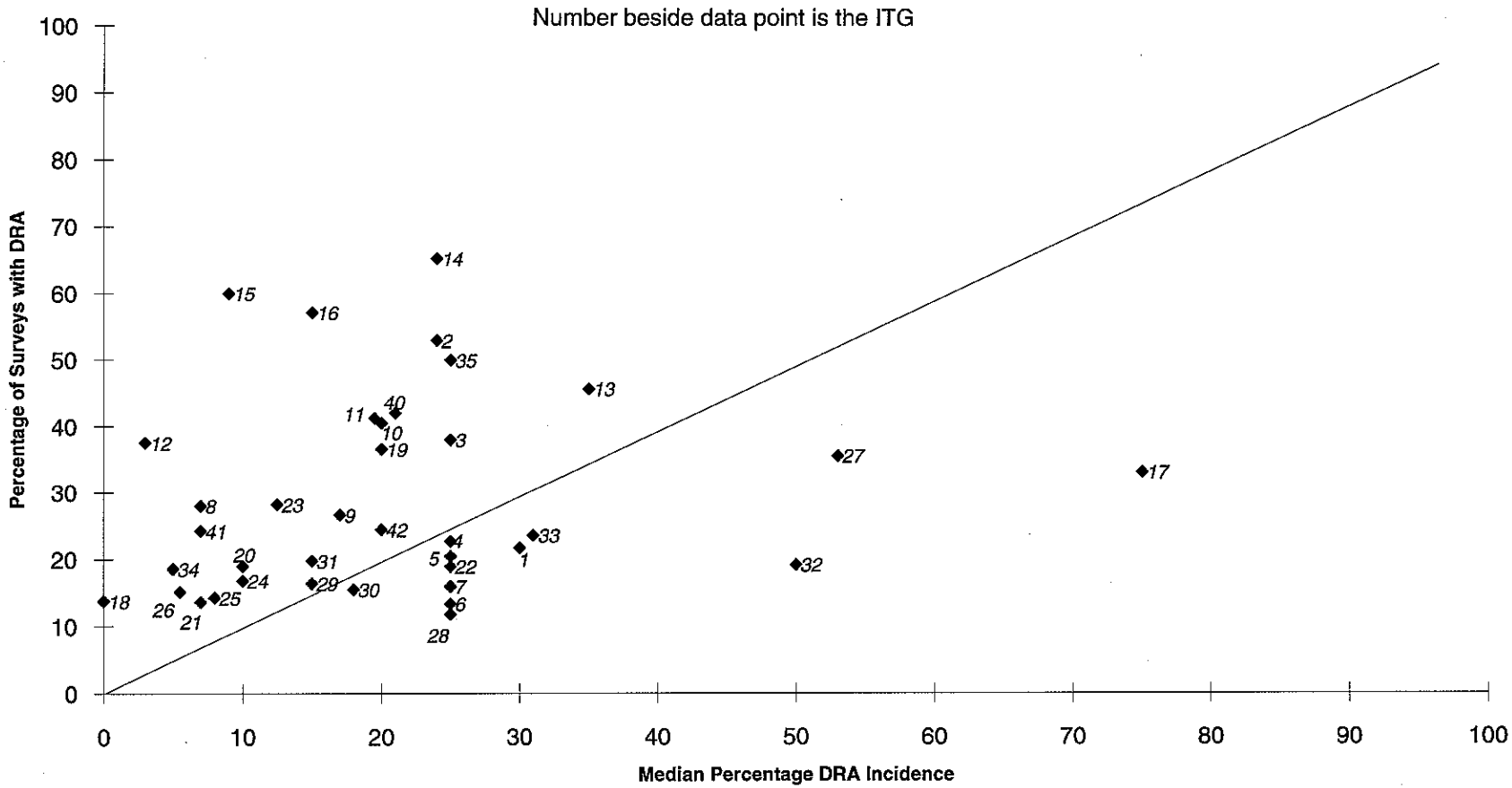


Figure 7: Mean DRA Incidence by ITG in the Nelson Forest Region (Pixel Survey Data)

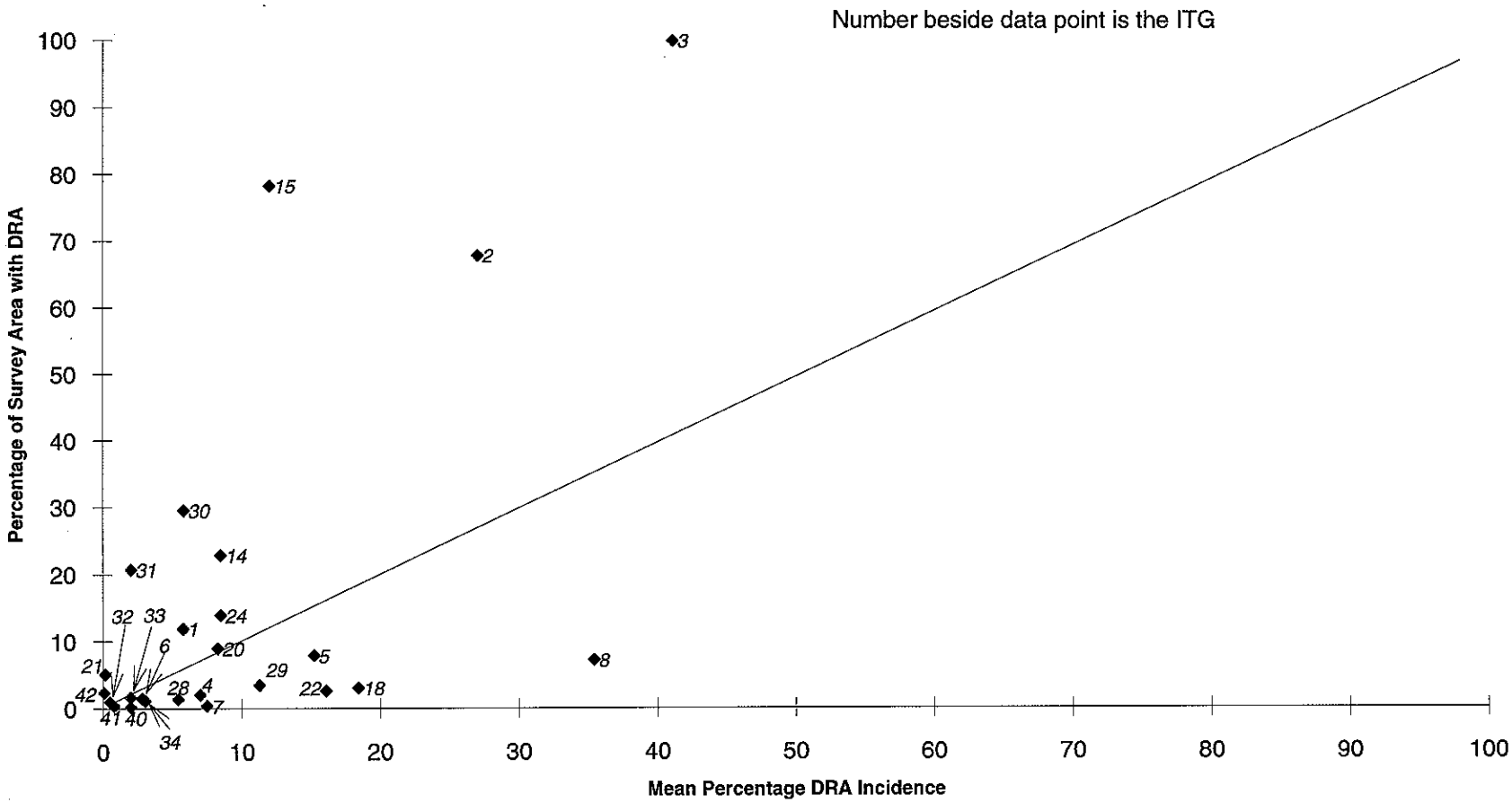
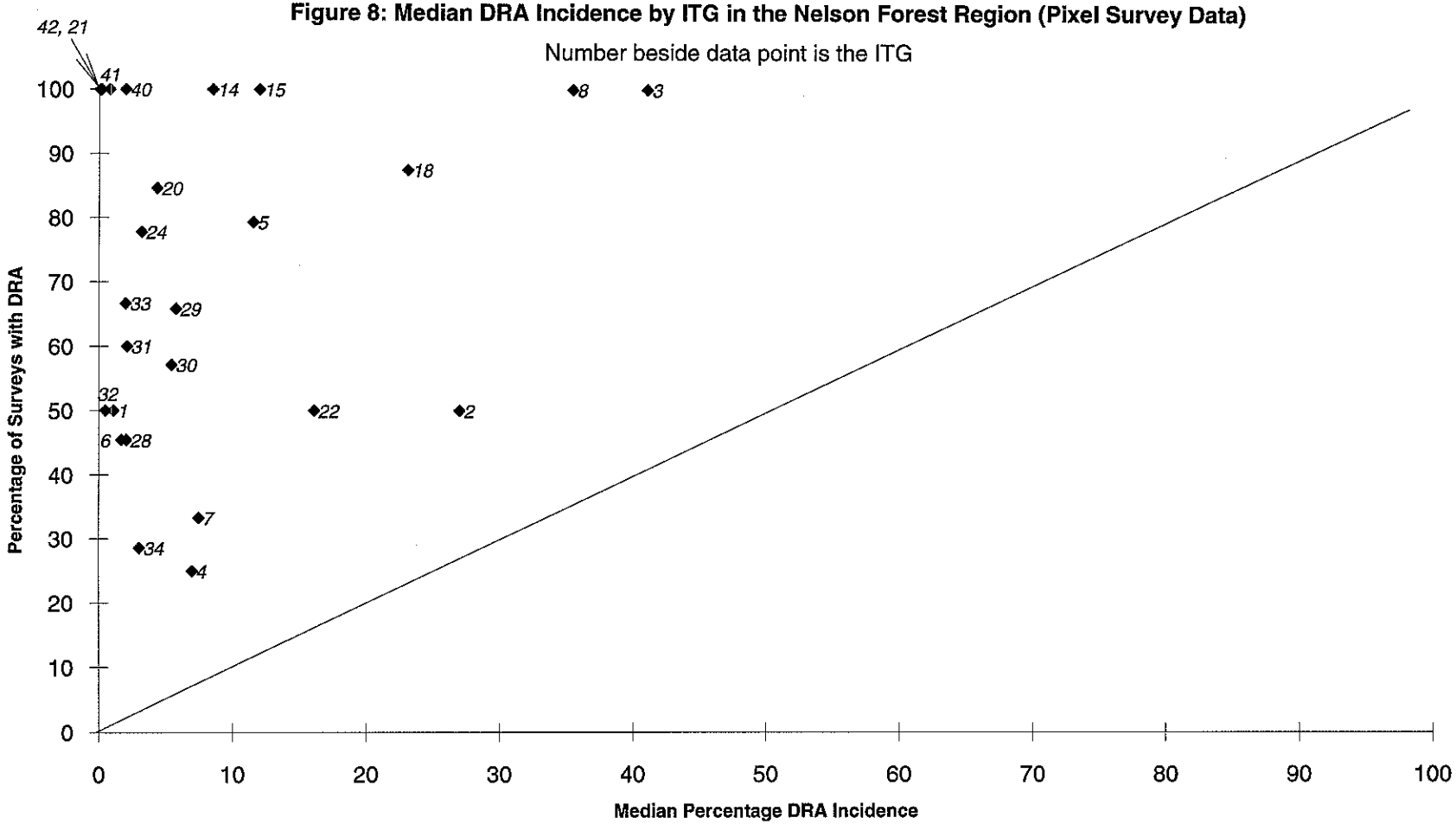


Figure 8: Median DRA Incidence by ITG in the Nelson Forest Region (Pixel Survey Data)



4.3 DRA Incidence by Tree Density

In Figures 9 to 20, tree density is measured by 'total stems per hectare'. Density classes were established to group the tree density values. The density classes were loosely based on stocking standards for the Nelson Forest Region.

The ISIS data set contained many zero values in the *total stems per hectare* field, whereas, the pixel data set had none. It is likely that DRA was found in areas with zero stems per hectare because the symptoms were observed on stumps or brush species.

The pixel survey data (Figures 11 and 12) were analysed to the biogeoclimatic zone level because there were not enough data records to produce statistics at the subzone level.

Figure 9: Mean DRA Incidence by Tree Density in the Nelson Forest Region (ISIS Data)

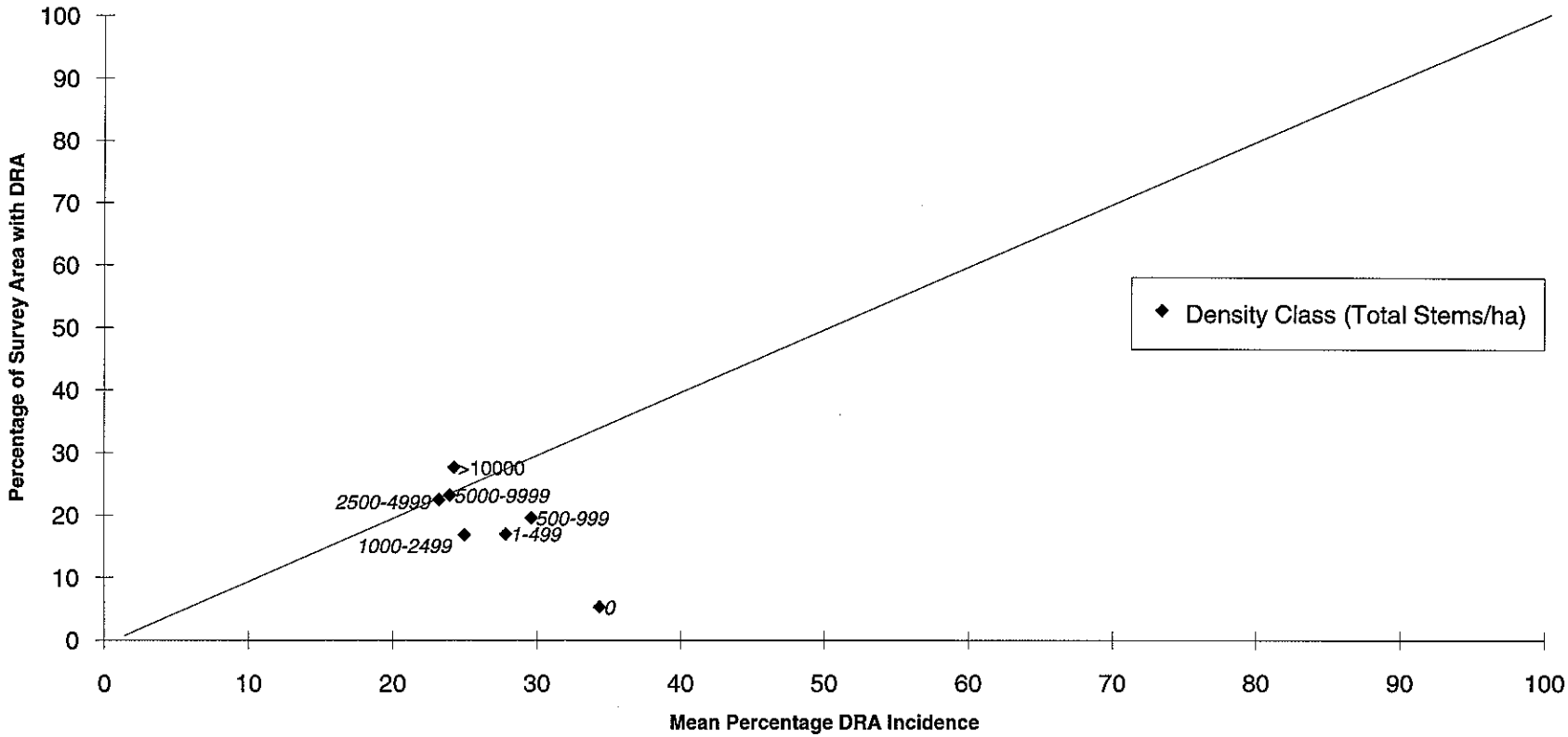


Figure 10: Median DRA Incidence by Tree Density in the Nelson Forest Region (ISIS Data)

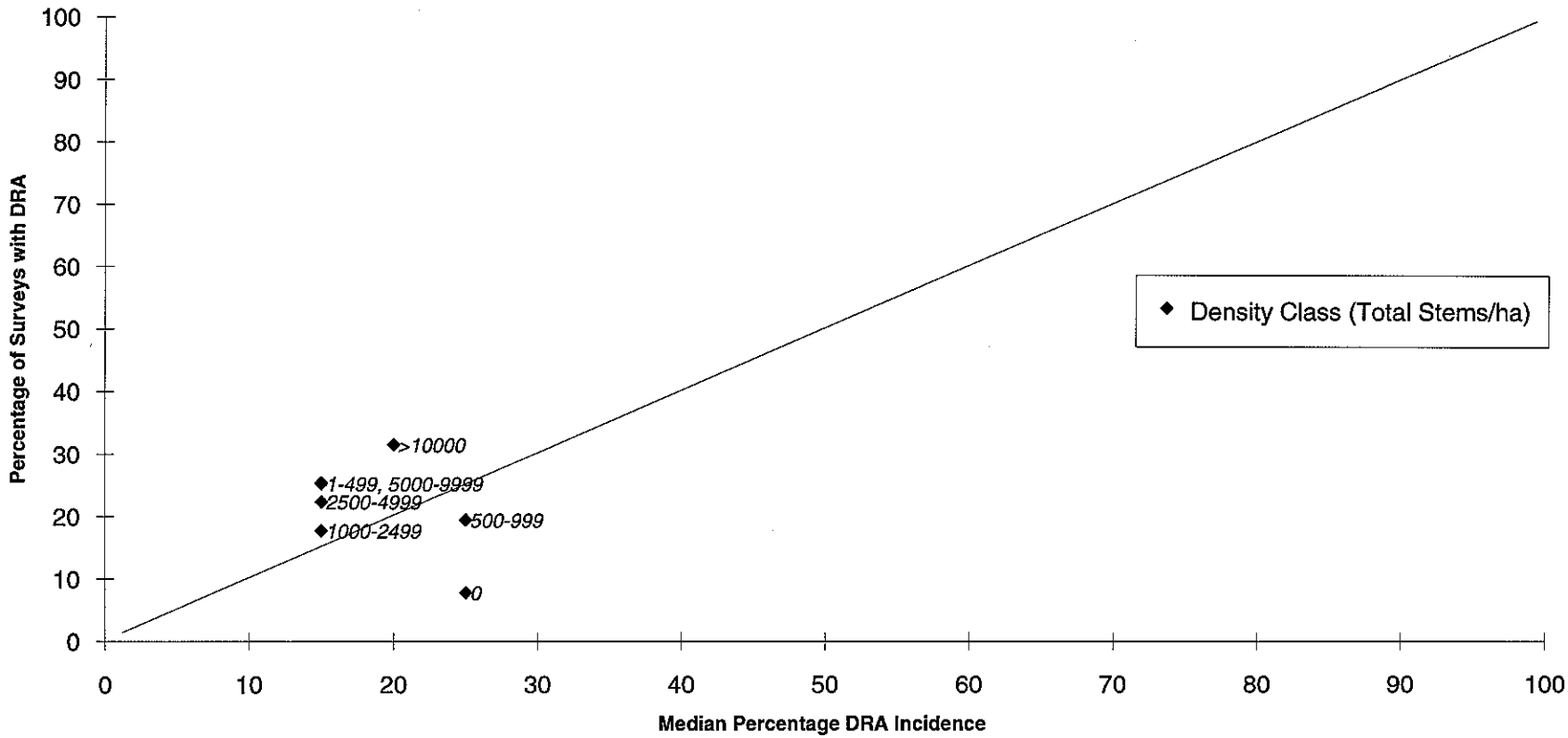


Figure 11: Mean DRA Incidence by Tree Density in the Nelson Forest Region (Pixel Survey Data)

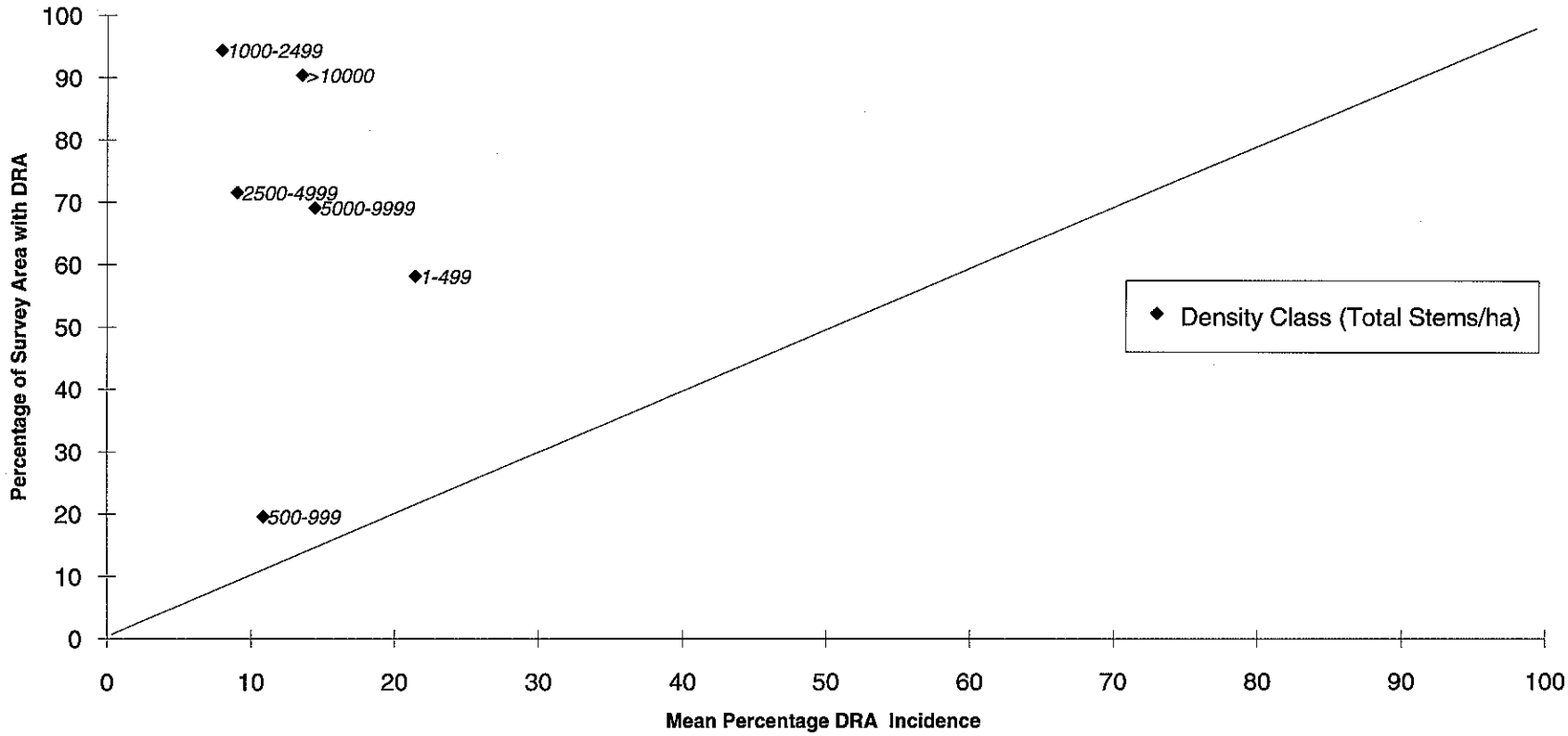


Figure 12: Median DRA Incidence by Tree Density in the Nelson Forest Region (Pixel Survey Data)

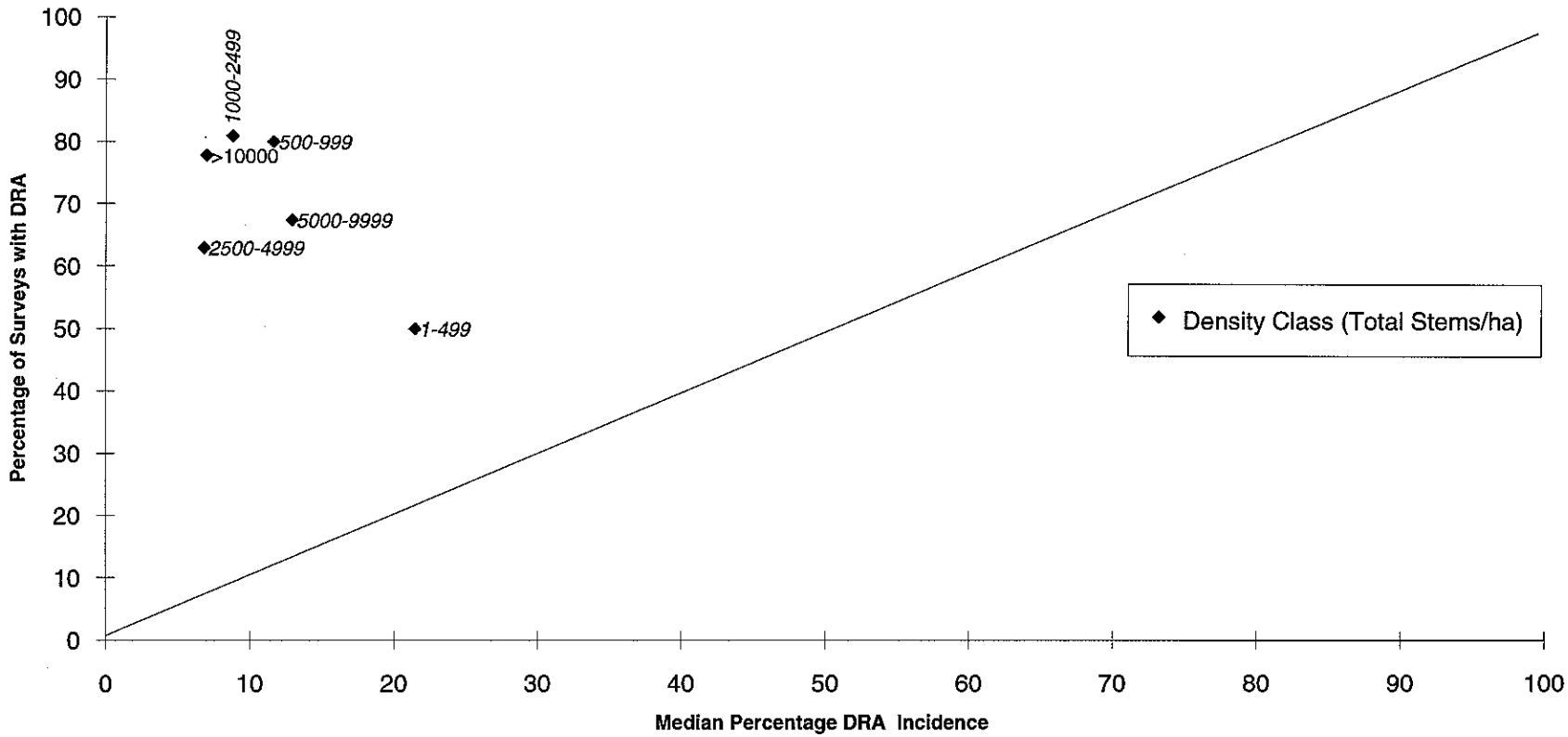


Figure 13: Mean DRA Incidence by Tree Density in the ESSF Zone of the Nelson Forest Region (ISIS Data)

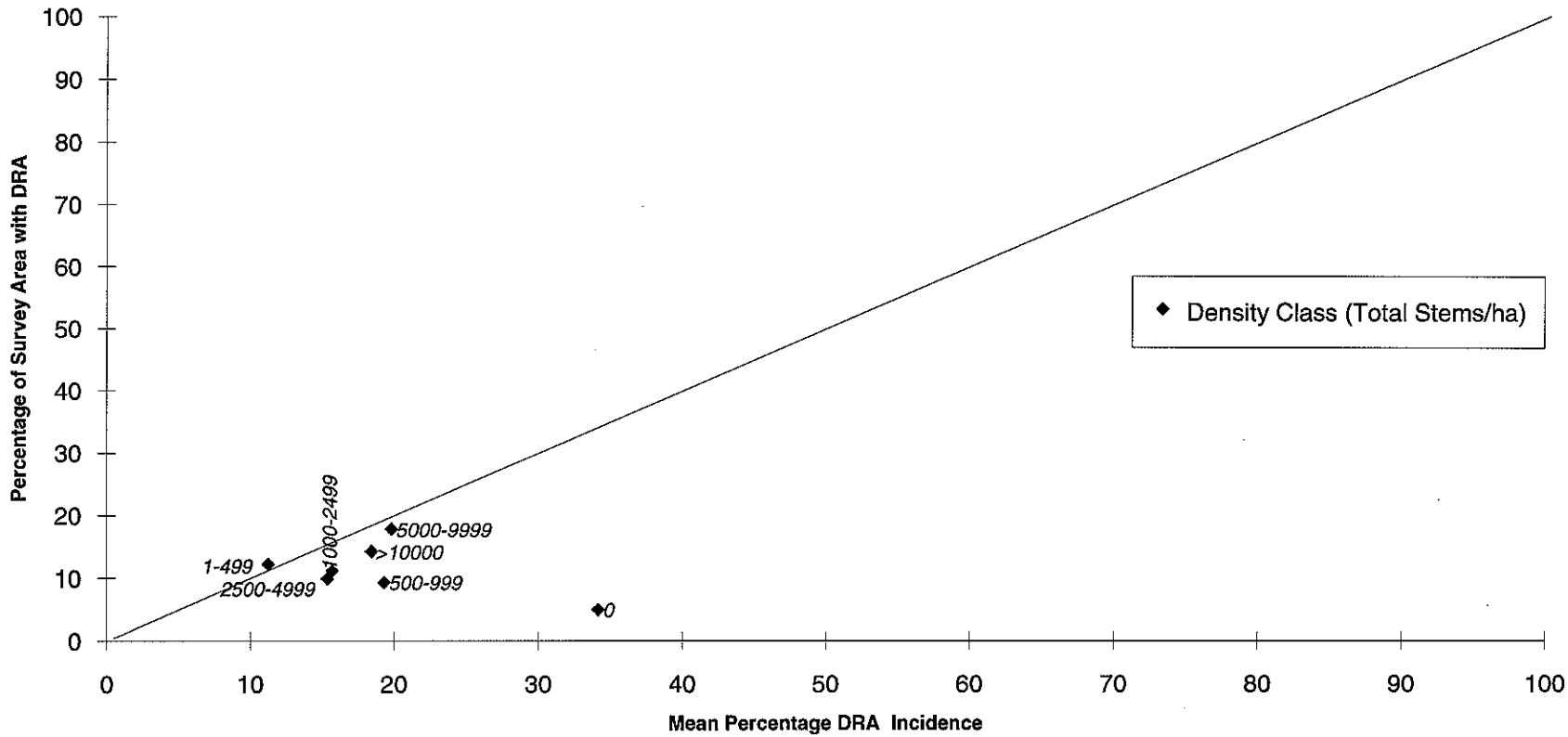


Figure 14: Median DRA Incidence by Tree Density in the ESSF Zone of the Nelson Forest Region (ISIS Data)

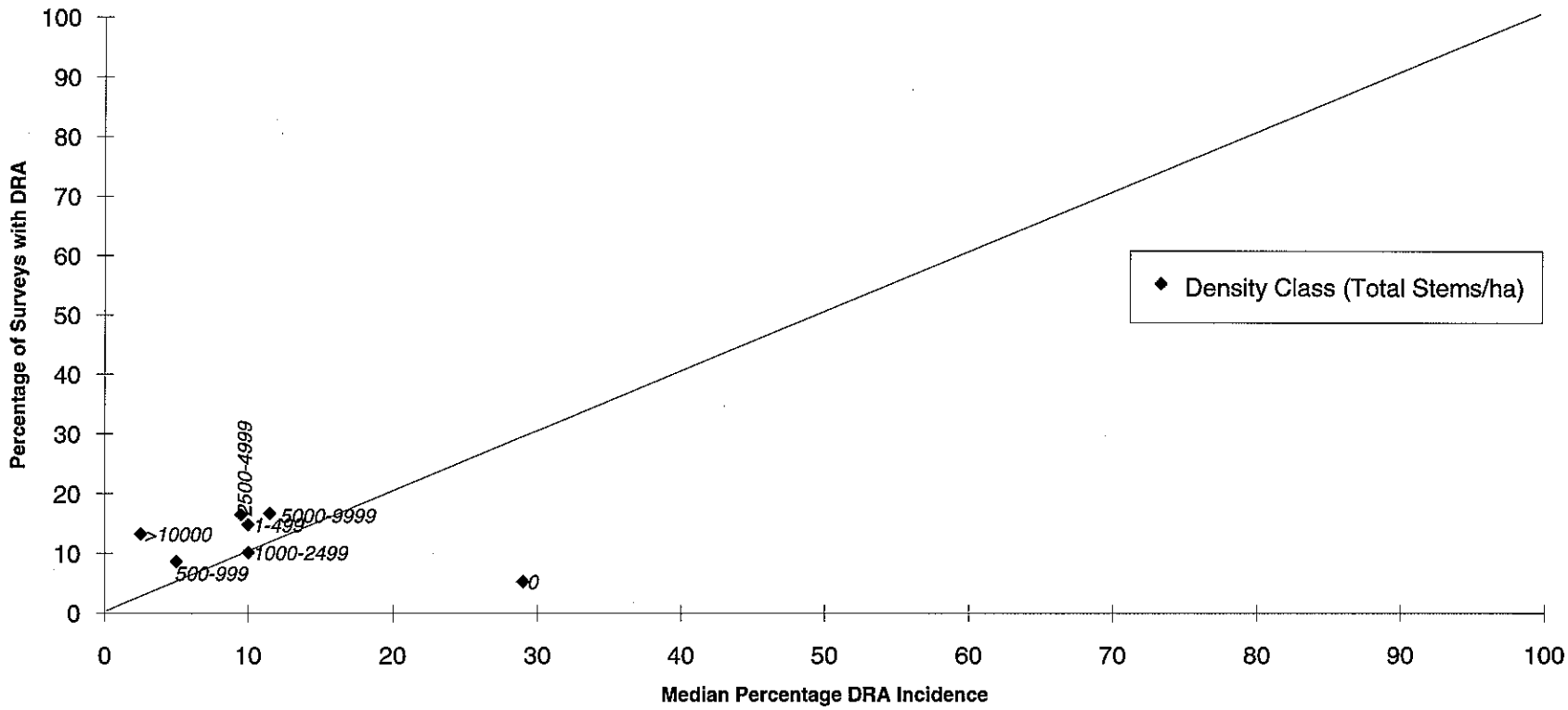


Figure 15: Mean DRA Incidence by Tree Density in the ICH Zone of the Nelson Forest Region (ISIS Data)

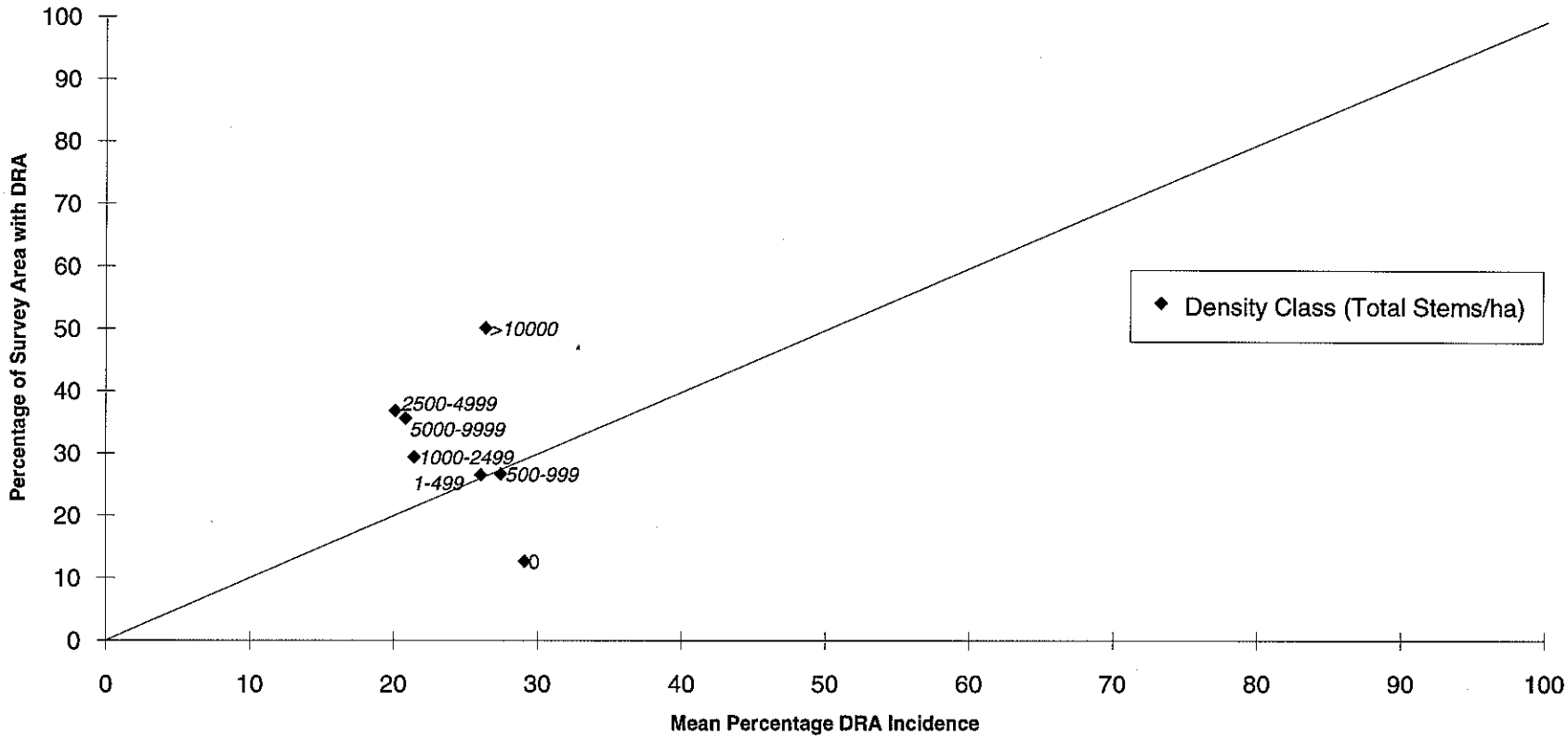


Figure 16: Median DRA Incidence by Tree Density in the ICH Zone of the Nelson Forest Region (ISIS Data)

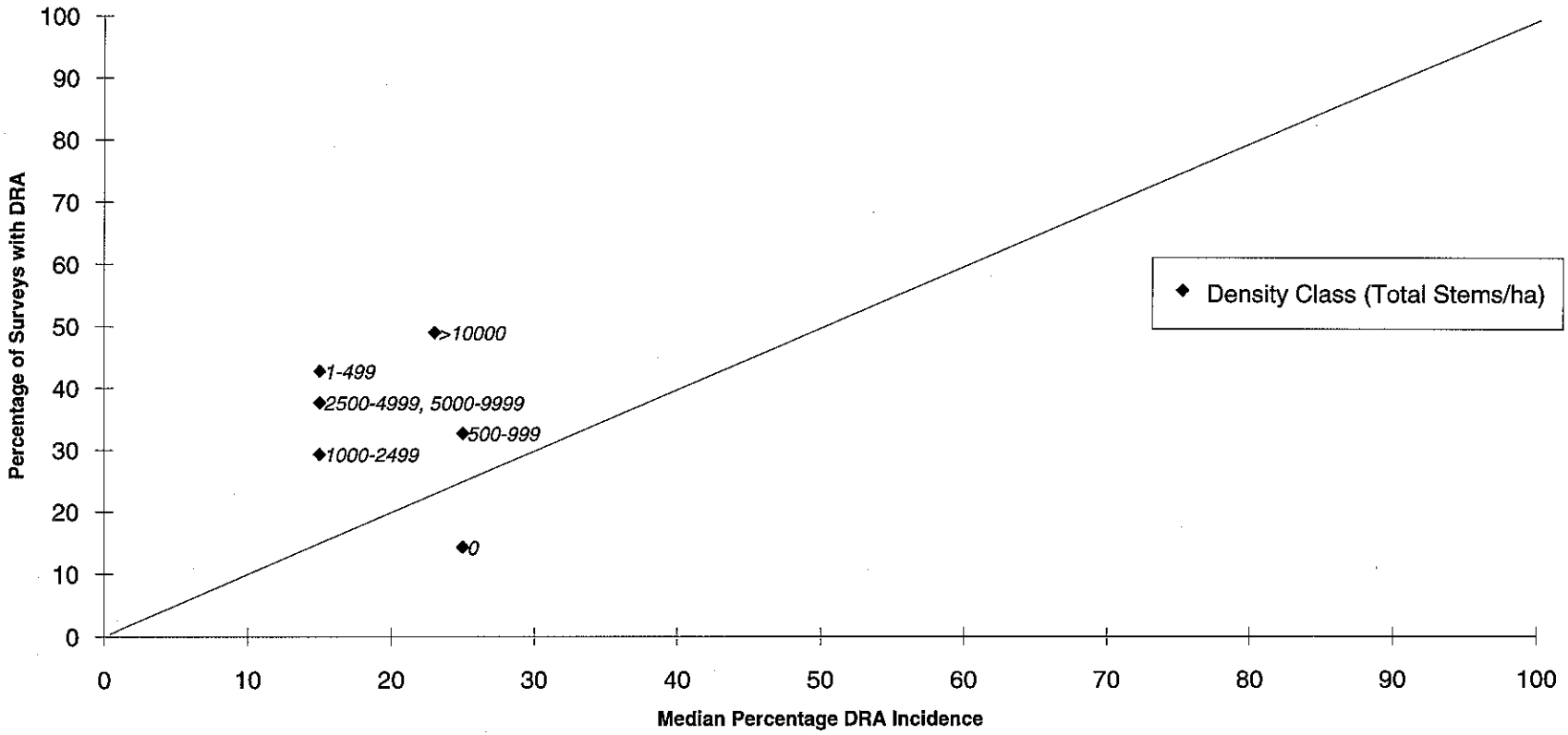


Figure 17: Mean DRA Incidence by Tree Density in the IDF Zone of the Nelson Forest Region (ISIS Data)

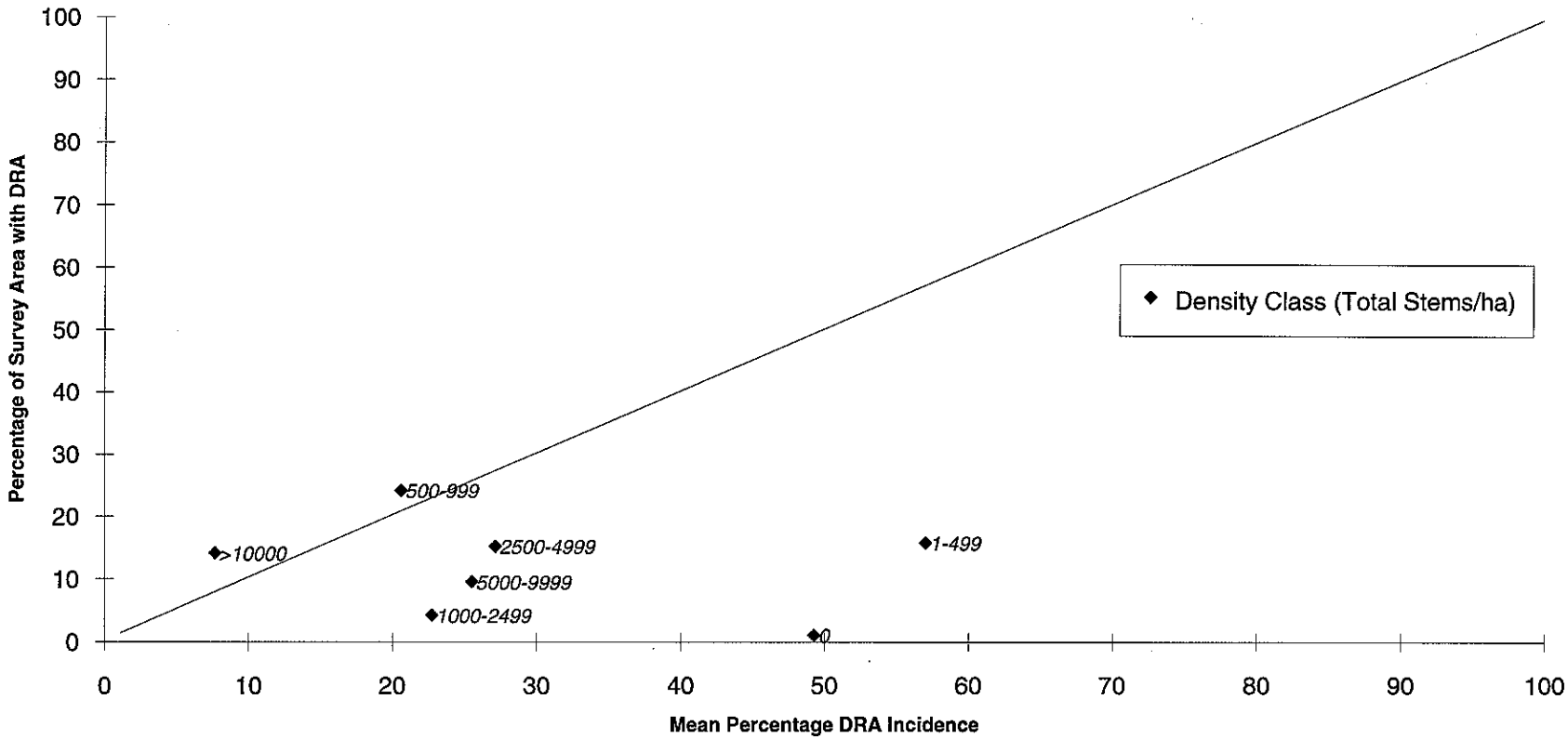


Figure 18: Median DRA Incidence by Tree Density in the IDF Zone of the Nelson Forest Region (ISIS Data)

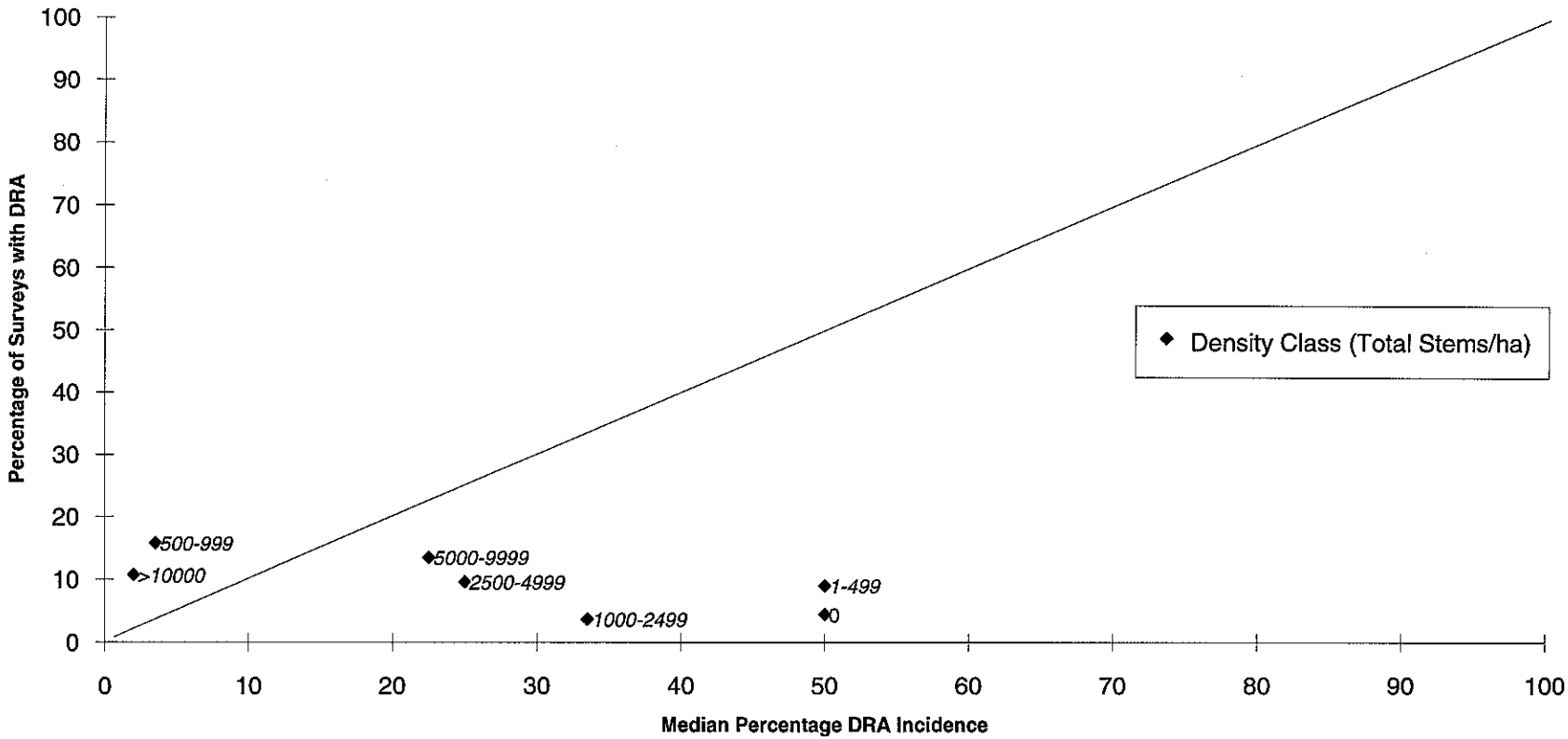


Figure 19: Mean DRA Incidence by Tree Density in the MS Zone of the Nelson Forest Region (ISIS Data)

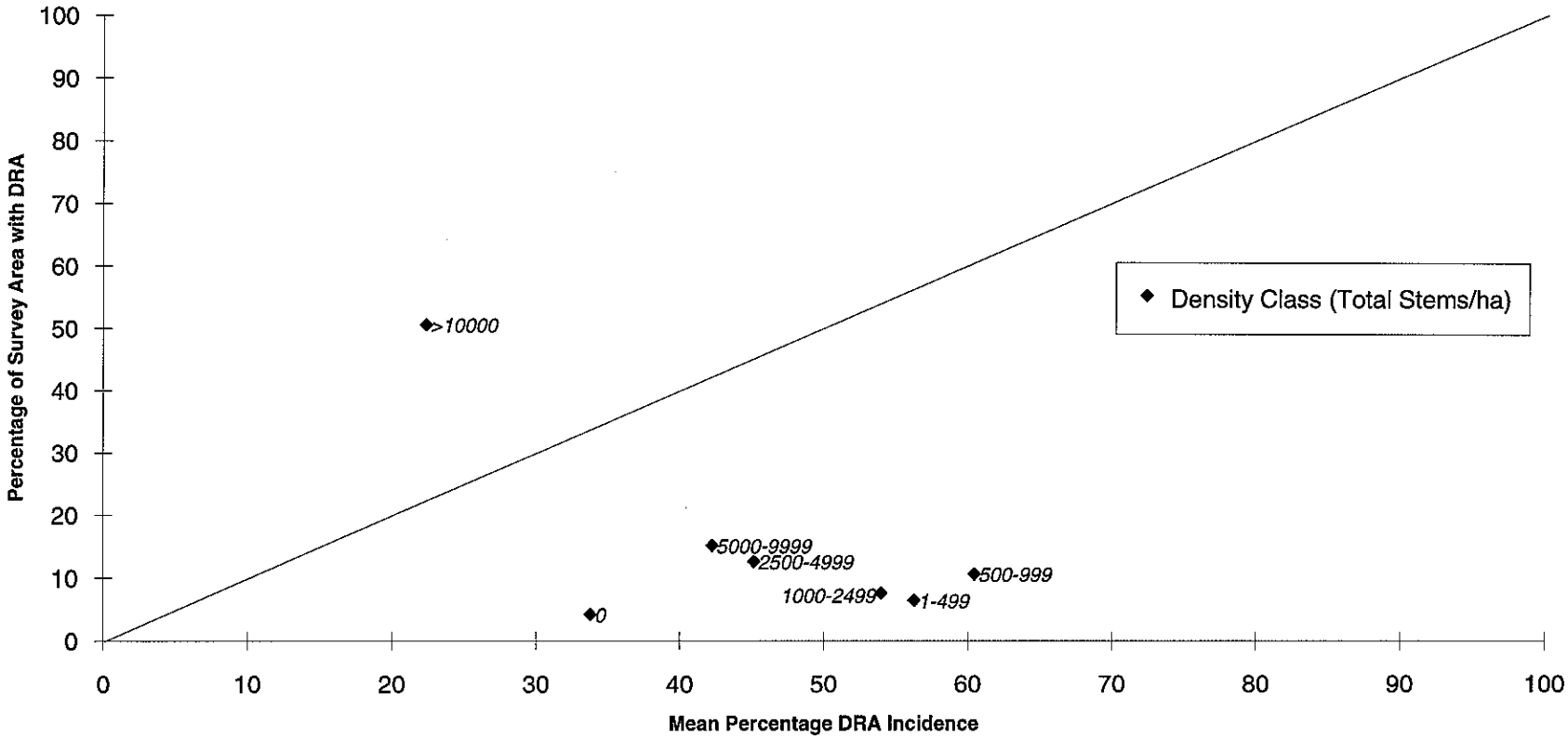
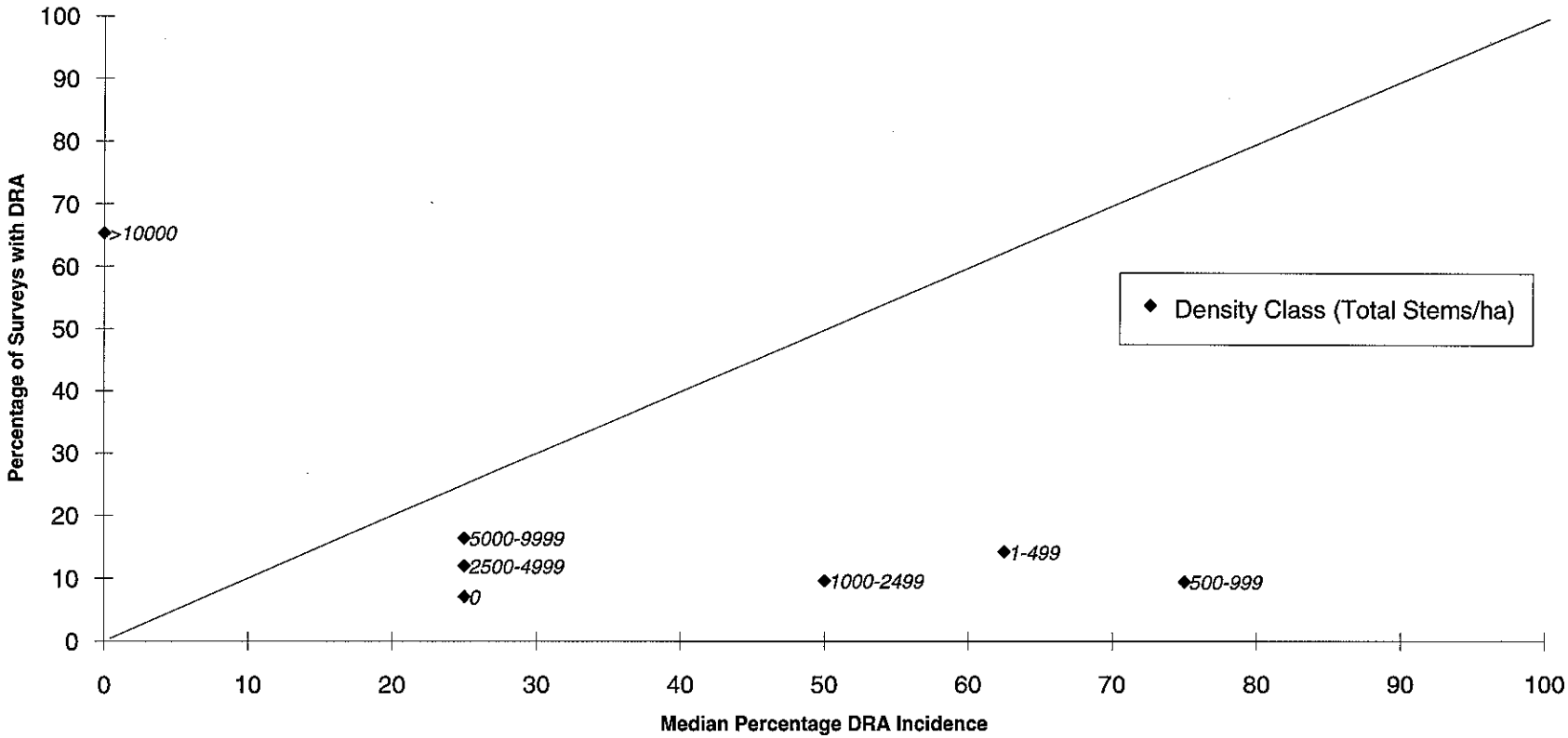


Figure 20: Median DRA Incidence by Tree Density in the MS Zone of the Nelson Forest Region (ISIS Data)



4.4 DRA Incidence by Growth Type Group Within Biogeoclimatic Zones

Figures 21 to 30 were based on ISIS data only, as there were too few records in the pixel survey data for this analysis. All the five biogeoclimatic zones were analysed by Growth Type Group, and ICH had enough data to analyse to the ITG level. The number beside each data point on the graph represents the GTG or ITG number. A list of the ITGs included in each GTG can be found in Table 5. Since the PP zone contained only one GTG, this was included in Figures 29 and 30 along with the MS data.

Figure 21: Mean DRA Incidence of Each ITG in the ICH Zone of the Nelson Forest Region (ISIS data)

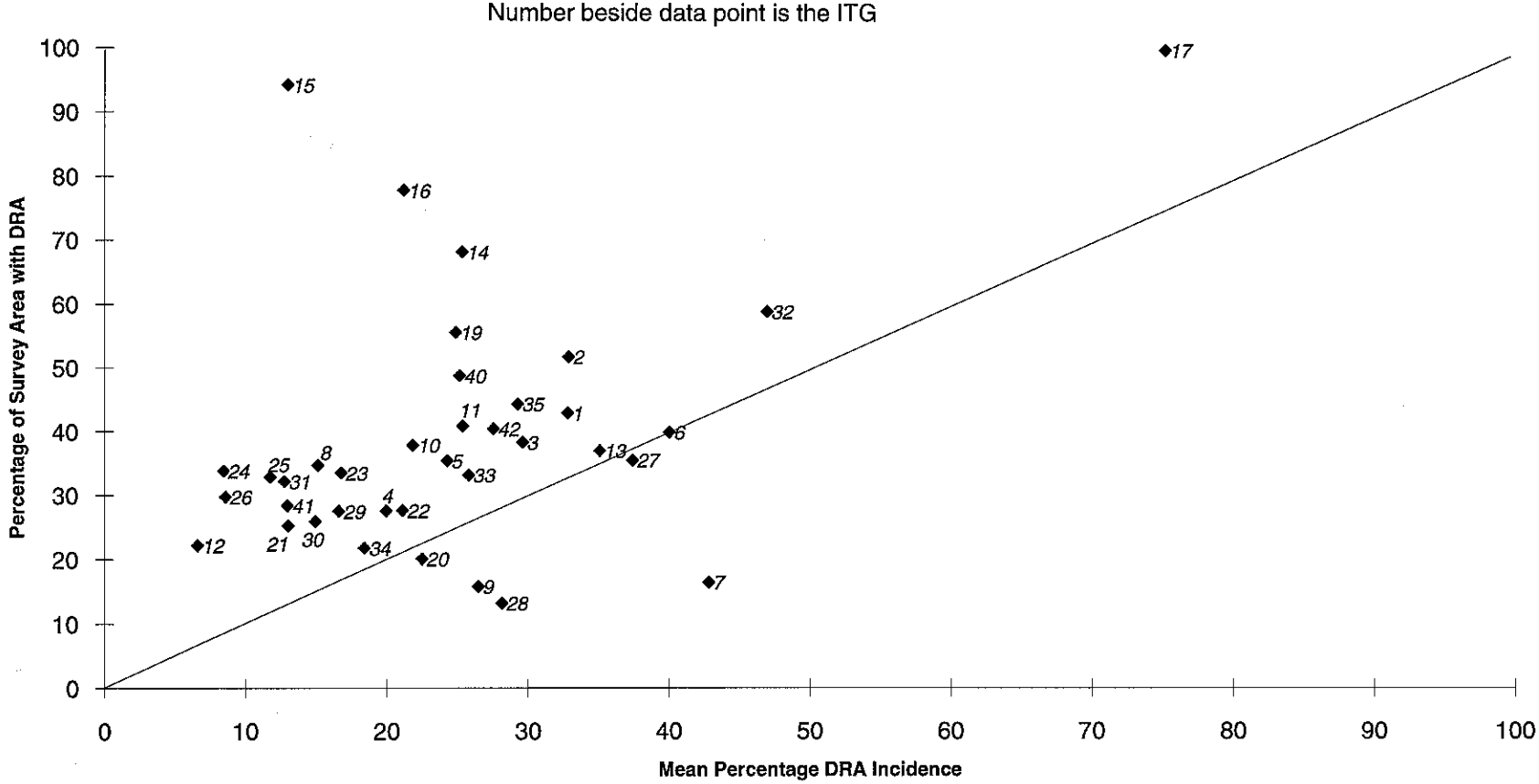


Figure 22: Median DRA Incidence of Each ITG in the ICH Zone of the Nelson Forest Region (ISIS data)

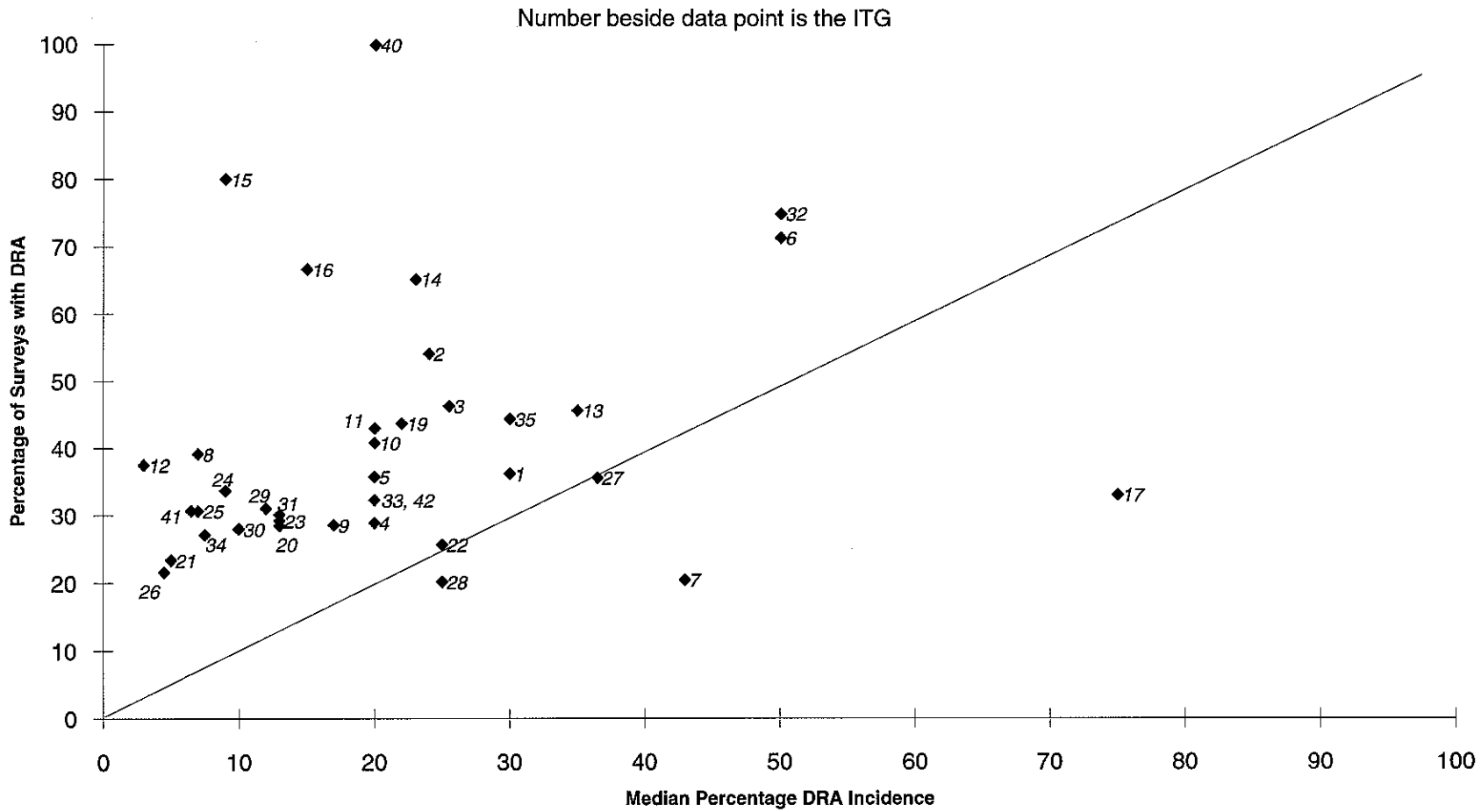


Figure 23: Mean DRA Incidence of Each GTG in the ICH Zone of the Nelson Forest Region (ISIS data)

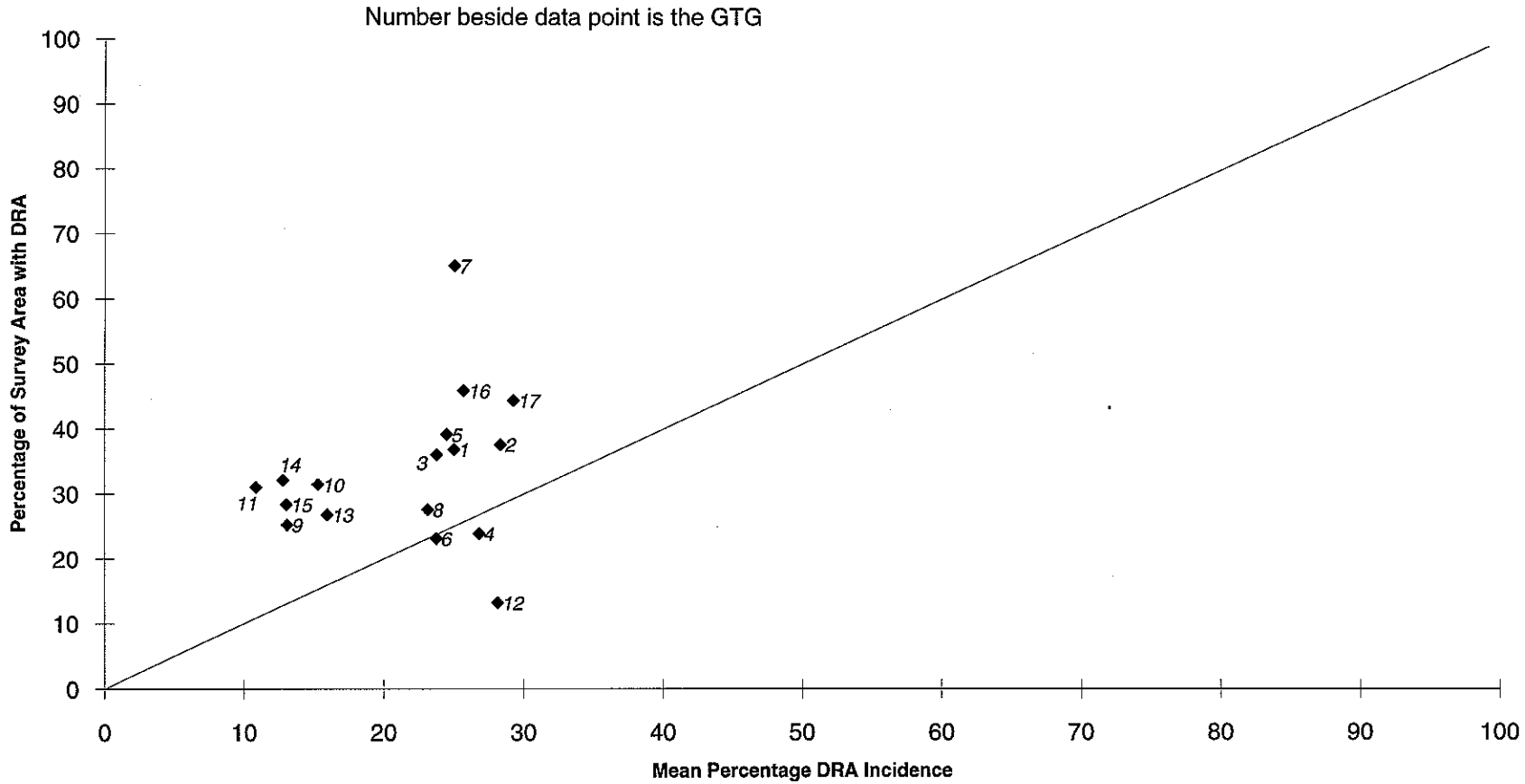


Figure 24: Median DRA Incidence of Each GTG in the ICH Zone of the Nelson Forest Region (ISIS data)

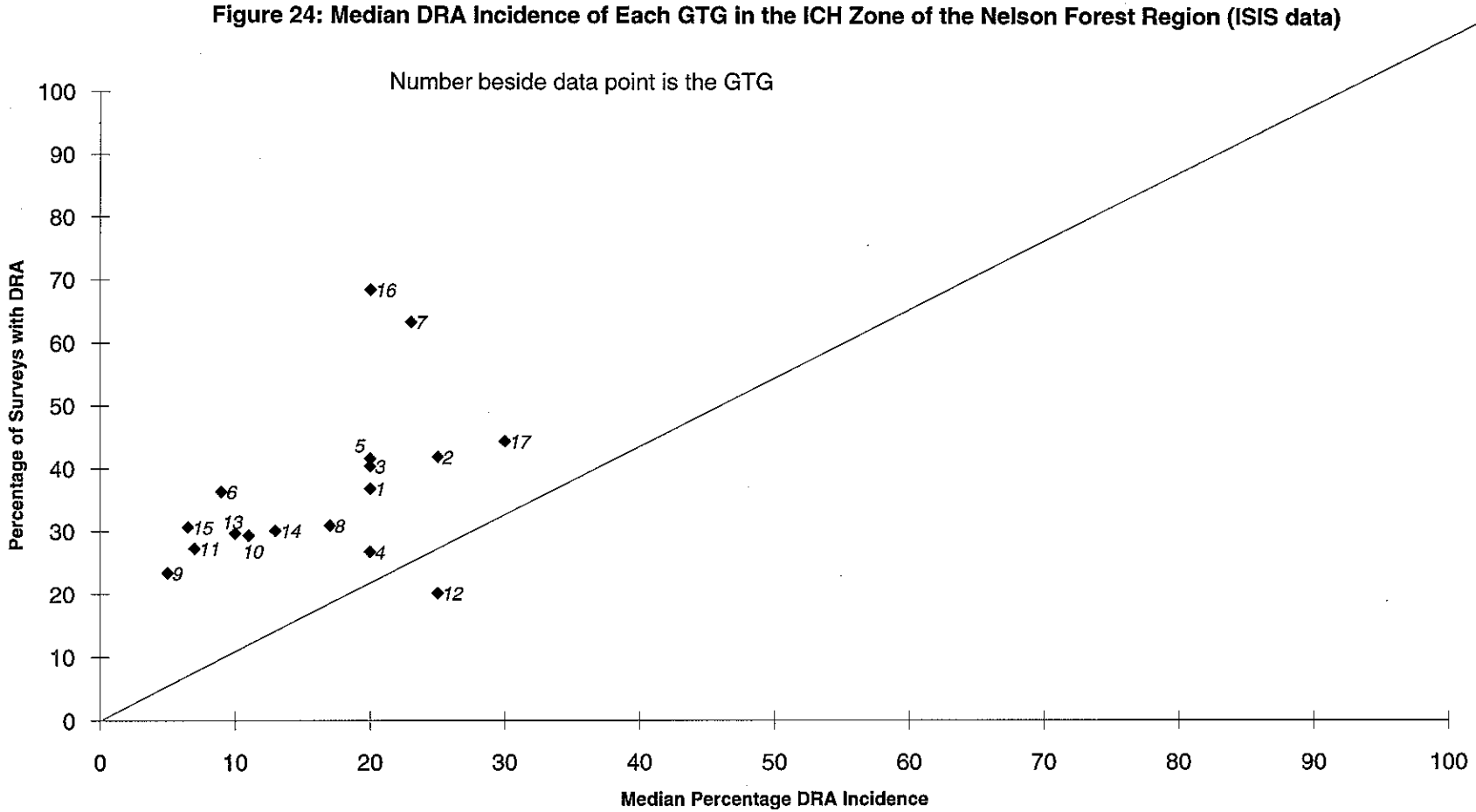


Figure 25: Mean DRA Incidence of Each GTG in the ESSF Zone of the Nelson Forest Region (ISIS data)

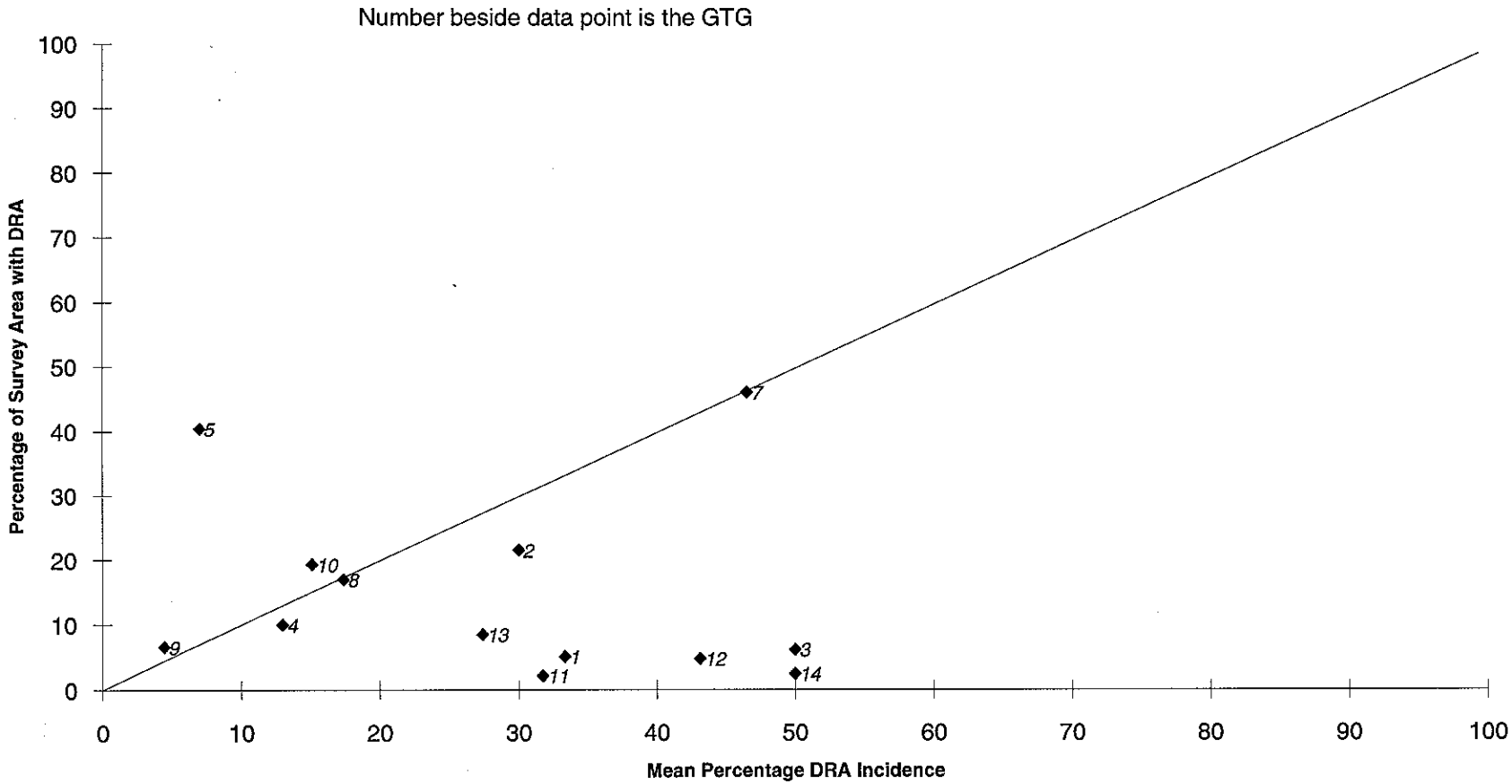


Figure 26: Median DRA Incidence of Each GTG in the ESSF Zone of the Nelson Forest Region (ISIS data)

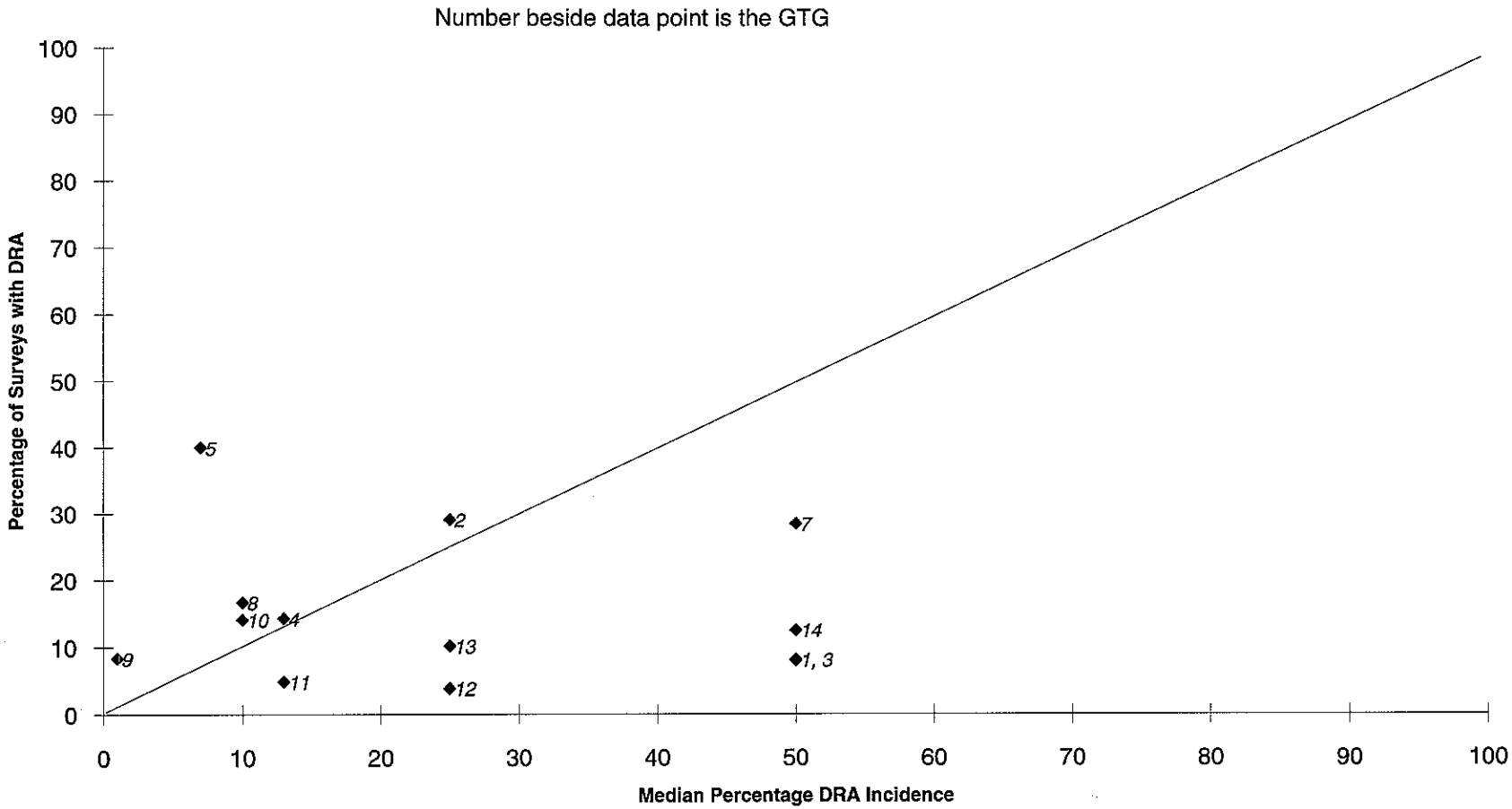


Figure 27: Mean DRA Incidence of Each GTG in the IDF Zone of the Nelson Forest Region (ISIS data)

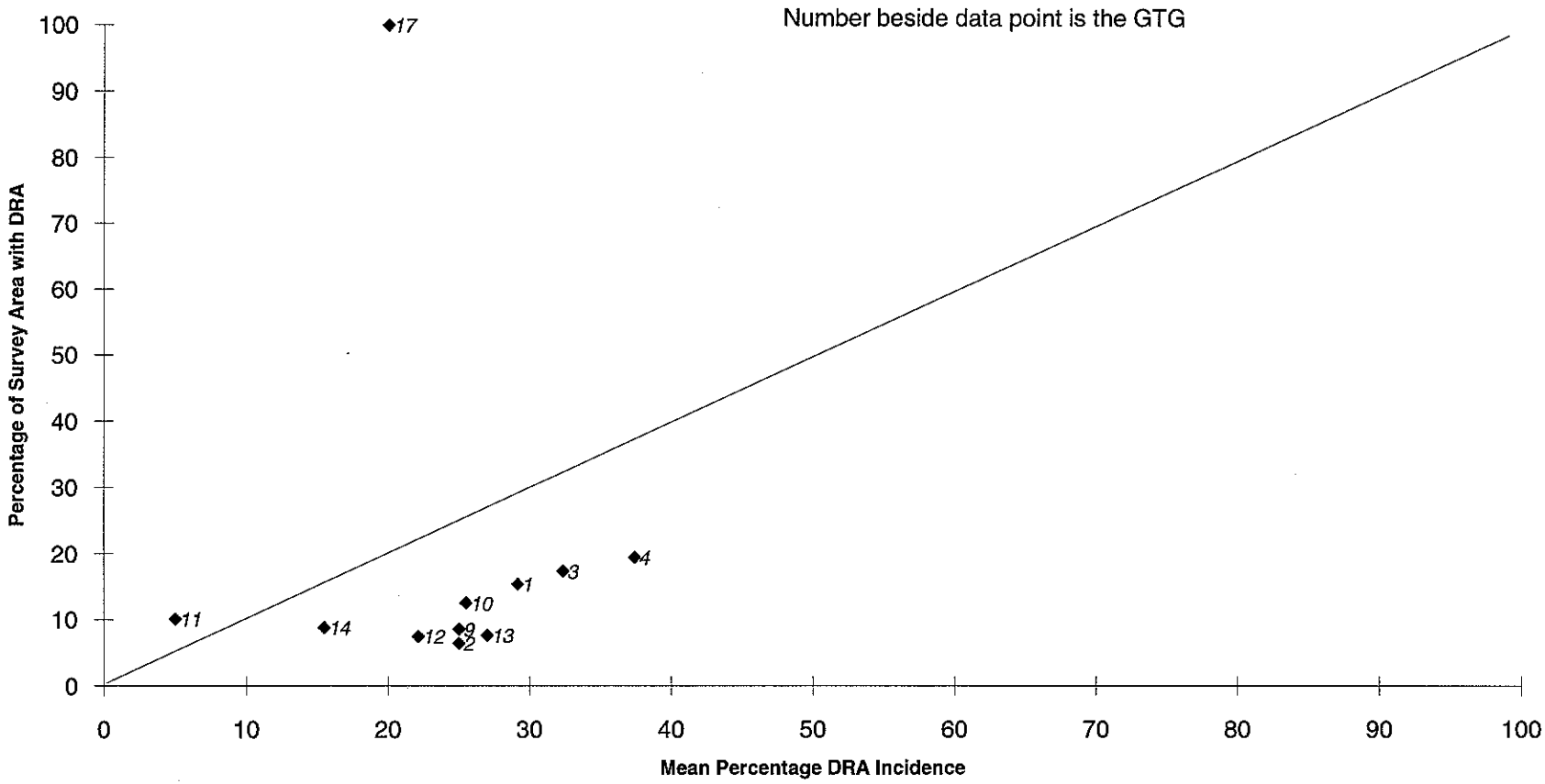


Figure 28: Median DRA Incidence of Each GTG in the IDF Zone of the Nelson Forest Region (ISIS data)

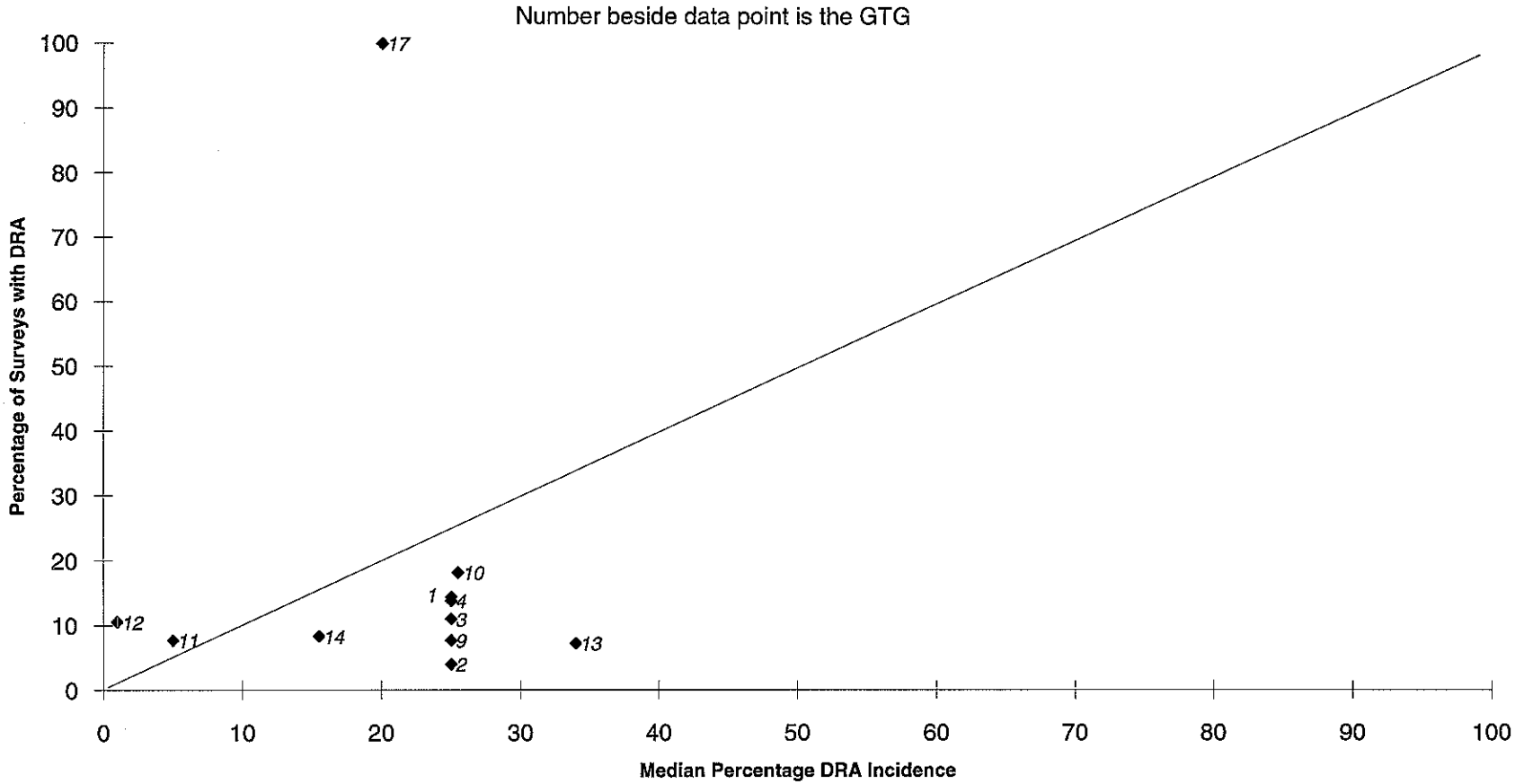


Figure 29: Mean DRA Incidence of Each GTG in the MS and PP Zones in the Nelson Forest Region (ISIS data)

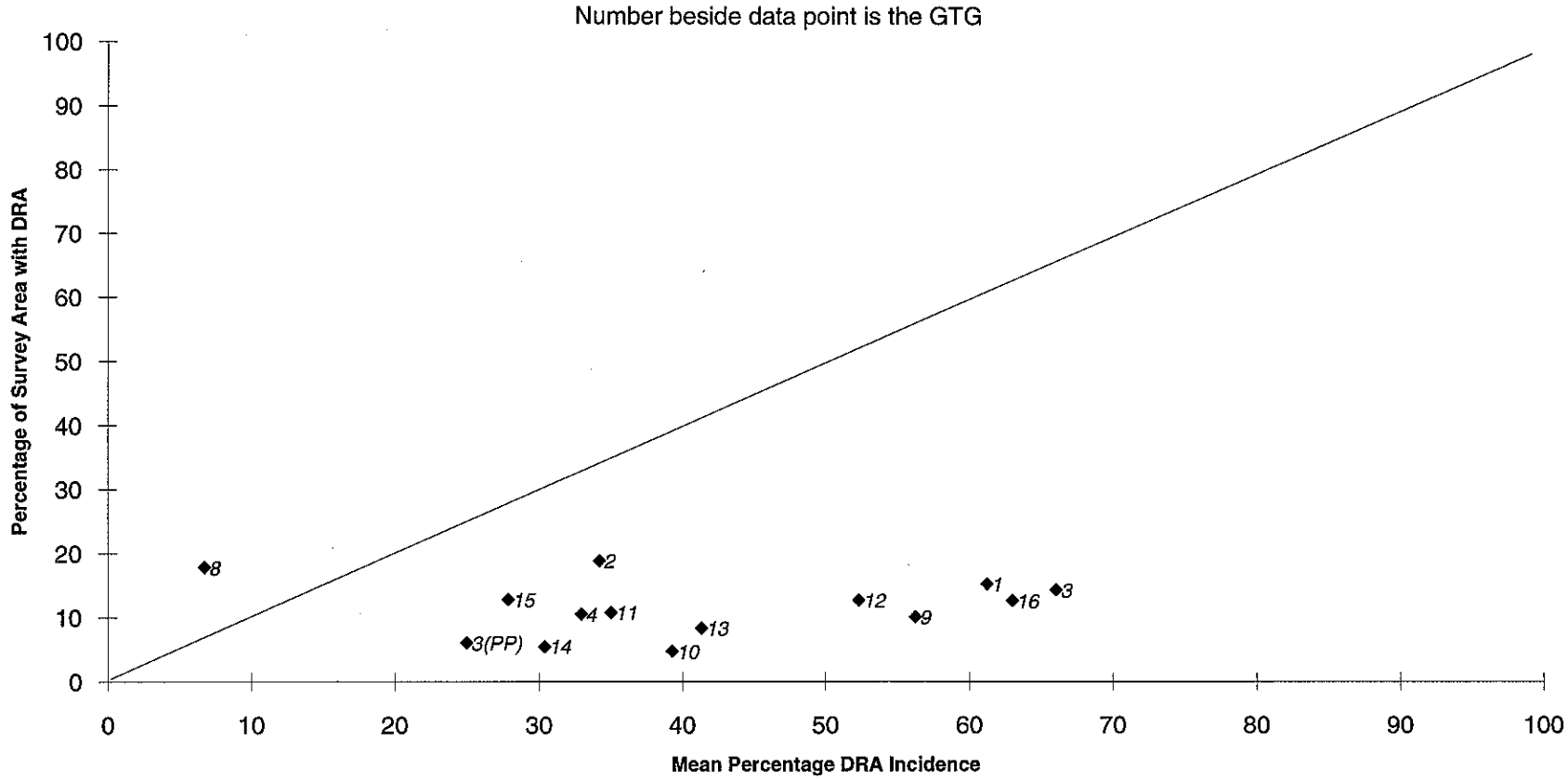
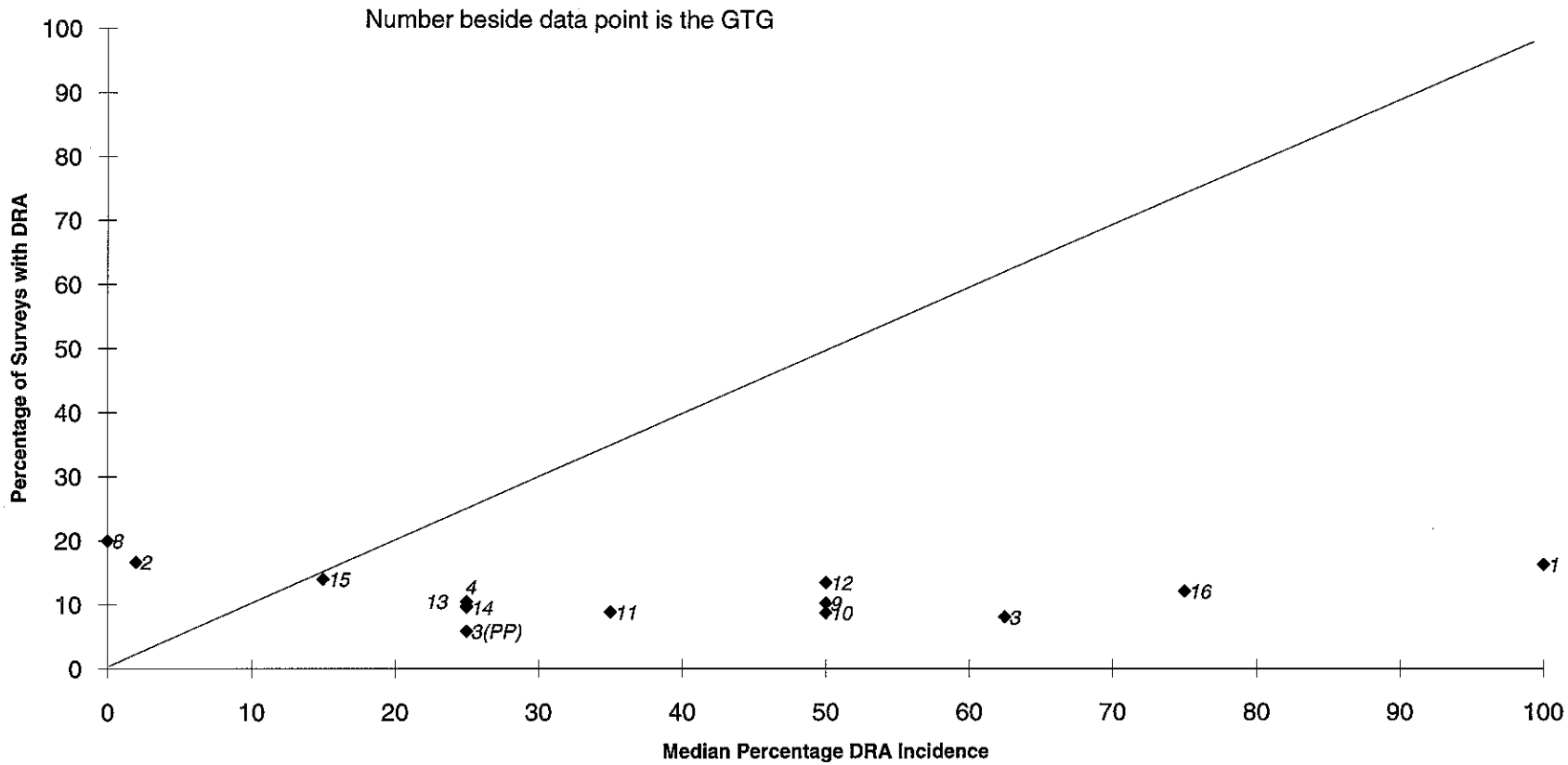


Figure 30: Median DRA Incidence of Each GTG in the MS and PP Zones of the Nelson Forest Region (ISIS data)



4.5 DRA Incidence by Age

ISIS data was analysed by the average age of the trees, normally in post-harvest conditions. The average ages were grouped into age classes for analysis purposes. These are almost identical to those used in forest inventory. The only difference occurs in age class one which includes trees from zero to twenty years of age, as opposed to one to twenty. The age classes and age class codes used in Figures 31 to 40 are identified in Table 6.

Table 6: Age Classes and Age Class Codes

Age Class Code	Age Class (years)
1	0-20
2	21-40
3	41-60
4	61-80
5	81-100
6	101-120
7	121-140
8	141-250
9	250 +

ISIS data was analysed to the zone level because there was insufficient data to analyse to the subzone level. Pixel survey data was not analysed by age class because the *average age* field was not recorded in the majority of the data.

Figure 31: Mean DRA Incidence by Age Class in the Nelson Forest Region (ISIS Data)

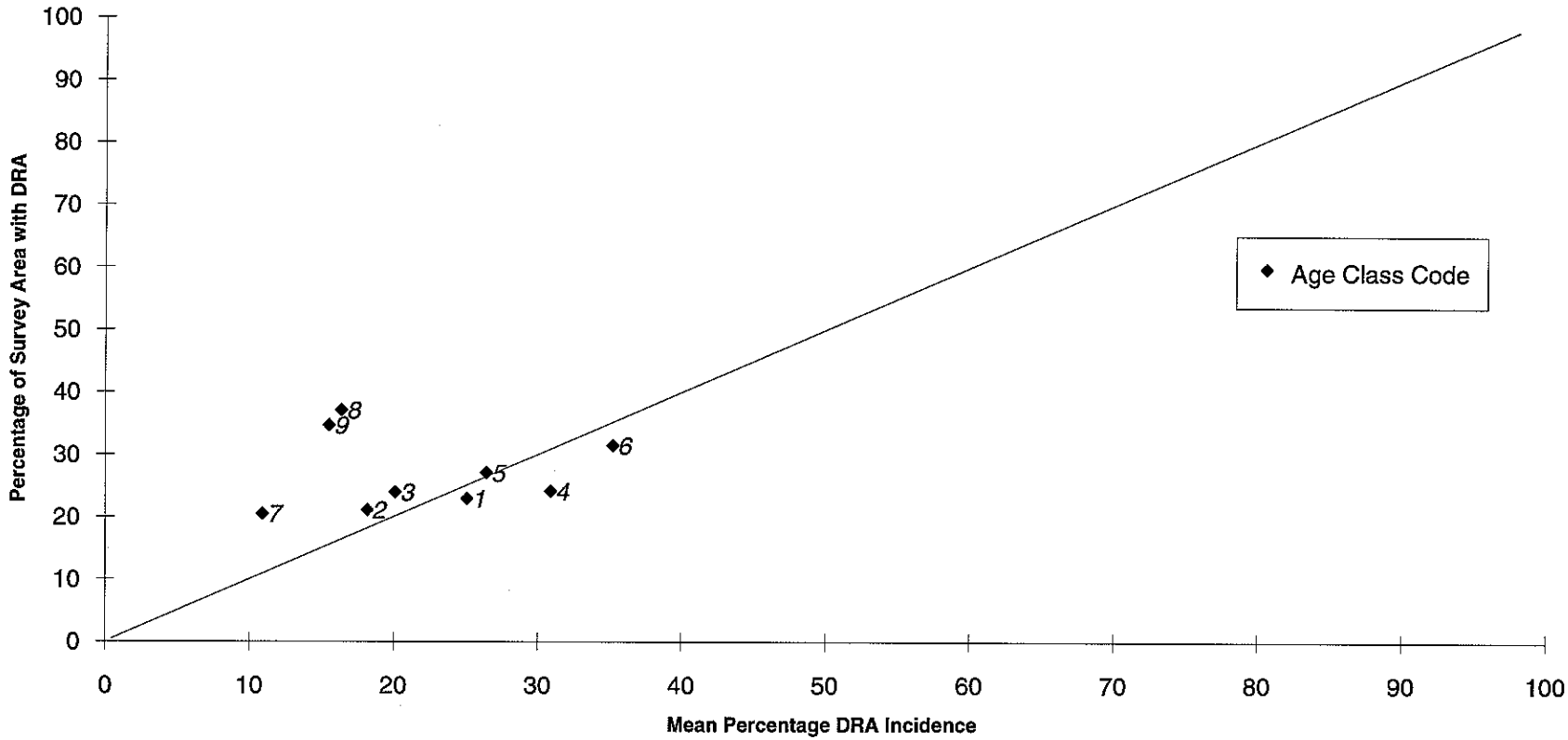


Figure 32: Median DRA Incidence by Age Class in the Nelson Forest Region (ISIS Data)

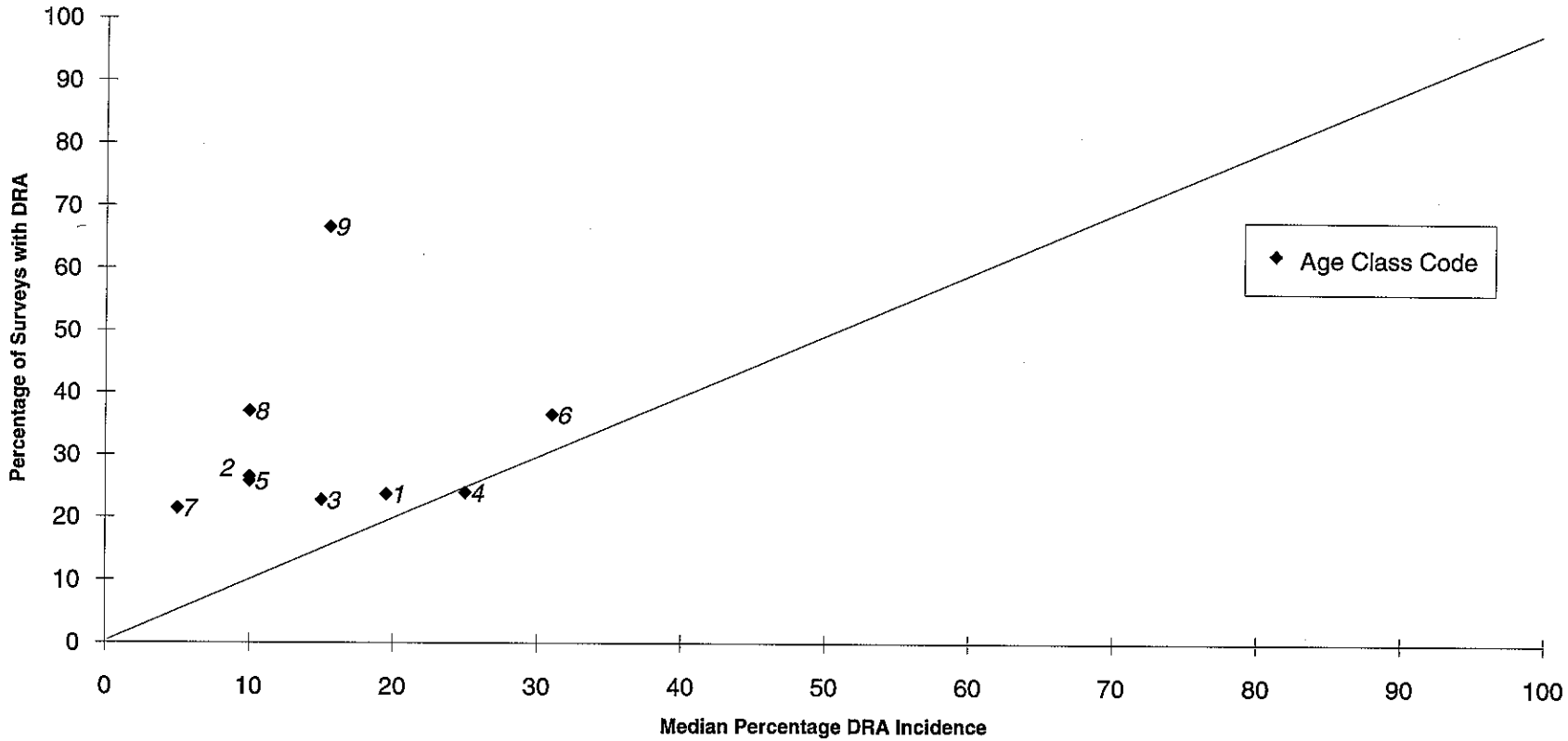


Figure 33: Mean DRA Incidence by Age Class in the ESSF Zone of the Nelson Forest Region (ISIS Data)

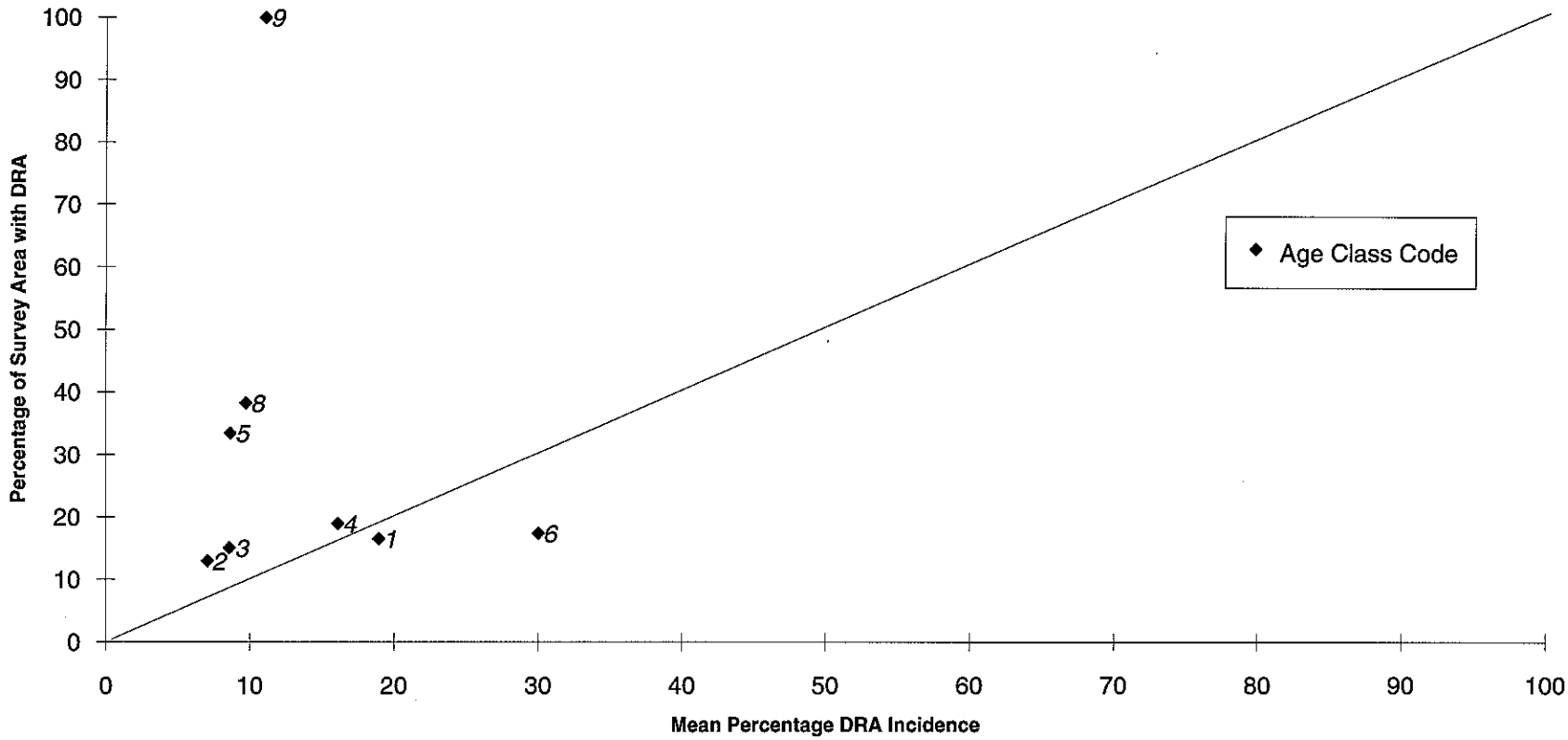


Figure 34: Median DRA Incidence by Age Class in the ESSF Zone of the Nelson Forest Region (ISIS Data)

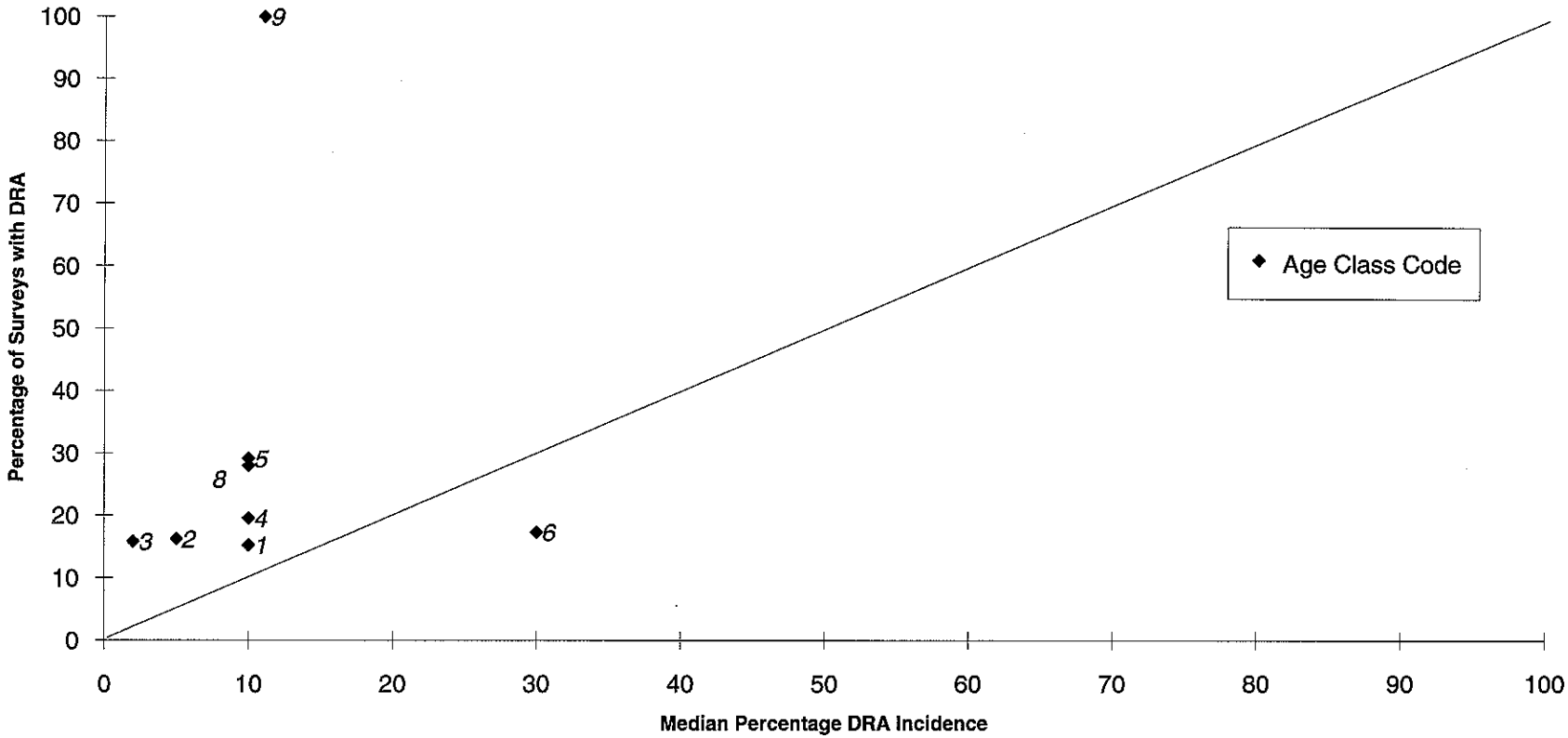


Figure 35: Mean DRA Incidence by Age Class in the ICH Zone of the Nelson Forest Region (ISIS Data)

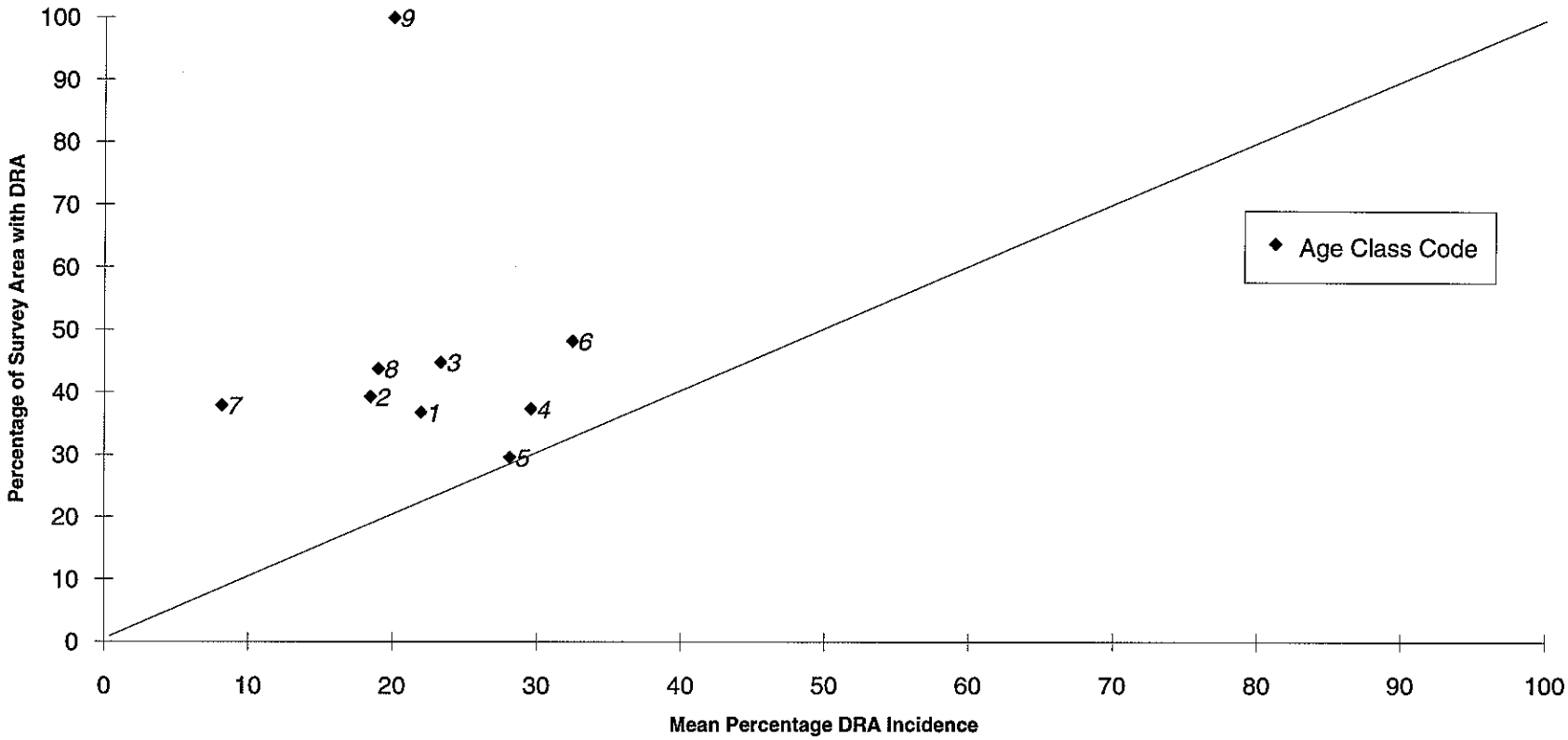


Figure 36: Median DRA Incidence by Age Class in the ICH Zone of the Nelson Forest Region (ISIS Data)

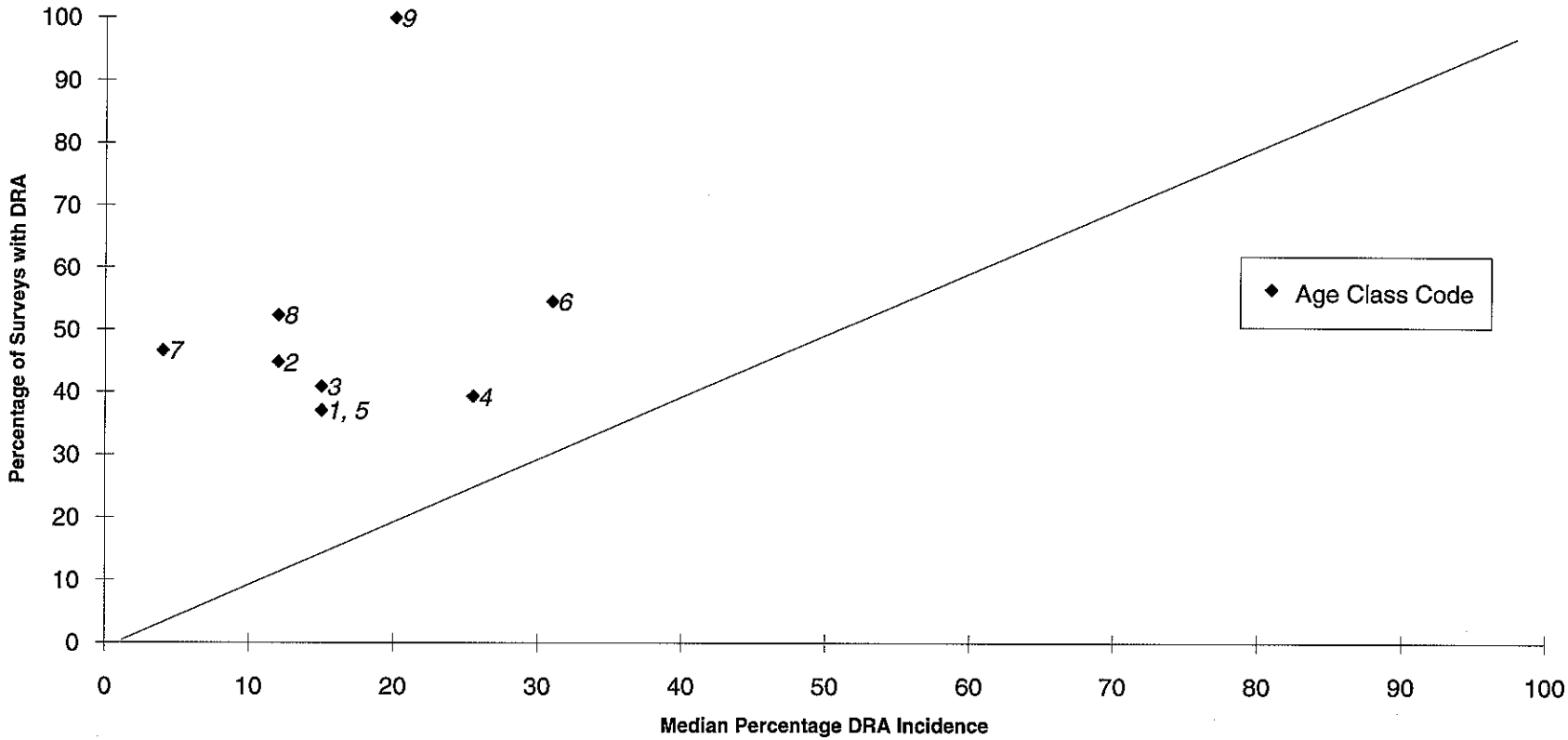


Figure 37: Mean DRA Incidence by Age Class in the IDF Zone of the Nelson Forest Region (ISIS Data)

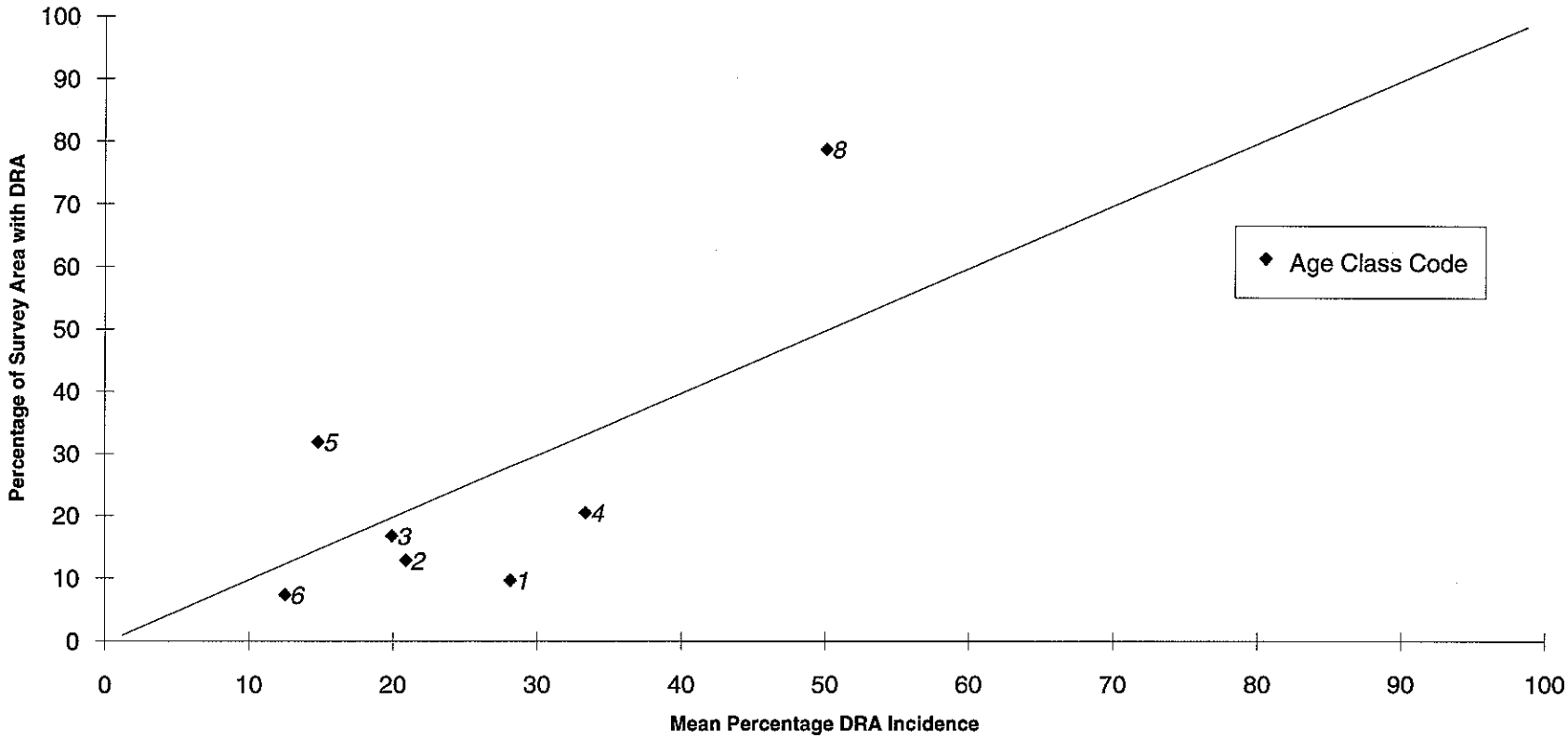


Figure 38: Median DRA Incidence by Age Class in the IDF Zone of the Nelson Forest Region (ISIS Data)

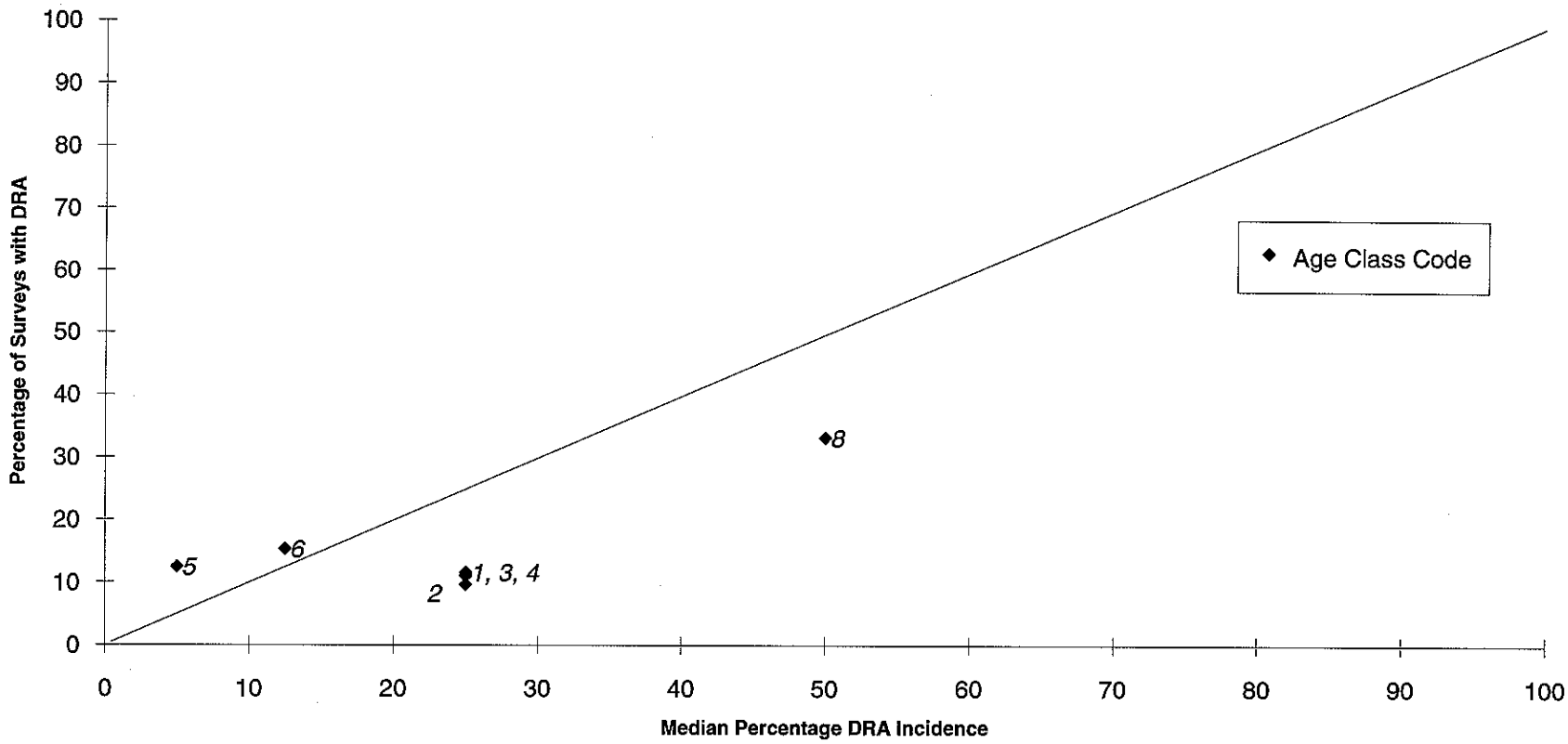


Figure 39: Mean DRA Incidence by Age Class in the MS Zone of the Nelson Forest Region (ISIS Data)

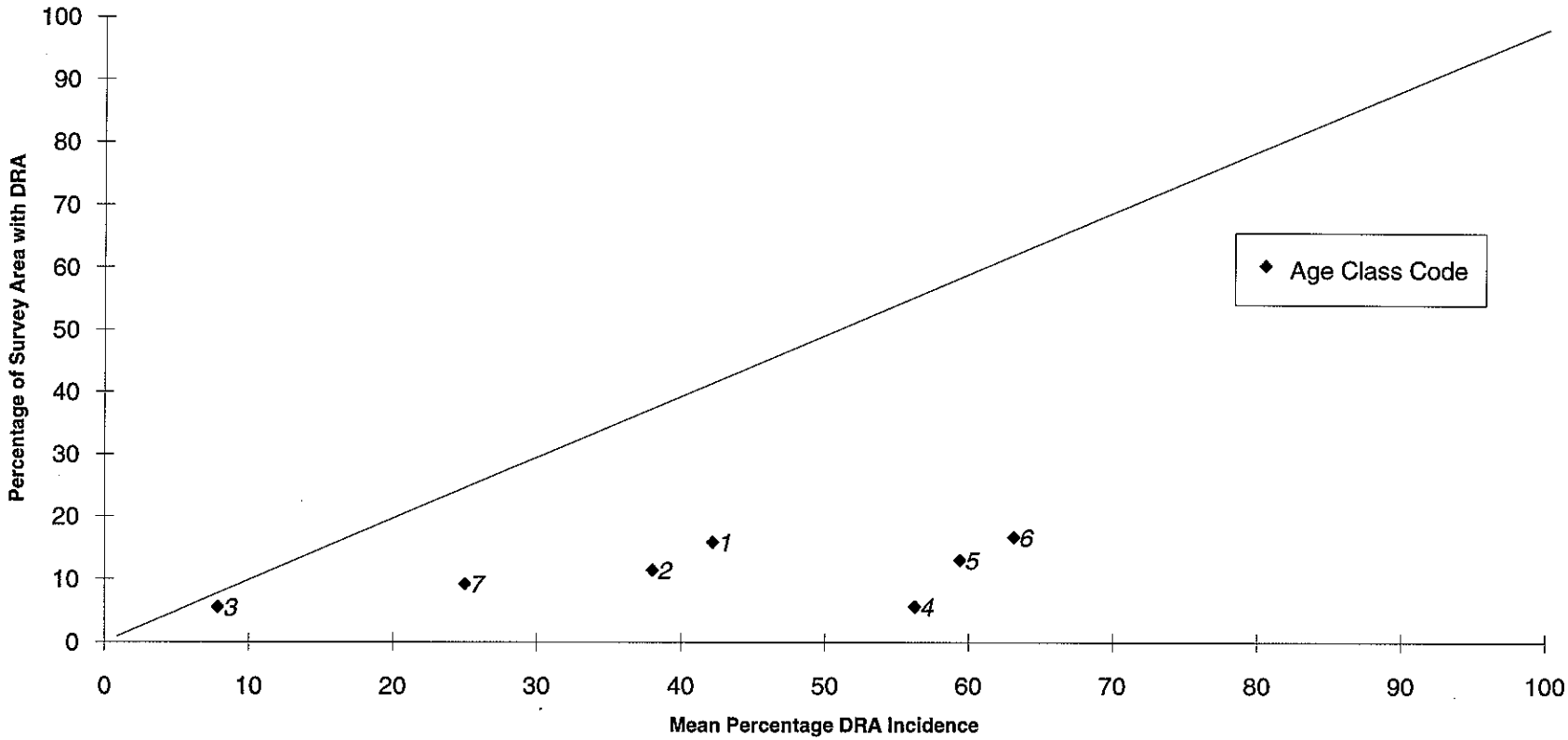
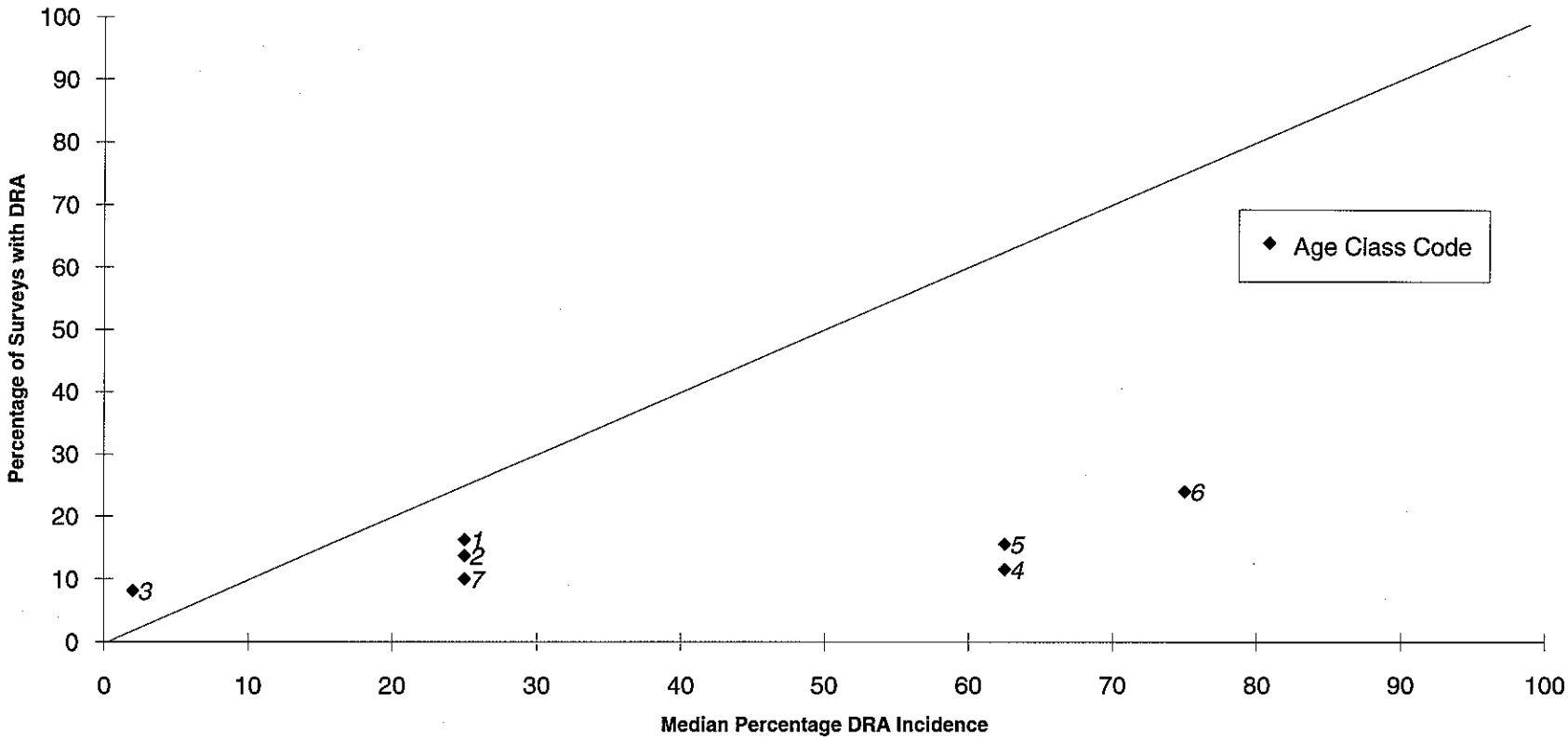


Figure 40: Median DRA Incidence by Age Class in the MS Zone in the Nelson Forest Region (ISIS Data)



5.0 Discussion

The discussion of the results of the statistical analysis and of the document comparison are presented in the following sections.

Some general interpretations of the results have been generated while keeping in mind the inherent problems in each data set. An average incidence of DRA of 24.5% was found in 20.5% of the survey area (or 19.2% of the surveys) in ISIS. An average incidence of DRA of 13.85% was found in 49% of the survey area (or 46.5% of the surveys) in the pixel survey data. DRA was found in all of the biogeoclimatic zones and subzones surveyed.

5.1 Data Interpretation

As previously mentioned, the graphs will be interpreted by a statistician at a later date. There are, however, a few observations that can be made at this point.

There is a tendency for each pair of graphs (mean, median) for each parameter to exhibit similar results. There are few similarities between ISIS and pixel survey graphs for the same parameter. This is likely a reflection of the different characteristics of the data sets.

For most of the data results, there are very large standard errors that do not appear on the graphs but will have great implications on the data interpretation.

Due to the biased nature of the data sets, the results cannot be projected onto a greater population. The extent to which the results can be interpreted in terms of distribution and incidence has not yet been determined.

5.2 Comparison with other Documents

An annotated bibliography of information accumulated by forest health staff was compiled to identify reports with similar objectives (see Appendix D). There were few direct comparisons to the results of this report, therefore, the purpose of comparison is to add information and to note trends. Perhaps the following comments would be more relevant to the interpretations made by a statistician.

A spreadsheet presenting results from a White Pine Blister Rust Survey (Rod Martin Tree Improvements, 1992) shows that the average percent incidence of DRA was 14.65% in 17 openings. Because the openings were not selected for DRA susceptibility, there is an element of randomness to the survey, however, it is not necessarily a good root rot survey.

In *Augmenting the AAC Through Pest Treatment* (MacKenzie, 1991), pest incidence percentages were not given. The most useful statistical information was the percentage of survey area and percentage of surveys that had root disease. Four biogeoclimatic units were surveyed: IDFg3, MSa, ICH, and ESSFc. The data were from an early version of the Comprehensive Pest Inventory database (Nelson Forest Region) which used suspect parameters to select survey sites. From Table 7, ESSFc, followed by ICH, is shown to have the highest proportions of infected area sampled and infected polygons sampled. The far right column is the proportion of each parameter within the suspect sample set.

Table 7: Percent of Area and Percent of Surveys Infected by DRA from *Augmenting the AAC Through Pest Treatment* (MacKenzie, 1991)

Biogeoclimatic Zone	Infected Polygons	% of polygons sampled	Area infected (ha)	% of area sampled	% of 91% suspect
IDFg3	45	41	2357.2	39	35
MSa	30	34	2251.2	46	41
ICH	127	67	4586.4	59	58
ESSFc	32	89	506.2	79	72

An informal report from Nelson Forest Region attempts to use inventory labels to estimate DRA presence instead of quantifying DRA presence from past root rot surveys. Parameters such as crown closure, presence of deciduous trees, conifer-leading and site class were used to detect DRA-suspect areas. A probability factor of 0.7 was used as it was found that 70% of the sites conferred, when sampled, with the hypothesis. Table 8 shows that the ESSF and IDF biogeoclimatic zones have the highest probability of DRA. Some problems associated with this method are the 'discrepancy sites' that are a result of incorrect inventory labeling as opposed to DRA incidence.

Table 8: DRA Probability by Biogeoclimatic Zone from *Nelson Region -Total Area Reported in SEG Files...*(Forgis Consulting and D. Norris)

Biogeoclimatic Zone	% of Total Area, DRA probable	Total Area (ha) DRA probable
IDF	60	222,763
MS	57	230,417.5
ESSF	60	977,627
ICH	48	720,892

In *Root Disease Impact Analysis in Fir Plantations of the Arrow and Kootenay Lake Timber Supply Areas* (Hopkins and Stewart, 1992), the average percent incidence of root disease in 16 ICH openings was 18.2%. This figure is not far from the ICH averages presented in the data analysis of our report despite being confined to randomly selected openings within fir plantations.

The ICH biogeoclimatic zone was the subject of *Forest Pest Risk Assessment for All Site Series and Chronosequences (Seral Stages) of the ICH Biogeoclimatic Zone* (JMJ Holdings, 1992). The report found that DRA occurred more in drier subzones within the ICH.

In the pilot project reported in *Boundary Satellite Image Forest Disease Interpretation* (Strathinnes, 1990), Western Cedar and Douglas Fir growth types were shown to have the highest occurrence of DRA.

The *Forest Level Multipest Survey Analysis Report* (Caune, 1994) analyses DRA in six ITGs in the ICHdw subzone by age class using computational severity class. The results may be compared to the final interpretation of the data presented in our report.

From analysing the Comprehensive Pest Inventory (CPI) data set for use in this report, 35 polygons in the ICH were found to have a percent incidence of DRA. The mean percent incidence was 3.74%. Of the 64 polygons in CPI with DRA (including ICH and all other zones), the mean percent incidence was 15.14% in 8.6% of all polygons.

6.0 Recommendations

The original objective of this analysis was to determine the distribution and incidence of DRA in the Nelson Forest Region based on available data. It became clear as the analysis progressed that this task was not going to be satisfactorily completed. The main problem was the limitations of the data sets as discussed in detail in Sections 2 and 3. Some of the same limitations were previously mentioned in *Augmenting the AAC Through Pest Treatment* (Mackenzie, 1991). Therefore, an important part of this analysis is to give some recommendations as to how things can be changed in the future. The following recommendations are suggested:

1) A new standard survey be designed to determine DRA (and other root disease) incidence. The pixel survey appeared inadequate at producing an accurate picture of incidence within a survey area, and also of the tree species affected within that area. The reduction of the original field data into a single statistic (percentage of pixels infected) for entry into ISIS further decreases the value of the data. DRA affects individual trees, and the reporting of incidence on a strictly spatial basis ignores the relationship between the disease and its host. The pixel survey is not sufficient for producing a data set in enough detail to allow the kind of analysis which was requested.

   Any future surveys should record the variables required to carry out a detailed statistical analysis. The most basic analysis would require the following data fields: survey location (including elevation and slope); survey area; survey intensity (percentage of total area sampled for DRA); forest cover information (ITGs or species composition); site index; site stocking; tree age and height; tree density (total stems/ha and well-spaced stems/ha); DRA incidence (preferably tallied by number of stems affected); tree species affected by DRA (host species); BEC information down to the level of subzone or variant, and, if possible, to the site series or site association, and finally; some measure of disease severity. The skill of the field surveyors in recognizing DRA is also very important. There must be adequate training available to make sure that the data entered is to a particular standard.

   Any survey areas need to be randomly selected. This is essential in order for any of the analysis results to be projected over a larger area. It must also be emphasized that surveys should be carried out in all of the biogeoclimatic zones, in proportion to the total area of the biogeoclimatic zone within the area of interest. The surveys conducted using these criteria must be of a sufficient number to permit statistical analysis.

   Finally, any data received from these surveys must be examined with the same level of scrutiny as in this report. This should be done within the first year of implementation, so the validity of the survey can be checked before it is handed over to operators in the field.

2) A standard method of data storage needs to be developed in coordination with the new survey method. This data must be stored in a form that is as close to field data as practical. The field data is mostly real data, as opposed to that which is derived from it, as in the case of pest incidence based on pixel survey data. The derived data found in ISIS has only limited value in any data analysis. It is very important that all the information be stored in one standard file type so that it will not be necessary to search through three different data sets, as occurred in the current analysis.

   Hopefully, this data set can be cross-referenced with Inventory Branch data. One problem noted during this analysis was the difficulty, or inability, in finding Inventory polygon information about Silviculture openings, and vice versa. Some linkage between the two branch databases would help in future interpretation of survey data.

3) There must be an examination of the requirements needed for data that will be used for growth and yield projections. This knowledge is essential for proper forest management, and it is not currently available. It may be necessary to set up a series of plots to monitor growth and yield within the different biogeoclimatic zones of the Nelson Forest Region.

Some of these recommendations are similar to those in *Augmenting the AAC Through Pest Treatment* (Mackenzie, 1991). It is hoped that the recommendations above will help reiterate the problems, and produce a system in the future that will allow a detailed analysis of DRA in the Nelson Forest Region. Some of the recommendations have been addressed in the new Forest Level Multi-Pest Survey (FLMPS) currently under evaluation. Unfortunately, the data received from FLMPS did not contain the raw data necessary for further analysis. FLMPS also needs to be put through the same validation procedure as in the present analysis, before it can be seen as the survey that will answer some of the questions about DRA.

Hopefully, the recommendations above will help anyone wanting to do a similar project in the future. It is extremely important that field data can be collected and stored in a way that will make it useful to regional and district managers for planning.

7.0 Conclusions

From the few interpretations of the results made in this report, DRA appears to be a problem in the Nelson Forest Region and occurs in each biogeoclimatic zone and subzone surveyed. However, based on the available data and the analyses conducted here, it is difficult to draw any firm conclusions about the distribution and incidence of DRA. Similarly, the review of documents revealed only a few to compare with the results of this report.

It was apparent during the analysis that there were many problems with the existing data sets. Inconsistencies, missing real data, biases, and incomplete records limited the problem analysis in terms of both generating results and interpretation.

The findings of this report may show the extent of DRA based on available data, but they do not reliably show the distribution and incidence of DRA in the Nelson Forest Region. Any Forest Region attempting to analyse ISIS and pixel survey data in a similar manner may encounter the same problems. The recommendations of this report identify the pixel survey method, data entry, sampling, and data variables as areas needing specific improvements.

The results of this report will be further interpreted in the near future which will assist in clarifying the quality of the data sets and to determine the sort of conclusions that can be drawn.

Perhaps now that the conditions of the existing data has been appraised, the Armillaria Research Working Group can implement changes in the methods of survey, sampling, data collection and storage.

8.0 References

A Field Guide for Site Identification and Interpretation for the Nelson Forest Region, Land Management Handbook #20, T.F. Braumandl and M.P. Curran, B.C. Ministry of Forests, May 1992.

Augmenting the AAC through Pest Treatment, Bruce MacKenzie, Ministry of Forests, Nelson Forest Region, Forest Health Program, Spring 1991.

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Detection, Recognition and Management of Armillaria and Phellinus Root Diseases in the Southern Interior of British Columbia, FRDA Report 179, Duncan Morrison, Hadrian Merler, Don Norris, September 1991.

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Impact Assessment of Armillaria Root Disease in the Nelson Region, J. Beale, January 6, 1995.

Nelson Forest Region - Total Area Reported in the SEG Files... Forgis Consulting and Don Norris, January 1995.

Personal Communication, Don Norris, Nelson Forest Region, May 17, 1995.

Relational Data Dictionary 2.0, Inventory Branch.

Root Disease Impact Analysis in Fir Plantations of the Arrow and Kootenay Lake Timber Supply Areas, Kory Hopkins and Rick Stewart, December 1992.

Appendix A: Example of Forest Health ISIS Screen

Appendix A Typical Forest Health Observation Screen in ISIS

```
    Add     Update   View     eXit     Help
--------------------------------------------------------------------------------
SUR37M01   Forest Health Observation (MFH)  M View    V 1.00.00  DB SQLP1

Opening.....> 82K 054 0.0  13          License No/Blk..> A03530
Location..... AMERICAN-HORSEFLY SLOPE     Cutting Permit..>
Open Type.... SP    Status... DFT        Gross Area (ha).. 73.0
--------------------------------------------------------------------------------
Comments. N                              Observations  1 to  2 of  2

  Observation *-- Activity --* Std  *---------- Pest ---------* (%)  Incid
Opt   Date    Base>Tech> Meth> Unt> Code Description          Incid Area (ha)
   1992 10 30  SU   FH   PLOT   1   DSB White Pine Blister Rust  61
   1992 09 16  SU   FH   PLOT   1   DRA Armillaria Root Disease  25




 MSG074I List successfully displayed
Command ===>
 F12=Cancel  F13=ATU     F14=PHSPAdm F15=RecAct  F16=PrjMgmt  F17=Audit
 F19=LandStat F21=ForCover F22=SoilDist F23=OthrKeys F24=Sendnote
```

Appendix B: ISIS and Pixel Database Fields

Appendix B

The following pages give a detailed outline of all of the fields available for query design in the databases produced in Microsoft Access®. The databases are: 1) DRA_RNE.MDB, which includes all of the openings listed in ISIS from 1990 to 1995 in the Nelson Forest Region with records of DRA, as well as the pixel survey data; and 2) NOT_DRA.MDB, which includes all of the rest of the openings listed in ISIS in the Nelson Forest Region.

Properties

Date Created:	2/10/95 11:57:54 AM	Def. Updatable:	Yes
Last Updated:	2/10/95 2:06:04 PM	Record Count:	1102

Columns

Name	Type	Size
REGION	Text	6
DISTRICT	Text	6
OPENING_SKEY	Number (Long)	4
UTM_ZONE	Number (Double)	8
UTM_EASTING	Number (Double)	8
UTM_NORTHING	Number (Double)	8
MAPSHEET_GRID	Text	8
MAPSHEET_LETTER	Text	8
MAPSHEET_SQUARE	Text	8
MAPSHEET_QUAD	Text	8
MAPSHEET_SUBQUAD	Text	8
OPENING_NUMBER	Text	7
DISTURBANCE_DATE	Text	10
DISTURBANCE_CD	Text	2
PREV_TREE_SPP1	Text	4
PREV_TREE_SPP2	Text	4
PREV_AGE_CLASS_CD	Text	5
PREV_HGHT_CLASS_CD	Text	5
PREV_STOCK_CLASS_CODE	Text	5

Properties

Date Created:	2/10/95 2:40:25 PM	Def. Updatable:	Yes
Last Updated:	2/10/95 2:41:32 PM	Record Count:	369

Columns

Name	Type	Size
OPENING_SKEY	Number (Long)	4
STOCKING_SKEY	Number (Long)	4
STOCKING_ID	Text	3

Properties

Date Created:	2/10/95 10:14:19 AM	Def. Updatable:	Yes
Last Updated:	2/10/95 11:59:28 AM	Record Count:	1081

Columns

Name	Type	Size
ECO_STRATA_SKEY	Number (Long)	4
OPENING_SKEY	Number (Long)	4
ECO_STRATA_ID	Text	6
BGC_ZONE	Text	4
BGC_SUBZONE	Text	6
BGC_VARIENT	Text	7
BGC_PHASE	Text	5
BGC_SITE_SERIES	Text	6
SITE_CLASS	Text	5

Properties

Date Created:	2/10/95 2:45:10 PM	Def. Updatable:	Yes
Last Updated:	3/14/95 11:02:22 AM	Record Count:	1102

Columns

Name	Type	Size
OPENING_SKEY	Number (Long)	4
OBSERVATION_DT	Text	10
STOCKING_SKEY	Number (Long)	4
PEST_SPECIES_CD	Text	7
PEST_INCIDENCE_PCT	Number (Single)	4
INCIDENCE_AREA	Number (Single)	4
UPDATE_TIMESTAMP	Text	10

Properties

Date Created:	2/21/95 9:56:40 AM	Def. Updatable:	Yes
Last Updated:	4/4/95 9:41:38 AM	Record Count:	3815

Columns

Name	Type	Size
OPENING_SKEY	Number (Long)	4
STOCKING_SKEY	Number (Long)	4
SILV_POLYGON_NO	Text	4
SILV_POLYGON_AREA	Number (Double)	8
SILV_POLYGON_SUFFIX	Text	1
FOR_COVER_LAYER_CD	Text	2
FOR_COVER_RANK_CD	Text	1
STOCKING_CLASS_CD	Text	3
STOCKING_TYPE_CD	Text	3
AVERAGE_AGE	Number (Single)	4
AVERAGE_HEIGHT	Number (Single)	4
TOTAL_STEMS_PER_HA	Number (Single)	4
WELL_SPACED_SPH	Number (Single)	4
TREE_SPP1	Text	3
TREE_SPP1%	Number (Single)	4
TREE_SPP2	Text	3
TREE_SPP2%	Number (Single)	4
TREE_SPP3	Text	3
TREE_SPP3%	Number (Single)	4
TREE_SPP4	Text	3
TREE_SPP4%	Number (Single)	4
TREE_SPP5	Text	3
TREE_SPP5%	Number (Single)	4
REFERENCE_YEAR	Text	4
SITE_CLASS_CODE	Text	1
INVENTORY_TYPE_GROUP	Number (Double)	8

Properties

Date Created:	2/9/95 5:19:20 PM	Def. Updatable:	Yes
Last Updated:	3/14/95 10:45:59 AM	Record Count:	6772

Columns

Name	Type	Size
OPENING_SKEY	Number (Long)	4
ACTIVITY_TU_SKEY	Number (Long)	4
ACTIVITY_TU_ID	Text	8
SILV_BASE_CODE	Text	4
ACT_TECHNIQUE_CD	Text	9
ACT_METHOD_CODE	Text	6
ACT_FUND_SRCE_CD	Text	4
ACT_TRTMNT_AMT	Number (Single)	4
ACT_COMPLETION_DT	Text	10
ECO_STRATA_SKEY	Number (Long)	4
LG_ECO_STRATA_SKEY	Number (Long)	4

Properties

Date Created:	3/7/95 10:17:41 AM	Def. Updatable:	Yes
Last Updated:	3/14/95 10:32:47 AM	Record Count:	3598

Columns

Name	Type	Size
REGION	Text	6
DISTRICT	Text	6
OPENING_SKEY	Number (Long)	4
UTM_ZONE	Number (Double)	8
UTM_EASTING	Number (Double)	8
UTM_NORTHING	Number (Double)	8
MAPSHEET_GRID	Text	3
MAPSHEET_LETTER	Text	1
MAPSHEET_SQUARE	Text	3
MAPSHEET_QUAD	Text	1
MAPSHEET_SUBQUAD	Text	1
OPENING_NUMBER	Text	4
DISTURBANCE_DATE	Text	10
DISTURBANCE_CD	Text	1
PREV_TREE_SPP1	Text	4
PREV_TREE_SPP2	Text	4
PREV_AGE_CLASS_CD	Text	1
PREV_HGHT_CLASS_CD	Text	1
PREV_STOCK_CLASS_CODE	Text	1

Properties

Date Created:	3/7/95 10:18:10 AM	Def. Updatable:	Yes
Last Updated:	3/7/95 9:57:06 AM	Record Count:	4212

Columns

Name	Type	Size
ECO_STRATA_SKEY	Number (Long)	4
OPENING_SKEY	Number (Long)	4
ECO_STRATA_ID	Text	1
BGC_ZONE	Text	4
BGC_SUBZONE	Text	6
BGC_VARIENT	Text	1
BGC_PHASE	Text	1
BGC_SITE_SERIES	Text	2
SITE_CLASS	Text	1

Properties

Date Created:	3/7/95 10:14:55 AM	Def. Updatable:	Yes
Last Updated:	4/27/95 3:09:47 PM	Record Count:	12843

Columns

Name	Type	Size
OPENING_SKEY	Number (Long)	4
STOCKING_SKEY	Number (Long)	4
SILV_POLYGON_NO	Text	4
SILV_POLYGON_AREA	Number (Double)	8
SILV_POLYGON_SUFFIX	Text	1
FOR_COVER_LAYER_CD	Text	2
FOR_COVER_RANK_CD	Text	1
STOCKING_CLASS_CD	Text	3
STOCKING_TYPE_CD	Text	3
AVERAGE_AGE	Number (Single)	4
AVERAGE_HEIGHT	Number (Single)	4
TOTAL_STEMS_PER_HA	Number (Single)	4
WELL_SPACED_SPH	Number (Single)	4
TREE_SPP1	Text	3
TREE_SPP1%	Number (Single)	4
TREE_SPP2	Text	3
TREE_SPP2%	Number (Single)	4
TREE_SPP3	Text	3
TREE_SPP3%	Number (Single)	4
TREE_SPP4	Text	3
TREE_SPP4%	Number (Single)	4
TREE_SPP5	Text	3
TREE_SPP5%	Number (Single)	4
REFERENCE_YEAR	Text	4
SITE_CLASS_CODE	Text	1
INVENTORY_TYPE_GROUP	Number (Double)	8

Properties

Date Created:	2/21/95 9:49:12 AM	Def. Updatable:	Yes
Last Updated:	4/7/95 10:41:46 AM	Record Count:	461

Columns

Name	Type	Size
ID	Number (Long)	4
REGION	Text	50
DISTRICT	Text	50
UTM_ZONE	Number (Double)	8
UTM_EASTING	Number (Double)	8
UTM_NORTHING	Number (Double)	8
MAPSHEET_GRID	Text	50
MAPSHEET_LETTER	Text	50
MAPSHEET_SQUARE	Text	50
MAPSHEET_QUAD	Text	50
MAPSHEET_SUBQUAD	Text	50
OPENING_NUMBER	Text	50
SILV_POLYGON_NO	Text	50
SILV_POLYGON_AREA	Number (Double)	8
AVERAGE_AGE	Number (Double)	8
AVERAGE_HEIGHT	Number (Double)	8
TOTAL_STEMS_PER_HA	Number (Double)	8
WELL_SPACED_SPH	Number (Double)	8
INCIDENCE_AREA	Number (Double)	8
PEST_INCIDENCE_PCT	Text	50
BGC_ZONE	Text	50
BGC_SUBZONE	Text	50
BGC_VARIANT	Text	50
BGC_PHASE	Text	50
BGC_SITE_SERIES	Text	50
SITE_CLASS_CODE	Text	50
REFERENCE_YEAR	Number (Double)	8
INVENTORY_TYPE_GROUP	Number (Double)	8
ANALYSIS_UNITS	Text	50
COMMENTS	Text	50

Appendix C: Detailed Methods of Analyses

Notes on Data Manipulation for Figures 1 and 2.

STEP 1 Query Design for Pest Incidence (Microsoft Access®)

The query design to determine pest incidence by BEC zone and subzone was based on three tables from the *DRA_RNE* database of ISIS data made by Mei Ching. The three tables were: *Ecostrata Information for DRA, PHSP or Observed Pest DRA*, and *Forest Cover with DRA*. Query column headings were: BGC Zone, BGC Subzone, Opening 'Skey', Update Time Stamp, and Pest Incidence. The linking field was Opening Skey and all fields were sorted in ascending order. Unique values for query properties was used. This made a query of 888 records called *bgc and pest incidence ap 16/03*.

The field 'Polygon Numbers' was not included because **all of the polygons from the same opening had the same pest incidence**. These would have needed averaging but the same was accomplished by having only one record per opening.

STEP 2 Editing Query Output(Microsoft Excel)

The 888 records were reduced by **removing all but the most recent record for each opening**. The rationale for this was gained from looking back into the database where it was shown that the different dates/pest incidences were for the same polygon (area) and therefore only one could be used.

There were some records that had the same date, same polygon, but different pest incidence. In this case, **only the first of the two records was used because it was the most recent entry** in the original ISIS database. Perhaps the more recent entry was a correction.

The final record count was 780 (or 780 openings) which was achieved by deleting older records that were for the same physical area (bgccompl.xls).

Many records had old subzone/variant codes and needed updating which would have been easier if the BGC variant field was included in the query.

STEP 3 Query Design for Survey Area with DRA (Microsoft Access)

Two queries were needed to calculate the Survey Area with DRA (area of DRA infected openings surveyed divided by the total area surveyed). The only difference between the two queries were the databases used (*DRA_RNE* and *NOT_DRA*). This resulted in all the unique area values in hectares for DRA and non-DRA infected polygons.

Both queries had the same design using two database tables. The tables used were *Ecostrata Information for DRA/Ecostrata Not DRA,* and *Forest Cover with DRA/Forest Cover Not DRA* with a linkage field of 'Opening Skey'. The fields were BGC Zone, BGC Subzone, Opening Skey, Silviculture Polygon Number, and Silviculture Polygon Area. All fields were in ascending order and unique values for query properties were used. *(bgc and pest incidence for area; bgc_areas_ap)*

Many records had old subzone/variant codes and needed updating which would have been easier if the BGC variant field was included in the query.

STEP 4 Final Table (Microsoft Excel)

From the first spreadsheet (pest incidence), the mean, standard error, standard deviation, minimum and maximum, and number of records (openings) were calculated using the 'analysis tools' function. **Any BGC Subzones that had only one record were not calculated separately** but were absorbed into the relevant BGC Zone.

From the second spreadsheet (proportion), the hectares for each zone and subzone were totaled. **To calculate the proportion, the area affected by DRA was divided by the total area of each zone and subzone**. The figure is the percent of surveyed area infected with DRA (or 'proportion').

The final figures (*dra_area.xls* and *nodrarea.xls*) from both queries were arranged on a spreadsheet (*bgcarea.xls*) by zone and subzone.

Figure Update:

Later in the study, it was determined that the median, quartiles, and percentage of surveys with DRA was required. The Not_DRA database was used to determine the number of surveys without DRA (*bfc_area.xls*). The number of surveys with DRA was already known and the median and quartiles were calculated in *bgccomp2.xls*. The final proportions from both DRA and Not-DRA are in a spreadsheet, *bgcisare.xls.*

Notes on inconsistencies:

- there are some records with the same date, same polygon with different pest incidence
- there are 0% incidence in some DRA infected sites
- there are more recent records in the database tables from Mei Ching than in the ISIS database
- why does the pest incidence fluctuate?

Notes on Data Manipulation for Figures 3 and 4.

The source of data came from the Microsoft Access table *Pixel Survey Data* in the *DRA_RNE* database. Ken White made the table from three pixel survey files, one each from Arrow, Cranbrook, and Invermere Forest Districts.

Three records did not have a BGC zone or subzone assigned so they were deleted from the subsequent queries. Less than 10 records had no pest incidence value assigned so these were filled in with zero values. One record had 5-10 percent pest incidence. This was either an expression of range or a typo for 5.10%. The **value was updated to be 5.10%.**

Query #1 All pixel survey data (Proportion).

A query (*pixel_bgc_01_ap_with isis*) from the Pixel Survey Data table was made using *BGC Zone, BGC Subzone, BGC Variant, Mapsheet Letter, Mapsheet Square, Mapsheet Subquad, Opening Number, Silviculture Polygon Number, Silviculture Polygon Area, Pest Incidence Percent, Reference Year,* and *District.* Some of these fields were not yet required but were included for future reference.

The query was saved to MS Excel (*t2adata.xls*) where some BGC subzone/variants were updated before running statistics with the *analysis tools* function. The results were saved on a separate spreadsheet. The **records totaled 458**. This is total pixel survey data set to be used for the proportion calculations.

Query #2 Pixel Survey Data with ISIS overlap records and zero percent pest incidence values removed.

Using the table created in the second query, the *Pest Incidence Percent* field was given the criteria to recognize values over zero. The resulting query (*pixel no isis no zero values*) of **213 records** was exported to MS Excel® (*t2cdata*) and analyzed.

The data from both queries was put on a spreadsheet (*pixprop.xls*) to calculate the proportions, etc.

ISIS ITG Table Production (Figures 5 and 6).

Assumptions made during production of the ITG Table. There were several assumptions made when dealing with the data that had been pulled from ISIS. The first was that the data recorded were accurate. I feel that since we have used data recorded after 1990, most of it was accurate. When assigning ITGs and getting the mean percentages, we have used the most recent record when multiple records were available. This was found to be necessary, as some areas had been surveyed at different times. There was often a discrepancy between the pest incidence percentages recorded for these different time periods. Sometimes the difference was minor, and other times it was quite significant. The reason behind these discrepancies is not clear.

Query Design for the ITG Table. The process of assigning ITGs consumed a large part of the time required to complete this table. The ITGs were derived by hand from tables provided by Inventory Branch. This was done to the records from both the RNE_DRA and RNE_NODRA databases. The data in these databases were first sorted by tree species 1, and then by tree species 2, both in ascending alphabetical order. This sped up the coding process substantially. The fields included in the query to obtain this information were: **District**, **Mapsheet Grid**, **Mapsheet Letter**, **Mapsheet Square**, **Opening Number**, **Silv. Polygon No.**, **Silv. Polygon Area**, **Silv. Polygon Suffix**, **Tree Spp 1**, **Tree Spp 1%**, **Tree Spp 2**, **Tree Spp 2%**, **and Site Class Code**. These were taken from the tables *Forest Cover with DRA*, and *Opening Info with DRA*.

There was a total of 1617 records, once the unique records option was chosen in Microsoft Access®. A similar query was used to assign ITGs to the non-DRA openings. All of the ITGs were derived from inventory surveys. When there were multiple layers listed, only the base layer was used to calculate mean percent incidence. In other words, the Forest Cover Layer Code field had the criteria set as "Is Null". This means that only records where this column was blank would show up. I made sure to include the polygon area field, so that this information could be included in the final table (as part of the proportion statistic).

In order to get the mean and median percent incidence, it was necessary to make a second query with the following fields: **District**, **Opening Number**, **Silv. Polygon No.**, **Silv. Polygon Area**, **Inventory Type Group**, **Update Timestamp**, **Pest Incidence Pct**, and **Opening Skey**. These were taken from the *PHSP or Observed Pest DRA* table, and the query, *Step 8:ISIS data sorted by ITG code*. This query also had a total of 1617 records.

Pixel Survey ITG Table Production-(Figures 7 and 8).

The same assumptions were made during the production of this table as with the ISIS data table. The amount of data was much less (461 records), and quite a few of these (117 records) were duplicate records with the ISIS data. There was also some data which were deleted, usually where there was no forest cover information to derive an ITG.

The reasons for this varied, but there were some cases where the openings listed had multiple polygons, each with different forest cover data. Since these openings had pest incidence at the opening level, we could not pick one of the polygons forest cover data over any other set. Finding the ITG codes, and entering them, proved to be quite a difficult task. ISIS had to be searched for many of the openings, because the original data obtained from the Invermere and Arrow Forest Districts did not contain ITGs.

When the records which were duplicated in ISIS, and those which had no forest cover information were eliminated, there were only 179 records left. There were some of these records which had no pest incidence. I was unsure whether to include these in the calculation of the mean percent pest incidence. If they were included, that would make the pixel survey data treatment different from the ISIS data treatment. There was no proportion statistic included, as **all** of the area for which we have data was surveyed by pixel survey. The query ran on the pixel survey data consisted of simply sorting the database by ITG in ascending order. The portion of the table which had ITGs was copied over into Microsoft Excel®, where the duplicate records were eliminated. The data were then analyzed using the descriptive statistics add-on feature in Microsoft Excel®.

Notes on Data Manipulation for Figures 11 and 12.

1. DRA Incidence

There are 461 pixel survey entries in Pixel Survey Data in the *DRA_RNE* database. A query (*pixden1*) was made to remove records with >0 stems per ha and/or >0% pest incidence. There were no records with 0 stems per hectare, the purpose was to select records with a value entered in that field.

Therefore, the total records with values in both total stems per hectare and percent pest incidence was 102 polygons. This was exported to MS Excel as *pixden2.xls* for analysis.

2. Proportion

Using the pixel survey database, a query was made for pest incidence (=0), total stems per hectare, and polygon area. All records with a blank entry for density were removed bringing the total to 46 records. These areas were added to the areas of the >0 pest incidence to arrive at the total area surveyed for each density group. (*pixden0.xls*)

Notes on Data Manipulation for Figures 9, 10, 13 to 20.

1. Query called *densitya* with 4366 records made from *Forest Cover with DRA* and *PHSP or Observed Pest DRA*. Fields are: *For_Cover_Layer, Opening_Skey, Silv_Polygon _No, Silv_Polygon _Area, Total_Stems_Per_Ha, Reference_Year, Pest_Incidence_Pct, Update_Timestamp,* and *Stocking_Class_Code.* Query is sorted by *Forest Cover Layer* field.

2. Exported to MS Excel (*densitya.xls*) to remove Silviculture entries **(removed S,1S etc. from Forest Cover Layer)** 2929 records.

3. Imported to access as densitya table.

4. Query called *density b* made to sort on stocking class.

5. Moved to MS Excel as *density b*. xls to **remove: np, s, u r, or, m g, a, and af from the stocking class column as non-forest areas** now 2336 records

6. Imported to access as *densityb1*.

7. Query called *densityc* made to sort by opening number.

8. Moved to MS Excel as *density c.xls*
   - **records of same area from earlier years were deleted**
   - **records treated individually if different areas or density in same polygon** (maybe a different polygon suffix) **or if an even aged stand**
   - added layers together for each polygon with the same area into new field called *polygon total stems per ha*
   - **records were deleted if the same density for two layers indicating already summed**
   - now 2080 records
   - **deleted** records of the same polygon, density, date but different pest incidence by matching polygon area with pest incidence area or by averaging pest incidences for the same polygon

9. Now 2024 records (*densityc1* in Access)

10. Made a query (*totdenisis*) to delete *Forest Cover Layer* and *Total Stems/ha* columns because they are now represented by new column and used Unique Values Filter
    - now at 1958 records

11. Moved to MS Excel as *totdenisis.xls* for statistics by density class and deleted null value polygon total stems per hectare as they are not a total value
    - now 1981 files

12. Returned to *totdenisis* query and added BGC zones in a new query with *Ecostrata* table (*DensityISIS*)

13. Moved to MS Excel as *densityi.xls* to calculate statistics by BGC and deleted null value polygon total stems per hectare as they are not a total value

14. **now 1813 records**

PROPORTION

A To determine the total area of non-DRA within each density class, the same steps were used to reduce the database as with the DRA database, therefore:
- delete the silviculture records, delete the non-forest areas
- add layers of each polygon (forest layer code)
- no additional deletions are needed because there is no pest incidence related to this data set. (*tree_den.xls*).

B The area and number of surveys by BGC was done in *nondenb.xls* (6767 records). Calculations by density class were done in *tree_den.xls.*

C The total areas within each density class and BEC can then be added to arrive at the denominator for proportion. The results are in *propoisis.xls.*

ICH ITG Table Production (Figures 21 and 22).

This table was designed by similar methods as the ITG table which included all BEC zones. The primary difference was the query was sorted by BEC zones, and then only the ICH areas were chosen to be shown. Another difference was that it was not necessary to generate ITGs, as this had already been done. This shortened the time required to set up this table considerably. This query was then linked to the pest incidence in the *PHSP or Observed Pest DRA* table in order to get the mean and median percentage pest incidence.

Other Problems. It is still not clear if the use of mean percentage pest incidence as an indicator of pest occurrence is valid. I believe that it can be used to give an indication of pest incidence, but it **cannot** be used to produce the area infested simply by multiplying the total area surveyed by the mean percentage pest incidence. This is due to the fact that the areas from which these percentages were derived are not the same size.

The statistic "proportion" is only useful in giving an idea of how much of the area surveyed contained **some** amount of DRA, versus the areas which had **no** DRA. For example, one could say that in the Nelson Forest Region, 19.8% of the area surveyed in ISIS within ITG 1 contained DRA. Of this area, the mean percentage pest incidence was 40.45%.

GTG by BEC zone table production (Figures 23 to 30).

This table used only ISIS data, as the pixel survey data contained too few records for any meaningful statistics to be produced. The procedure was quite similar to the ITG table production, with a few changes.

The same query (*Step 8:ISIS data sorted by ITG code*) was used, except that the BEC zone field was added, and then this field had the criterion set as the BEC zone of interest. This was exported to Microsoft Excel® and duplicate records were eliminated as before. This dataset was then exported back to Microsoft Access®, and sorted by ITG. This was then put back into Microsoft Excel®, and the ITG data was sorted into GTGs. This meant copying and pasting pest incidences and polygon areas, and then doing the necessary statistics to get the data needed. In order to produce the percentage of surveys with DRA and percentage of survey area with DRA statistic, it was necessary to sort the nonDRA database by BEC zone and ITG, and then to export this information to Microsoft Excel®. Here it was grouped into GTGs within each BEC zone, and total number of surveys and total area surveyed was found.

Notes on Data Manipulation for Figures 31 to 40

1. A query (*age1*) was made using DRA_RNE database tables *Ecostrata Information for DRA, PHSP or Observed Pest DRA*, and *Forest Cover with DRA*. The query fields were: *BGC_Zone, BGC_Subzone, BGC_Varient, Average_Age, Pest_Incidence, Opening_Skey, Silv_Polygon_Number, Silv_Polygon_Area, For_Cover_Layer, Stocking_Class*, and *Inventory_Type*. The *unique values* query property was used. There were 4480 records in the query.

2. The file was sorted on *Forest Cover Layer* and exported to Excel (*age1.xls*). All the S, 1S, 2S, 3S, and 4S records were deleted. (2994 records)

3. The file was returned to Access (*age11*) and a query (*age2*) was made to remove the *Forest Cover Layer* field and sort on *Stocking Class*. Next it was exported to Excel (*age2.xls*).

4. All records with np, s, u, r, or , m g, a, and af in the *Stocking Class* field were deleted. (2390 records)

5. The file was returned to Access (*age21*) and a query (*age3*) was made to sort by BGC zone (there were not enough records to go to the subzone layer) and it was exported to Excel (*age4b.xls*) for analysis.

6. A second query (*age4*) was made with the *age21* table to sort by average age (for analysis by age for the entire region) and exported to Excel as *age4.xls* for analysis.

7. Proportional statistics were gained by using the *Not_DRA* database and following the same steps outlined above. Two files resulted: *nonagef1.xls* (by age) and *nonagef2.xls* (by *BGC Zone*). Proportions were calculated in *isisprop.xls* in the age directory.

Appendix D: Summary of Documents from the Nelson Forest Region

Summary of Documents from the Nelson Forest Region

Note: Comments regarding usefulness or relevance of reports correspond to a specific search for distribution and incidence of DRA data in the Nelson Forest Region and do not attempt to evaluate the quality of the document.

A Cost Benefit Analysis of Root Disease Management Options, Bruce MacKenzie, Summer 1991.

"The goal of this study is to explore the relative worthiness of several root disease management techniques by simulating their effects in two common root disease management situations."

This report has a good analysis of the success of root rot management options, but there is no discussion of incidence or distribution of DRA.

*A Preliminary Investigation of the Effects of **Armillaria ostoyae** on Stand Productivity in the Golden Timber Supply Area*, Laird Pittman, 1989.

"The purpose of this report is to describe the results of a preliminary investigation of the effects of Armillaria root disease on stand productivity within the Golden T.S.A. The disease is described in terms of disease impact, disease behaviour and symptomatology, treatment of infected stands, and economic implications."

Line intersect surveys were used in the ICH zone to give the DRA percent infection and location. The data and maps presented in the appendices might be useful in adding to our database, although opening numbers are not given. (Maps showing proximity of infection levels within each area; maps of line intersect survey layout for each location; maps indicating plot location for each infection level; plot information; results of statistical analysis of plot information; map of study locations.)

A Report Concerning Forest Health Issues in British Columbia, Fred Marshall, 1991.

This report "discusses several issues with emphasis on the practical and philosophical aspects of forest health plans, and the decision making process relative to forest management issues that are inherently involved with forest health problems. The Ministry of Forests has and utilizes various techniques in this regard, and examples of these are summarized in this report". There are some very general, broad statistics on 'forest pest losses'.

Armillaria - Regeneration Survey: Golden TSA, Draft, Laing and McCulloch Forest Management Services, 1987.

The report gives the results of "...a combination Armillaria-Regeneration Survey of 16 openings in the Golden Timber Supply Area".

This pilot project, conducted in ICH and ESSF zones, found 63% confirmed infection. The data are summarized and appended, and may be useful if this information is not already in CPI or ISIS. ('Block Summaries by Infection Classes').

Armillaria Root Rot in the Nelson Region, Emile Begin, Correspondence to J. Beale. November 17, 1992.

Preliminary results from 3000 ha of root rot pixel surveys in Invermere Forest District indicate that the entire area is heavily infected with DRA. Approximately 50,000 ha (22% of the operable land base) may contain DRA.

Augmenting the AAC Through Pest Treatment, Ministry of Forests, Nelson Forest Region, Forest Health Program, Spring 1991.

"The two main objectives of this study are to provide an accurate picture of the incidence of pests in the Nelson Forest Region, and to estimate the impacts these pests are having on timber productivity."

This report combines information from the MOF, Inventory Branch database and the Comprehensive Pest Inventory database in Nelson Forest Region. Four biogeoclimatic zones, ICH, MS, IDF, and ESSF, covering 429 polygons were ground surveyed for root disease incidence. The data are projected upon all suspect forested land in the Nelson Forest Region. There are some good graphs and general statistics about root rot (not necessarily DRA) incidence, but no detailed sets of data. There should be opportunities for comparisons with the data analysis produced by this office.

Available DRA Information in Nelson Forest Region (DRA2.xls)

This is a useful four page MS Excel spreadsheet print-out summarizing surveys completed in the past decade, and who to contact for more information.

Blister Rust Surveys, Rod Martin Tree Improvements, 1992.

The single spreadsheet contains a column of '% pixels with root rot' for 17 'unit areas'.

Boundary - Arrow Satellite Image Forest Disease Interpretation, Strathinnes Forestry Consultants Ltd., 1990.

"This project was executed in an attempt to qualify a theory that satellite imagery was a useful tool in the detection and location of diseased and/or discrepancy sites in the Nelson Forest Region." The methodology tested for the project gave mixed results. The field work undertaken for the site discrepancy analysis is presented in graphs and the specific data (no opening numbers) are appended, including DRA occurrence in plots ('Cruise Tally Sheets').

Boundary Satellite Image Forest Disease Interpretation, Strathinnes Forestry Consultants Ltd., 1990.

"This project was completed in an attempt to further qualify last years pilot project results (Boundary-Arrow Satellite Image Forest Disease Interpretation) and enhance the quality and quantity of information obtained for interpretive purposes." A co-relation between root disease presence and a certain satellite image was found. Overall, a probability of approximately 60% was found between root rot presence and satellite imagery techniques combined with a Fir timber growth type. 40% of the forest cover labels were changed to reflect the leading species ground surveyed.

Statistical interpretation revealed that DRA occurred most frequently and at the highest intensity of all diseases and was found most frequently in Cw and Fd growth types.

Comprehensive Pest Inventory (CPI) Database Description, Ministry of Forests, Nelson Forest Region, Spring 1991.

"This document describes the Nelson Forest Region's pest database known as the Comprehensive Pest Inventory (CPI). It has been designed and implemented as a storehouse of pest related knowledge about the forests in the Nelson Forest Region. Because of its design, it is also a resource for ground-truthing inventory data in our area."

There is no DRA data in this document, but the descriptions of the CPI pest and pest hazard fields may be useful to interpret CPI spread sheets.

Comprehensive Pest Inventory, Summary Report, District 6 Boundary, Ministry of Forests, March 1991.

This appears to be a print out of the CPI data base as a summary report. The information is divided under four headings: polygon identification, observed inventory label, survey observations, and derived quantities. There should not be any new information on this print out that is not in the pixel survey data or on disk.

Comprehensive Pest Management Survey Report, Hellroaring Creek.

Detailed data and its preliminary interpretation is provided in a loose format. The information includes species composition of infected trees, and number of trees infected by code and stems per hectare.

Detection of Armillaria Root Disease in the Southern Portion of the Robson Valley Using 1:5000 Colour Aerial Photographs, Tim and Josefine Qureshi, April 1993.

"This paper presents the results of a test carried out in the summer of 1992, to determine whether the incidence of Armillaria in young plantations could be reliably predicted by using only large scale aerial photographs." The methodology was found to be reliable in certain conditions, but is likely not relevant, and the results are not in the Nelson Forest Region.

Forest Health Data Collection and Management, Kory Hopkins, Ministry of Forests, Summer 1992.

"The main objective of this project is to preserve existing pest data and make recommendations for future data collection and storage. It was also used to determine if there were any distinct similarities in polygons with identical pest occurrences." Some useful information in the report includes the background context, statistical soundness, and uses of the Comprehensive Pest Inventory database.

Forest Level Multipest Survey Analysis Report, Deirdre Caune, Caune and Associates Computing, December 1994.

The report contains "information regarding exploratory analysis done with data collected from the Forest Level Multipest Survey. The data used in the analysis were the variable plot sample data collected from Arrow TSA during 1992 and 1993." From an alternate source, the survey is described as twenty, nine-plot clusters in the ICHdw. In much of the analysis, DRA is not singled out. Statistical analysis that does include DRA is oriented towards impacts such as mortality, volume. The report did find that DRA affected the most number of trees of any damage agent. This document will be useful for comparing similar parameters for other data sets.

Forest Pest Risk Assessment for All Site Series and Chronosequences (Seral Stages) of the ICH Biogeoclimatic Zone, JMJ Holdings Inc., March 1992.

The purpose of the report is to produce an "...analysis of Ministry of Forest silviculture data bases for risk assessment of selected forest pests found in the ICH biogeoclimatic zone (Beale and Norris, 1991). The incidence and intensity of these fungi and insects were determined for all tree species within each subzone variant and site series by seral stages (or chronosequences)".

The report should be useful in drawing conclusions regarding the relationship between DRA and biogeoclimatic zone, especially ICH. The data are well organized for more specific comparisons of data and data analysis.

Invermere-Cranbrook Armillaria Root Disease Training Course, and attachments.

Attachments include descriptions of DRA life cycle and management of infected sites and various undated tables of general statistics which are likely irrelevant.

Mause Creek Silviculture Survey Summary and Silviculture Survey Plot Cards

The cards are undated and contain references to field observations of DRA.

Nelson Region - Total Area Reported in SEG Files..., Forgis Consulting and Don Norris, January 1995.

Various parameters that may indicate DRA incidence were used to project the operable area in the Nelson Forest Region that is suspect, or DRA affected. The parameters are mainly from inventory labels and include areas with: conifers leading coupled with a poor site class; deciduous tree presence; a crown cover class of 5 or less, etc. The results are to the Biogeoclimatic Zone level with the overall conclusion that 47.6% of the Nelson Forest Region's operable area is DRA affected. There is no discussion of the figures used in this two page (plus fax cover) exercise, however, the results should be useful for comparisons.

Re: *Review of 1992 & 1993 Soil Disturbance Surveys Stumping & Pushover Logging in the Nelson Forest Region*, Bruce Fraser, Don Norris. 1994.

There are two sets of review comments on a soil disturbance report of which there is no copy in "the box". The comments are not relevant, and the original report is likely not useful unless there are original DRA data in an appendix.

Root Disease Impact Analysis in Fir Plantations of the Arrow and Kootenay Lake Timber Supply Areas, Kory Hopkins, Rick Stewart, December 1992.

Sixteen openings were sampled using pixel surveys for a statistical projection of root disease in ICH zone Douglas-fir plantations. Of the plantation area, 18.2% was infected. Parameters included stock, age, and infection rate. Table One summarizes the data which may be useful if it is not in CPI or ISIS. ('List of Plantations Surveyed, 'Healthy versus Affected Stems'.)

Root Disease in the Coeur d'Alene River Basin: An Assessment, Idaho Panhandle National Forests, January 1992.

"Forest Stands on National Forest System lands within the Coeur d'Alene River Basin were evaluated for presence and severity of root disease. Stands within the grand fir and Douglas-fir forest cover type were stratified by habitat type, age and stocking. Using a systematic procedure, sample stands were selected and evaluated for root disease using standard resource aerial photography."

The report found quantifiable relationships between tree species and age, and root disease severity. Using yield projections, it was found that tree mortality would exceed tree growth if untreated for root disease. These findings may provide useful comparisons with the results of the Nelson Forest Region data analysis.

Site Discrepancy Assessment for the Arrow Timber Supply Area, Laing & McCulloch Forest Management Services, 1991.

"The objectives of the study were to locate 100 stands that were identified as 'discrepancy sites' on the forest cover maps, measure site class, and determine the proper inventory label, and reasons for any apparent discrepancy." The results of the field work are presented in the appendices which may be a useful addition to the data base, although opening numbers are not given. The draft report of December 1988, provides more specific data ('Pest Impact Summary Tables').

Site Discrepancy Survey, Revelstoke Forest District, Thorsen Roethel Forestry Services, October 1991.

"The purpose of the site discrepancy assessment was to geographically locate problem areas and for priorizing their treatment". Very general remarks and figures regarding DRA are provided, which are unlikely to allow for comparisons with other reports.

Socio-Economic Assessment of Timber Supply Scenarios for the Golden TSA, Crane Management Consultants Ltd., March 1994.

"It is the objective of this study to evaluate, using a multiple accounts methodology, the economic, environmental and social impacts of the alternative harvest rate scenarios." This document contains no forest health related information.

Statistical Analysis, Caribou Creek, Bob Taylor, Evans Products Company Ltd., May 1988.

There are no root rot or DRA data on these spread sheets, but the number of live and dead trees are given.

The Multipest Survey: Possible Data Capturing System, Kory Hopkins, Fall 1992. (disk attached)

The report describes the Forest-Level Multipest Survey in terms of its origins, function, and method of data collection. "With all of the data being collected there must be some way of capturing it in a digitized form to be able to properly analyze the data. This report will describe one possible way in which to enter, store, and analyze data." The survey methodology may assist interpretation of data and highlight inadequacies in data collection.

Wickman Creek Operational Trial, B. Patterson, Kimmur Forestry Consultants Ltd., March 27, 1990.

The purpose of the report is "To determine the amount, location, distribution and the stage of development of the infection of the trees by, but not restricted to, *Armillaria mellea*, other root diseases, dwarf mistletoe, and Douglas-fir bark beetle through an operational timber cruise, pixel survey, and a line intercept survey".

The combined cruise, pixel, and line intercept surveys for DRA covered 396.9 ha in the MS and ESSF biogeoclimatic zones. Several sets of results are offered originating from the three survey types and opinions of the field staff. The survey methods are debated because unconfirmed symptoms were used to achieve a 66% rate of infection. If confirmed symptoms (mycelial fans) were used, only 7% infection occurred.

Raw data for all three surveys and maps are provided in the appendices, but opening numbers are not given. ('Root Disease Survey' original field forms, Wickman Creek, 90/03/14 and; 'Pixel Survey Notes' 02/23/90).

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Appendix E: Tables of Data Analyses Results

Data for Figures 1 and 2: DRA Incidence by Biogeoclimatic Zone and Subzone in the Nelson Forest Region (ISIS Data)

Biogeoclimatic Zone and Subzone	Number of surveys with DRA	Survey Area with DRA (ha)	Percent of Surveys with DRA	Percent of Survey Area with DRA	Mean	Standard Error	Standard Deviation	Median	Quartiles	Minimum	Maximum
ESSF											
ESSF (dc,dk,vc,wc,wm)	115	7964.30	4.75	14.60	16.37	2.07	22.16	7.00	2.00, 25.00	0.00	100.00
ESSF dk	33	3169.90	2.43	10.29	22.55	5.23	30.06	2.00	0.00, 50.00	0.00	100.00
ESSF wc	50	3377.40	12.66	27.95	16.18	2.62	18.55	10.00	5.00, 23.75	1.00	100.00
ESSF wm	27	1256.50	5.25	12.95	11.44	3.25	16.90	5.00	1.00, 11.50	0.00	59.00
ICH											
ICH (dw,mk,mw,vk,wk,xw)	504	22020.10	15.17	33.93	22.73	0.95	21.37	18.00	5.00, 30.00	0.00	100.00
ICH dw	58	1947.10	22.75	37.47	29.07	3.38	25.74	24.50	5.25, 50.00	0.00	87.00
ICH mk	55	2234.00	8.06	17.25	14.55	2.26	16.79	10.00	1.00, 22.50	0.00	75.00
ICH mw	378	17260.70	18.76	40.89	23.16	1.09	21.17	19.50	5.00, 30.00	0.00	92.00
ICH vk	3	84.00	3.49	7.60	21.67	3.33	5.77	25.00	20.00, 25.00	15.00	25.00
ICH wk	9	474.20	3.24	13.99	13.78	3.57	10.71	10.00	5.00, 25.00	0.00	25.00
IDF											
IDF (all)	53	2240.80	4.43	10.29	29.51	4.17	30.36	25.00	2.00, 50.00	0.00	100.00
IDF dm	51	2219.80	4.31	10.27	29.02	4.22	30.14	25.00	2.00, 50.00	0.00	100.00
MS											
MS (dk,dm)	107	4441.56	4.89	11.20	39.04	4.03	41.70	25.00	0.00, 100.00	0.00	100.00
MS dk	105	4421.60	5.02	11.65	39.50	4.09	41.93	25.00	0.00, 100.00	0.00	100.00
PP											
PP (dh)	1	118.00	0.98	4.43	25.00					25.00	25.00

Data for Figures 3 and 4: Incidence of DRA by Biogeoclimatic Zone and Subzone in the Nelson Forest Region (Pixel Survey Data)

Biogeoclimatic Zone and Subzone	Number of Surveys with DRA	Survey Area with DRA (ha)	Percent of Surveys with DRA	Percent of Survey Area with DRA	Mean	Standard Error	Standard Deviation	Median	Quartiles	Minimum	Maximum
ESSF											
ESSF (dk,wc,wm)	55	3627.10	61.80	61.80	14.48	1.71	12.67	11.73	3.80, 23.50	0.18	50.00
ESSF dk	49	3145.60	62.03	63.20	15.48	1.84	12.90	12.50	4.5, 24.40	0.18	50.00
ESSF wm	5	419.40	83.33	77.14	6.90	3.30	7.39	4.20	3.80, 4.50	2.00	20.00
ICH											
ICH (dw,mk,mw)	32	2033.80	27.83	31.43	15.79	2.78	15.72	12.38	5.00, 22.00	1.00	60.00
ICH mk	7	354.50	63.64	55.59	17.65	7.30	19.31	12.90	5.40, 20.13	2.00	57.61
ICH mw	22	911.40	21.78	17.99	14.00	2.93	13.73	11.05	5.00, 20.53	1.00	60.00
IDF											
IDF dm	22	955.80	39.29	46.73	11.73	2.49	11.67	7.46	1.78, 17.13	0.20	35.71
MS											
MS dk	102	3655.90	52.04	56.39	13.49	1.32	13.30	9.76	3.12, 20.53	0.10	67.10
PP											
PP dh	1		100.00	100.00	0.50			0.50		0.50	0.50

Data for Figures 5 and 6: DRA Incidence (by ITG) Across all Biogeoclimatic Zones in the Nelson Forest Region (ISIS Data)

ITG	Number of surveys with DRA	Survey area with DRA (ha)	Percentage of surveys with DRA	Percentage of survey area with DRA	Mean	Min.	Max.	Standard Error	Median	Quartiles a) 25%	b) 75%	Total area surveyed (ha)
1 (Fd)	75	1361.7	21.74	19.8	40.45	0	100	4.11	30	10	60	6875.7
2 (FdCw)	54	845.5	52.94	50.47	32.09	0	75	3.23	24	20	46	1675.4
3 (FdH)	35	618.3	38.04	32.87	28.60	2	75	3.15	25	14	42.5	1881.3
4 (FdS)	49	892.4	22.69	23.65	26.22	0	100	4.01	25	1	26	3774.1
5 (FdPl)	79	1637.1	20.47	20.84	37.49	0	100	3.98	25	7.5	50	7854.1
6 (FdPy)	13	439	13.4	14.26	30.77	25	50	3.04	25	25	25	3077.5
7 (FdL)	35	726.1	15.98	17.85	35.57	0	100	4.40	25	25	50	4068.2
8 (FdDecid)	44	905.3	28.03	24.97	20.41	0	100	3.60	7	5	28	3626.1
9 (Cw)	4	23.8	26.67	15.42	26.50	2	70	15.84	17	3.5	40	154.3
10 (CwFd)	30	349.1	40.54	38.29	21.40	1	75	3.24	20	10	24.25	911.8
11 (CwH)	78	1128.8	41.27	38.62	25.15	1	75	2.56	19.5	8	32	2922.8
12 (H)	3	12	37.5	22.22	6.67	2	15	4.18	3	2.5	9	54
13 (HFd)	16	251.9	45.71	37.08	35.06	3	92	7.58	35	5	51.5	679.3
14 (HCw)	107	1961.9	65.24	68.33	25.73	1	75	1.71	24	15	33	2871.3
15 (HB)	15	332	60	75.49	22.07	0	75	6.60	9	2.5	28	439.8
16 (HS)	12	207.4	57.14	66.18	21.17	2	75	7.41	15	6.5	15	313.4
17 (HDecid)	1	7	33.33	25	75.00	75	75	N/A	75	75	75	28
18 (B)	15	187.9	13.76	11.93	9.67	0	51	4.61	0	0	7.5	1575.1
19 (BH)	15	425.2	36.59	45.91	23.93	1	70	5.88	20	6.5	33	926.1
20 (BS)	160	3166.8	19.02	18.09	18.53	0	100	1.67	10	2	25	17503.4
21 (S)	43	642.7	13.65	14.03	14.84	0	100	3.44	7	2	14	4581.9
22 (SFd)	37	896.1	18.97	21.12	25.49	0	100	3.45	25	7	30	4243.1
23 (SH)	44	990.7	28.21	31.92	16.48	0	50	2.29	12.5	4.75	25	3103.8
24 (SB)	74	2041.6	16.82	21.22	12.85	0	100	1.75	10	4	15.25	9620.8
25 (SPl)	28	406.7	14.29	10.99	16.64	0	100	4.53	8	2	18	3702
26 (SDecid)	10	408	15.15	24.87	16.90	1	50	6.22	5.5	2.5	25	1640.6
27 (Pw)	10	175.1	35.71	35.61	43.80	5	84	9.22	53	20.75	56	491.7
28 (Pl)	91	1682.5	11.83	9.91	44.45	0	100	4.45	25	1	100	16976.3
29 (PlFd)	116	1981.7	16.43	14.22	23.15	0	100	2.58	15	1	26.25	13937.4
30 (PlS)	97	1603.3	15.5	12.07	23.82	0	100	2.79	18	2	30	13285.4
31 (PlDecid)	33	737.4	19.76	18.72	18.58	0	100	3.67	15	5	25	3938.8
32 (Py)	10	174.3	19.23	15.66	47.20	10	87	6.25	50	50	50	1113.1
33 (LFd)	17	337.2	23.61	25.18	37.35	1	100	8.28	31	6	50	1339
34 (L)	52	754.3	18.57	16.76	18.71	0	100	3.44	5	1	25	4501.5
35 (AcConif)	6	59	50	39.86	26.17	11	46	4.93	25	20	30	148
36 (AcDecid)	0	0	0	0	0	0	0	0	0	0	0	23
40 (E)	45	512.2	42.06	35.05	30.47	5	100	3.97	21	10	32	1461.5
41 (AtConif)	53	985.9	24.2	23.16	15.92	0	100	3.11	7	5	15	4256
42 (AtDecid)	11	184	24.44	23.4	27.55	5	75	6.75	20	11	40	786.3

Data for Figures 7 and 8: DRA incidence (by ITG) Across all Biogeoclimatic Zones in the Nelson Forest Region (Pixel Survey Data)

ITG	Number of surveys with DRA	Survey area with DRA (ha)	Percentage of surveys with DRA	Percentage of survey area with DRA	Mean	Min.	Max.	Standard Error	Median	Quartiles a) 25%	b) 75%	Total area surveyed (ha)
1 (Fd)	3	3.39	50	11.89	5.79	1	15.28	4.74	1.1	1.05	8.19	28.5
2 (FdCw)	1	19	50	67.86	27.00	27.00	27.00	0.00	27.00	27.00	27.00	28
3 (FdH)	2	12	100	100	41.00	22	60	19	41	31.5	50.5	12
4 (FdS)	1	1.5	25	2.05	7.00	7.00	7.00	0.00	7.00	7.00	7.00	73.2
5 (FdPl)	23	53.79	79.31	7.9	15.23	1.35	38.24	2.2	11.54	7.79	19.1	680.6
6 (FdPy)	5	7.77	45.45	1.5	2.82	0.2	7.7	1.3	1.7	1.5	3	517.8
7 (FdL)	1	0.36	33.33	0.39	7.50	7.50	7.50	0.00	7.50	7.50	7.50	91
8 (FdDecid)	1	0.36	100	7.2	35.42	35.42	35.42	0.00	35.42	35.42	35.42	5
14 (HCw)	2	32.24	100	22.86	8.50	1	16	7.5	8.5	4.75	12.25	141
15 (HB)	1	54	100	78.26	12.00	12.00	12.00	0.00	12.00	12.00	12.00	69
18 (B)	7	15.83	87.5	3.03	18.43	4.5	25	3.28	23.1	14.05	24.15	523
19 (BH)	0	0	0	0	0	0	0	0	0	0	0	5
20 (BS)	11	96.98	84.62	8.96	8.28	1.5	21	1.92	4.35	3.8	13.08	1082.9
21 (S)	1	4.2	100	5.12	0.18	0.18	0.18	0	0.18	0.18	0.18	82
22 (SFd)	1	5.07	50	2.59	16.10	16.10	16.10	0.00	16.10	16.10	16.10	196
23 (SH)	0	0	0	0	0	0	0	0	0	0	0	24.6
24 (SB)	7	58.43	77.78	13.89	8.50	1	24.5	3.63	3.2	2.4	13	420.8
25 (SPl)	0	0	0	0	0	0	0	0	0	0	0	484
28 (Pl)	5	8.54	45.45	1.39	5.42	0.6	13.64	2.5	2.06	2	8.78	611.8
29 (PlFd)	27	47.08	65.85	3.48	11.29	0.3	36.93	2.2	5.77	2	21.11	1353
30 (PlS)	4	28.87	57.14	29.55	5.83	2.3	10.1	1.87	5.46	2.91	8.38	97.7
31 (PlDecid)	3	51.5	60	20.73	2.04	0.68	3.33	0.77	2.12	1.4	2.73	248.8
32 (Py)	1	1.5	50	1.01	0.50	0.50	0.50	0.00	0.50	0.50	0.50	149
33 (LFd)	2	1.6	66.67	1.66	2.00	2	2	0	2	2	2	96.6
34 (L)	2	2.82	28.57	1.13	3.05	1.1	5	1.95	3.05	2.08	4.03	250
40 (E)	1		100	0.22	2.00	2.00	2.00	0.00	2.00	2.00	2.00	11
41 (AtConif)	1	1	100	0.39	0.80	0.80	0.80	0.00	0.80	0.80	0.80	256
42 (AtDecid)	1	6	100	2.34	0.10	0.10	0.10	0.00	0.10	0.10	0.10	256

Data For Figures 9, 10, 13 to 20: DRA Incidence by Tree Density in the Nelson Forest Region (ISIS Data)

BEC	total stems/ha:	0	1-499	500-999	1000-2499	2500-4999	5000-9999	>10000
ALL	# of surveys with DRA	56	58	96	392	571	453	185
	Survey Area with DRA	678.10	651.60	1650.40	6815.20	11987.90	8479.10	3463.60
	% of Surveys with DRA	7.84	25.44	19.47	17.79	22.40	25.31	31.57
	% of Survey Area with DRA	5.33	17.06	19.66	16.89	22.55	23.27	27.73
	Mean	34.36	27.84	29.61	24.97	23.21	23.96	24.24
	Standard Error	3.84	3.72	2.92	1.42	1.06	1.26	1.83
	Standard Deviation	28.75	28.37	28.61	28.10	25.26	26.75	24.87
	Median	25.00	15.00	25.00	15.00	15.00	15.00	20.00
	Quartiles	9.50, 50.00	6.25, 50.00	4.75, 50.00	5.00, 31.00	5.00, 30.00	5.00, 30.00	3.00, 43.00
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum	100.00	100.00	100.00	100.00	100.00	100.00	100.00
ESSF	# of surveys with DRA	6	4	9	60	100	84	28
	Survey Area with DRA	87.40	38.00	169.60	1129.10	1571.00	2120.40	613.60
	% of Surveys with DRA	5.31	14.81	8.65	10.17	16.53	16.73	13.27
	% of Survey Area with DRA	5.01	12.23	9.37	9.95	11.15	17.84	14.26
	Mean	34.17	11.25	19.33	15.38	15.71	19.83	18.43
	Standard Error	15.51	5.15	7.72	2.98	2.01	2.23	4.71
	Standard Deviation	38.00	10.31	23.16	23.11	20.13	20.44	24.94
	Median	29.00	10.00	5.00	10.00	9.50	11.50	2.50
	Quartiles	4.75, 45.00	7.50, 13.75	6.20, 15.50	1.00, 25.00	2.00, 25.000	2.00, 25.00	1.00, 28.25
	Minimum	0.00	0.00	1.00	0.00	0.00	0.00	0.00
	Maximum	100.00	25.00	50.00	100.00	100.00	100.00	100.00
ICH	# of surveys with DRA	30	45	64	261	359	283	138
	Survey Area with DRA	447.60	496.60	903.90	4499.00	6632.70	4861.70	2521.10
	% of Surveys with DRA	14.35	42.86	32.82	29.39	37.75	37.78	49.11
	% of Survey Area with DRA	12.70	26.58	26.73	29.48	36.92	35.66	50.18
	Mean	29.10	26.04	27.45	21.41	20.08	20.81	26.38
	Standard Error	3.62	3.62	2.87	1.32	0.95	1.23	1.97
	Standard Deviation	19.84	24.27	22.94	21.34	18.05	20.67	23.16
	Median	25.00	15.00	25.00	15.00	15.00	15.00	23.00
	Quartiles	16.50, 49.00	7.00, 50.00	6.50, 50.00	5.00, 25.00	5.00, 25.00	5.00, 30.00	5.00, 46.00
	Minimum	2.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum	75.00	75.00	75.00	90.00	75.00	92.00	88.00
IDF	# of surveys with DRA	11	3	12	18	30	20	3
	Survey Area with DRA	54.20	89.00	372.00	382.10	916.20	289.40	98.10
	% of Surveys with DRA	4.47	9.09	15.79	3.67	9.62	13.51	10.71
	% of Survey Area with DRA	1.08	15.92	24.26	4.27	15.28	9.59	14.16
	Mean	49.27	57.00	20.58	22.72	27.13	25.50	7.67
	Standard Error	9.56	23.07	8.76	5.28	3.78	5.51	6.69
	Standard Deviation	31.71	39.96	30.36	22.40	20.70	24.63	11.59
	Median	50.00	50.00	3.50	33.50	25.00	22.50	2.00
	Quartiles	46.00, 50.00	35.50, 75.00	0.75, 28.25	1.00, 50.00	14.50, 38.00	7.75, 39.00	1.00, 11.50
	Minimum	0.00	21.00	0.00	0.00	0.00	0.00	0.00
	Maximum	100.00	100.00	100.00	50.00	100.00	100.00	21.00
MS	# of surveys with DRA	9	4	11	51	80	66	17
	Survey Area with DRA	88.90	20.00	204.90	776.00	1776.60	1207.60	246.80
	% of Surveys with DRA	7.09	14.29	9.57	9.70	12.01	16.42	65.38
	% of Survey Area with DRA	4.23	6.47	10.70	7.66	12.68	15.22	50.67
	Mean	33.78	56.25	60.45	53.96	45.13	42.24	22.35
	Standard Error	13.69	25.77	12.60	6.19	4.81	5.51	9.28
	Standard Deviation	41.08	51.54	41.80	44.22	43.06	44.78	38.25
	Median	25.00	62.50	75.00	50.00	25.00	25.00	0.00
	Quartiles	0.00, 50.00	8.75, 100.00	22.50, 100.00	0.00, 100.00	0.00, 100.00	0.00, 100.00	0.00, 25.00
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maximum	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Data for Figures 11 and 12: Incidence of DRA by Tree Density in the Nelson Forest Region (Pixel Survey Data)

Density Class (Total Stems Per Hectare)	Number of Surveys with DRA	Survey Area with DRA (ha)	Percent of Surveys with DRA	Percent of Survey Area with DRA	Mean	Standard Error	Standard Deviation	Median	Quartiles	Minimum
1-499	2	39.00	50.00	58.21	21.43	3.07	4.34	21.43	19.90, 22.97	18.36
500-999	4	229.60	80.00	19.63	10.85	4.12	8.23	11.61	7.55, 14.91	0.20
1000-2499	17	1439.40	80.95	94.46	7.95	1.58	6.50	8.78	2.12, 11.54	0.68
2500-4999	34	1670.00	62.96	71.58	9.02	1.47	8.56	6.82	2.16, 12.99	0.10
5000-9999	31	2509.20	67.39	69.16	14.43	2.42	13.48	12.90	2.00, 20.9	0.30
>10,000	14	932.10	77.78	90.52	13.51	3.84	14.38	6.99	3.35, 24.28	2.00

Data for Figures 21 and 22: DRA incidence (by ITG) Within the ICH zone of the Nelson Forest Region (ISIS Data)

ITG	Number of surveys with DRA	Survey area with DRA (ha)	Percentage of surveys with DRA	Percentage of survey area with DRA	Mean	Min.	Max.	Standard Error	Median	Quartiles a) 25%	b) 75%	Total area surveyed (ha)
1 (Fd)	33	619.1	36.26	42.99	32.79	0.00	90.00	4.05	30.00	20.00	50	1440.1
2 (FdCw)	52	824.5	54.17	51.84	32.85	0.00	75.00	3.30	24.00	20.00	47.00	1590.4
3 (FdH)	32	557.3	46.38	38.4	29.59	5.00	75.00	3.15	25.50	16.50	38.75	1451.3
4 (FdS)	33	644.9	28.95	27.62	19.97	0.00	70.00	3.13	20.00	2.00	25.00	2335.1
5 (FdPl)	39	734	35.78	35.5	24.28	0.00	75.00	3.40	20.00	8.00	27.50	2067.8
6 (FdPy)	5	36	71.43	40	40.00	25.00	50.00	6.12	50.00	25.00	50.00	90
7 (FdL)	16	172.1	20.51	16.51	42.81	0.00	87.00	7.33	43.00	21.00	70.00	1042.6
8 (FdDecid)	36	809.3	39.13	34.73	15.17	0.00	50.00	2.36	7.00	5.00	25.00	2330.1
9 (Cw)	4	23.8	28.57	15.83	26.50	2.00	70.00	15.84	17.00	3.50	40.00	150.3
10 (CwFd)	29	336.1	40.85	37.9	21.86	1.00	75.00	3.32	20.00	10.00	25.00	886.8
11 (CwH)	77	1115.8	43.02	40.95	25.38	1.00	75.00	2.58	20.00	8.00	32.00	2725
12 (H)	3	12	37.5	22.22	6.67	2.00	15.00	4.18	3.00	2.50	9.00	54
13 (HFd)	16	251.9	45.71	37.08	35.06	3.00	92.00	7.58	35.00	5.00	51.50	679.3
14 (HCw)	107	1951.9	65.24	68.22	25.32	1.00	75.00	1.70	23.00	15.00	32.00	2861.3
15 (HB)	12	221	80	94.24	13.00	0.00	50.00	4.39	9.00	2.00	17.50	234.5
16 (HS)	12	207.4	66.67	77.85	21.17	2.00	75.00	7.41	15.00	6.50	15.00	266.4
17 (HDecid)	1	7	33.33	100	75.00	75.00	75.00	N/A	75.00	75.00	75.00	7
18 (B)	0	0	0	0	0	0	0	0.00	0	0	0	38.8
19 (BH)	14	392.2	43.75	55.66	24.86	1.00	70.00	6.23	22.00	5.25	34.00	704.6
20 (BS)	39	503.8	28.47	20.16	22.51	1.00	75.00	3.37	13.00	5.50	32.00	2499.1
21 (S)	25	377.9	23.36	25.26	13.08	0.00	75.00	4.04	5.00	2.00	13.00	1496.3
22 (SFd)	28	778.1	25.69	27.68	21.14	3.00	50.00	2.84	25.00	6.75	25.00	2811.4
23 (SH)	40	949.2	29.2	33.53	16.80	0.00	50.00	2.27	13.00	6.75	25.00	2830.5
24 (SB)	33	712.5	33.67	33.84	8.48	0.00	25.00	1.11	9.00	4.00	13.00	2105.5
25 (SPl)	19	281.7	30.65	32.84	11.79	1.00	50.00	3.31	7.00	2.50	12.00	857.8
26 (SDecid)	8	360	21.62	29.75	8.63	1.00	25.00	3.63	4.50	1.75	10.75	1210.2
27 (Pw)	10	175.1	35.71	35.61	37.40	5.00	83.00	8.29	36.50	20.00	56.00	491.7
28 (Pl)	21	243	20.19	13.26	28.14	1.00	90.00	6.03	25.00	1.00	50.00	1832.7
29 (PlFd)	73	1093.2	31.06	27.54	16.64	0.00	50.00	1.85	12.00	2.00	25.00	3969.5
30 (PlS)	52	782.3	27.96	25.92	14.98	0.00	75.00	2.27	10.00	2.00	24.25	3017.8
31 (PlDecid)	25	616.4	30.12	32.17	12.80	0.00	30.00	1.66	13.00	5.00	18.00	1915.8
32 (Py)	9	101.3	75	58.96	46.89	10.00	87.00	6.98	50.00	50.00	50.00	171.8
33 (LFd)	11	272	32.35	33.24	25.82	2.00	87.00	8.27	20.00	8.00	31.00	818.3
34 (L)	42	563.3	27.1	21.77	18.45	1.00	75.00	3.32	7.50	2.75	25.00	2587.4
35 (AcConif)	4	44	44.44	44.44	29.25	11.00	46.00	7.16	30.00	25.25	34.00	99
40 (E)	39	416.3	100	48.84	25.15	5.00	88.00	3.31	20.00	10.00	29.50	852.4
41 (AtConif)	46	867.6	30.67	28.4	13.02	0.00	75.00	2.35	6.50	5.00	15.00	3054.8
42 (AtDecid)	11	184	32.35	40.5	27.55	5.00	75.00	6.75	20.00	11.00	40.00	454.3

Data for Figures 23 to 30: DRA Incidence (by GTG) Within the Biogeoclimatic Zones of the Nelson Forest Region (ISIS Data)

BEC zone	GTG	Number of surveys with DRA	Survey area with DRA (ha)	Percentage of surveys with DRA	Percentage of survey area with DRA	Mean	Standard Error	Standard Deviation	Min.	Max.	Median	Quartiles a) 25%	b) 75%	Total area surveyed (ha)
ICH	1	118	2337.5	36.88	36.93	24.99	1.99	21.63	0	90	20	6	33	6329.7
	2	117	2026.7	41.94	37.69	28.32	1.97	21.26	0	75	25	14	37	5376.8
	3	89	1680.6	40.45	36.07	23.76	2.18	20.56	0	87	20	6	30	4659.7
	4	79	1182.5	26.78	23.94	26.81	2.95	26.24	0	87	20	5	50	4940
	5	110	1475.7	41.67	39.23	24.49	2.07	21.68	1	75	20	8.25	31.5	3762.1
	6	4	19	36.36	23.17	23.75	17.34	34.67	2	75	9	2.75	30	82
	7	147	2632.2	63.36	65.13	25.03	1.67	20.28	0	92	23	9	33	4041.5
	8	53	896	30.99	27.63	23.13	2.95	21.46	1	75	17	5	34	3242.5
	9	25	377.9	23.36	25.26	13.08	4.04	20.18	0	75	5	2	13	1496.3
	10	101	2439.8	29.36	31.49	15.29	1.34	13.42	0	50	11	5	25	7747.4
	11	27	641.7	27.27	31.03	10.85	2.54	13.22	1	50	7	2	12	2068
	12	21	243	20.19	13.26	28.14	6.03	27.64	1	90	25	1	50	1832.7
	13	125	1875.5	29.69	26.84	15.95	1.43	16.00	0	75	10	2	25	6987.3
	14	25	616.4	30.12	32.17	12.80	1.66	8.32	0	30	13	5	18	1915.8
	15	46	867.6	30.67	28.4	13.02	2.35	15.97	0	75	6.5	5	15	3054.8
	16	50	600.3	68.49	45.94	25.68	2.95	20.87	5	88	20	10	30	1306.7
	17	4	44	44.44	44.44	29.25	7.16	14.31	11	46	30	25.25	34	99
MS	1	53	989.1	16.51	15.36	61.23	5.90	42.99	0	100	100	25	100	6440
	2	14	209.2	16.67	18.93	34.21	11.84	44.28	0	100	2	0	75	1105.1
	3	14	556.2	8.09	14.41	66.07	7.83	42.86	0	100	62.5	25	100	3859.2
	4	16	274.4	10.46	10.55	32.93	10.46	39.15	0	100	25	0.25	43.75	2602
	5	0	0	0	0	0	0	0	0	0	0	0	0	88.6
	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	17	272	20	17.86	6.76	3.35	13.80	0	50	0	0	5	1522.6
	9	4	59	10.26	10.14	56.25	15.73	31.46	25	100	50	43.75	62.5	582.1
	10	7	72	8.75	4.73	39.29	13.20	34.93	0	100	50	12.5	75	1523.5
	11	6	108.4	8.82	10.84	35	11.40	27.93	0	75	35	16.25	50	1000.2
	12	55	1082.6	13.48	12.78	52.31	6.16	45.67	0	100	50	0	50	8467.8
	13	43	835.5	9.84	8.37	41.33	6.58	43.16	0	100	25	0	100	9984.3
	14	5	78	9.62	5.5	30.4	18.21	40.72	0	100	25	2	25	1418.4
	15	7	118.3	14	12.87	27.86	13.75	36.38	0	100	15	2.5	37.5	919.4
	16	5	92.9	12.19	12.74	63	18.14	40.56	20	100	75	20	100	729.1
	17	0	0	0	0	0	0	0	0	0	0	0	0	23

Data for Figures 23 to 30: DRA Incidence (by GTG) Within the Biogeoclimatic Zones of the Nelson Forest Region (ISIS Data)

BEC zone	GTG	Number of surveys with DRA	Survey area with DRA (ha)	Percentage of surveys with DRA	Percentage of survey area with DRA	Mean	Standard Error	Standard Deviation	Min.	Max.	Median	Quartiles a) 25%	b) 75%	Total area surveyed (ha)
IDF	1	34	837.6	14.41	15.39	29.15	5.30	30.88	0	100	25	1.25	50	5441.5
	2	1	28	4	6.38	25	0	0	25	25	25	25	25	438.8
	3	23	902.9	11	17.36	32.35	6.16	29.53	0	100	25	3.5	50	5200.9
	4	17	497.4	13.82	19.51	37.41	6.96	28.68	1	100	25	25	50	2549.6
	5	0	0	0	0	0	0	0	0	0	0	0	0	4
	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	1	6	7.69	8.56	25	0	0	25	25	25	25	25	70.1
	10	2	12	18.18	12.53	25.5	24.5	34.65	1	50	25.5	13.25	37.75	95.8
	11	1	19.7	7.69	10.09	5	0	0	5	5	5	5	5	195.1
	12	8	103	10.53	7.49	22.13	8.67	24.53	0	50	1	0.75	50	1376
	13	10	162	7.25	7.65	27	7.84	24.80	0	50	34	1	50	2116.8
	14	2	39	8.33	8.82	15.5	9.5	13.44	6	25	15.5	10.75	20.25	442.1
	15	0	0	0	0	0	0	0	0	0	0	0	0	222.8
	16	0	0	0	0	0	0	0	0	0	0	0	0	209
	17	2	15	100	100	20	0	0	20	20	20	20	20	15
ESSF	1	3	30	8.11	5.1	33.33	16.67	28.87	0	50	50	25	50	588.4
	2	7	114.3	29.17	21.56	30	7.76	20.54	1	50	25	17	50	530.1
	3	2	24	8	6.17	50	0	0	50	50	50	50	50	389
	4	4	38.4	14.29	9.98	13	6.93	13.86	1	25	13	19	25	384.8
	5	2	77.3	40	40.45	7	2	2.83	5	9	7	6	8	191.1
	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	4	126	28.57	46.14	46.5	16.70	33.40	11	75	50	21.5	75	273.1
	8	123	2628.5	16.67	16.99	17.38	1.89	20.92	0	100	10	2	25	15473.3
	9	13	158.5	8.33	6.55	4.46	1.41	5.09	0	12	1	0	10	2418.1
	10	51	1571.7	14.09	19.33	15.1	2.56	18.29	0	100	10	2	25	8129.4
	11	4	44.9	4.88	2.16	31.75	23.44	46.89	1	100	13	19	43.75	2079.3
	12	7	253.9	3.87	4.78	43.14	15.98	42.28	0	100	25	13.5	75	5307.4
	13	34	703	10.18	8.51	27.38	4.52	26.36	0	100	25	1	30	8264.5
	14	1	4	12.5	2.46	50	0	0	50	50	50	50	50	162.5
	15	0	0	0	0	0	0	0	0	0	0	0	0	59
	16	0	0	0	0	0	0	0	0	0	0	0	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	34

Data for Figures 23 to 30: DRA Incidence (by GTG) Within the Biogeoclimatic Zones of the Nelson Forest Region (ISIS Data)

BEC zone	GTG	Number of surveys with DRA	Survey area with DRA (ha)	Percentage of surveys with DRA	Percentage of survey area with DRA	Mean	Standard Error	Standard Deviation	Min.	Max.	Median	Quartiles a) 25%	b) 75%	Total area surveyed (ha)
PP	**3**	3	113	5.88	6.06	25	0	0	25	25	25	25	25	1863.8

Data for Figures 31 to 40: DRA Incidence by Age Class in the Nelson Forest Region (ISIS Data)

BGC Zone	Age Class Code	Age Class (years)	# of Surveys with DRA	Survey Area with DRA	% of Surveys with DRA	% of Survey Area with DRA	Mean	Standard Error	Standard Deviation	Median	Quartiles	Minimum	Maximum
All	1	0-20	1760	32355.80	23.78	23.01	25.08	0.63	26.35	19.50	5.00, 31.25	0.00	100.00
	2	21-40	249	4355.30	26.52	21.16	18.16	1.35	21.31	10.00	3.00, 25.00	0.00	100.00
	3	41-60	89	1750.40	22.76	24.01	20.10	2.20	20.75	15.00	2.00, 25.00	0.00	80.00
	4	61-80	83	1737.80	24.03	24.27	30.90	3.07	27.94	25.00	7.50, 50.00	0.00	100.00
	5	81-100	84	1785.00	25.77	27.16	26.43	3.11	28.53	10.00	5.00, 50.00	0.00	100.00
	6	101-120	52	811.80	36.62	31.62	35.19	3.99	28.75	31.00	10.00, 50.00	0.00	100.00
	7	121-140	9	172.40	21.43	20.55	10.89	3.51	10.54	5.00	4.00, 16.00	4.00	31.00
	8	141-250	20	436.40	37.04	37.15	16.35	4.22	18.87	10.00	5.00, 15.00	0.00	75.00
	9	251 +	2	8.00	66.67	34.78	15.50	4.50	6.36	15.50	13.25, 17.75	11.00	20.00
ESSF	1	0-20	274	6427.80	15.23	16.59	18.93	1.32	21.77	10.00	2.25, 25.00	0.00	100.00
	2	21-40	48	957.90	16.22	12.97	7.06	1.18	8.14	5.00	1.00, 10.00	0.00	45.00
	3	41-60	10	140.50	15.87	15.08	8.60	5.67	17.91	2.00	2.00, 4.25	1.00	59.00
	4	61-80	10	185.80	19.61	18.96	16.10	9.40	29.71	10.00	5.00, 10.00	2.00	100.00
	5	81-100	14	349.70	29.17	33.49	8.64	1.87	1.00	10.00	2.75, 10.00	1.00	25.00
	6	101-120	4	62.00	17.39	17.47	30.00	11.55	23.09	30.00	40.00, 50.00	10.00	50.00
	7	121-140	0										
	8	141-250	7	254.50	28.00	38.27	9.71	2.03	5.38	10.00	7.50, 10.00	3.00	20.00
	9	251 +	1	3.00	100.00	100.00	11.00			11.00		11.00	11.00
ICH	1	0-20	1109	18981.00	37.16	36.81	21.97	0.62	20.80	15.00	5.00, 30.00	0.00	92.00
	2	21-40	169	2828.30	44.83	39.30	18.46	1.36	17.73	12.00	4.00, 31.00	0.00	75.00
	3	41-60	63	1250.90	40.91	44.85	23.32	2.73	21.66	15.00	4.00, 34.5	0.00	80.00
	4	61-80	50	857.90	39.37	37.42	29.58	3.36	23.72	25.50	7.00, 50.00	0.00	90.00
	5	81-100	53	810.80	37.06	29.64	28.13	3.75	27.32	15.00	5.00, 50.00	1.00	75.00
	6	101-120	41	628.80	54.67	48.28	32.44	3.91	25.03	31.00	10.00, 50.00	0.00	80.00
	7	121-140	7	162.40	46.67	37.91	8.14	3.81	10.09	4.00	4.00, 7.75	4.00	31.00
	8	141-250	11	151.90	52.38	43.79	19.00	6.61	21.93	12.00	7.00, 15.00	4.00	75.00
	9	251 +	1	5.00	100.00	100.00	20.00			20.00		20.00	20.00
IDF	1	0-20	94	1496.60	11.01	9.70	28.14	2.72	26.36	25.00	3.00, 50.00	0.00	100.00
	2	21-40	9	237.10	9.68	12.86	20.89	5.03	15.09	25.00	11.00, 25.00	1.00	50.00
	3	41-60	9	269.10	11.25	16.79	19.89	5.36	16.09	25.00	2.00, 25.00	1.00	50.00
	4	61-80	12	464.00	11.65	20.52	33.33	7.51	26.00	25.00	19.50, 50.00	5.00	100.00
	5	81-100	9	513.00	12.50	31.97	14.78	5.82	17.46	5.00	1.00, 25.00	0.00	50.00
	6	101-120	2	22.00	15.38	7.35	12.50	12.50	17.68	12.50	6.25, 18.75	0.00	25.00
	7	121-140	0										
	8	141-250	1	30.00	33.33	78.95	50.00			50.00		50.00	50.00
	9	251 +	0										
MS	1	0-20	283	5450.40	16.27	16.01	42.20	2.36	39.63	25.00	0.00, 100.00	0.00	100.00
	2	21-40	23	471.00	13.77	11.51	38.04	8.87	42.55	25.00	0.00, 100.00	0.00	100.00
	3	41-60	7	89.90	8.14	5.57	7.86	4.44	11.74	2.00	0.50, 13.50	0.00	25.00
	4	61-80	8	52.80	11.59	5.72	56.25	15.49	43.81	62.50	18.75, 100.00	0.00	100.00
	5	81-100	8	111.50	15.69	13.19	59.38	14.12	39.95	62.50	25.00, 100.00	0.00	100.00
	6	101-120	8	99.00	24.24	16.84	63.13	15.32	43.34	75.00	50.00, 100.00	0.00	100.00
	7	121-140	1	10.00	10.00	9.26	25.00			25.00		25.00	25.00
	8	141-250	0										
	9	251 +	0										
PP	1	0-20	0										
	2	21-40	0										
	3	41-60	0										
	4	61-80	3	113.00	11.11	17.65	25.00			25.00		25.00	25.00
	5	81-100	0										
	6	101-120	0										
	7	121-140	0										
	8	141-250	0										
	9	251 +	0										