A Review of "Using capture-mark-recapture methods to estimate fire starts in the United Energy distribution area"

by Rho Environmetrics Pty Ltd and John Field Consulting Pty Ltd

A REPORT FOR UNITED ENERGY

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Contents

Summary

Following the disastrous fires in February 2009, the Victorian Government introduced an 'f-factor scheme' to provide incentives for Distribution Network Service Providers to reduce the risk of fire starts and hence reduce the risk and damage caused by fire starts.

The Australian Energy Regulator has the responsibility of setting up and administering the 'f-factor scheme', which is designed to provide incentives for Distribution Network Service Providers to reduce the risk of fire starts and hence reduce the risk and damage caused by fire starts. The target number of fire starts, which forms the basis of the 'f-factor scheme' is based on an average over the last five years. For United Energy, the number of fire starts from 2006 to 2010 was 561.

There has been a concern expressed by the distributors that the number of fire starts recorded historically may be an underestimate, and hence the target may be unrealistically strict. I have reviewed the report written by Rho Environmetrics in conjunction with John Field Consulting, on the subject of the application of Capture, Mark, Release and Re-capture methods. The authors, Dr Ray Correll and Dr John Field, analysed the number of cases reported by United Energy as well as the number of cases reported in the databases of the Country Fire Authority (CFA) and the Metropolitan Fire Brigade (MFB). They give an estimate of 1453 fires per year with a 95% confidence interval of 1036 - 1870 based on the Schnabel estimator.

Examining the distinct records in the three data bases it can be shown that the number of fire starts over the five year period cannot be less than 1253., i.e. at least 250 fire starts per year, which is considerably higher than the 561 fire starts over the five year period, with an annualised rate of 112 fire starts per year.

I have replicated the results in the report using the `RCapture` package in R. I have also used variations such as profile likelihood confidence intervals and lower bound estimates, but find that the results of the report are quite conservative and robust. I have also examined the assumptions of the capture-mark-recapture methods and find that most likely the methods used would lead to an underestimate of the number of fire starts. Accordingly, I believe that the estimate given in the report is the most reliable found to date.

Declaration

I confirm that, in preparing this report, I have made all inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld. I have been provided with a copy of the Federal Court's "Guidelines for Expert

Witnesses in Proceedings in the Federal Court of Australia" and this report has been prepared in accordance with those Guidelines.

1 Introduction

Following the disastrous fires in February 2009, the Victorian Government introduced an 'f-factor scheme' to provide incentives for Distribution Network Service Providers to reduce the risk of fire starts and hence reduce the risk of, and damage caused by, fire starts.

The Australian Energy Regulator has the responsibility of setting up and administering the scheme. For 2012 to 2015, providers will be rewarded or penalised at a rate of $25,000 for differences in the number of fire starts compared to their target f-factor.

The target number of fire starts is based on an average over the last five years. For United Energy, the actual number of fire starts recorded from 2006 to 2010 was 561.

There has been some concern expressed by the Victorian DNSPs that the number of fire starts recorded historically may be an underestimate, and hence the target may be unrealistically strict[1] The purpose of this report is to review the report written by Rho Environmetrics in conjunction with John Field Consulting, on the subject of the application of Capture, Mark, Release and Re-capture methods. The authors, Dr Ray Correll and Dr John Field, analysed the number of cases reported by United Energy as well as the number of cases reported in the databases of the Country Fire Authority (CFA) and the Metropolitan Fire Brigade (MFB).

In the next section I review the report. I summarise each section of the report and give relevant comments. Finally I make some additional comments and provide some conclusions.

2 Review of the Report

2.1 Introduction

2.1.1 Summary

A description of Capture-Mark-Recapture methods is given, together with the context of the current study.

2.1.2 My Comments

As the report notes, Capture-Mark-Recapture methods have been applied in non-animal situations. For example, Darroch et al. (1993) used these methods for examining census undercounts.

[1] This concern has been acknowledged by the AER in its draft determination; see section 3.5.1.

2.2 Data Sources

2.2.1 Summary

The three sources of data are described: the UE fire data base, the CFA fire data base and the MFB database.

There were 316 fire starts over the period 2006-2010 in the UE fire data base in the CFA area and 268 in the CFA fire date base. 17 fire starts were common to both databases, giving 567 as the total fire starts recorded in the UE/CFA area.

There were 234[2] fire starts over the period 2006-2010 in the UE fire data base in the MFB area and 500 in the MFB fire data base. 48 fire starts were common to both databases, giving 686 as the total fire starts recorded in the UE/MFB area.

2.2.2 My Comments

The information in the CFA and MFB databases, and in the dataset generated internally by United Energy, has some significant shortcomings.

The databases held, alternately, by the two fire agencies are non-overlapping because each agency has jurisdiction over separate geographic areas of the state. The CFA and the MFB operate in different, but contiguous parts of the region served by United Energy.

An upper bound for the number of common fire starts in the UE data base and the CFA database can be easily obtained. Table 1 gives the number of United Energy fire starts in CFA areas and the number of CFA fire incidents in United Energy areas for each of the days that are common to the two databases. The maximum number of matches on any day is the minimum of the number of fire starts and fire incidents on that day. For example, on the 31/12/10 there were 4 United Energy fire starts and 2 CFA fire incidents, and hence the maximum number of matches on this day was 2. Summing the row-wise minima we obtain a maximum number of matches over the whole period of 65. A lower bound for the number of fire starts recorded is $316 + 268 - 65 = 519$, considerably higher than the 316 recorded fire starts in the UE data base.

[2]There were an additional 11 fire starts in the three month period before the MFB fire data base began.

	Number of CFA Fires	Number of UE Fires		Number of CFA Fires	Number of UE Fires
01/01/06	1	1	31/01/09	1	1
20/01/06	1	1	01/02/09	1	2
09/02/06	2	1	06/02/09	4	2
09/04/06	1	1	07/02/09	1	2
06/10/06	1	1	08/02/09	1	3
18/10/06	1	1	13/02/09	1	1
08/12/06	1	1	01/03/09	1	2
14/12/06	1	2	03/03/09	2	3
15/12/06	1	1	04/03/09	1	5
16/12/06	1	1	05/03/09	1	3
19/12/06	1	2	10/03/09	1	1
08/01/07	1	1	11/03/09	1	1
03/02/07	2	1	15/04/09	1	1
11/02/07	2	16	28/04/09	1	1
06/03/07	2	1	27/05/09	1	1
16/04/07	1	1	28/05/09	1	1
01/07/07	1	1	10/06/09	1	1
31/07/07	1	1	21/08/09	1	1
09/11/07	1	1	29/12/09	1	1
18/02/08	1	1	08/01/10	1	1
25/02/08	1	1	11/01/10	1	1
14/03/08	1	1	21/02/10	1	2
02/04/08	7	1	22/02/10	2	2
21/06/08	1	1	10/07/10	1	1
15/12/08	1	2	31/08/10	1	1
01/01/09	1	1	05/09/10	4	3
11/01/09	1	1	22/11/10	1	1
28/01/09	4	1	26/12/10	1	1
30/01/09	2	1	31/12/10	2	4

Table 1: CFA Fire Incidents and UE Fire Starts on Common Dates

Similarly, an upper bound for the number of common fire starts in the UE data base and the MFB data base can be obtained. Table 2 gives the number of United Energy fire starts in MFB areas and the number of MFB fire incidents in United Energy areas for each of the days that are common to the two databases. The maximum number of matches on any day is the minimum of the number of fire starts and fire incidents. Summing the row-wise minima we obtain a maximum number of matches over the whole period of 134. A lower bound for the number of fire starts recorded is $234 + 500 - 134 = 600$, considerably higher than the 234 recorded fire starts in the UE database.

These results show that the minimum number of fire starts over the five year period is 1119, much higher than the 561 recorded by United Energy.

	Number of MFB Fires	Number of UE Fires		Number of MFB Fires	Number of UE Fires
05/04/06	1	1	19/02/08	2	1
12/04/06	1	1	20/02/08	9	6
16/05/06	1	1	27/03/08	2	1
30/08/06	1	1	03/05/08	2	1
12/10/06	1	3	16/05/08	1	1
25/10/06	1	3	22/11/08	1	2
28/10/06	1	1	24/11/08	1	1
02/11/06	2	4	24/01/09	3	6
13/11/06	1	1	27/01/09	2	1
15/11/06	1	1	28/01/09	8	5
03/12/06	1	1	29/01/09	3	1
14/12/06	22	11	30/01/09	1	1
15/12/06	1	6	06/02/09	6	6
21/12/06	1	2	07/02/09	2	3
22/12/06	3	2	08/02/09	8	8
16/01/07	2	1	21/02/09	2	1
31/01/07	3	1	25/02/09	3	1
07/02/07	1	1	01/03/09	1	1
11/02/07	3	2	03/03/09	30	17
12/02/07	1	3	04/03/09	1	5
16/02/07	1	1	05/03/09	1	1
19/02/07	1	2	08/06/09	1	1
08/03/07	1	1	26/08/09	1	1
16/03/07	2	1	17/09/09	1	1
23/03/07	2	2	27/09/09	1	1
16/04/07	2	4	16/12/09	2	1
27/05/07	2	1	09/01/10	1	2
05/10/07	1	2	23/01/10	2	1
19/10/07	1	1	05/02/10	2	1
20/10/07	2	1	06/02/10	2	2
28/10/07	1	1	08/02/10	2	2
17/11/07	1	1	14/02/10	1	1
18/12/07	1	1	21/02/10	2	1
10/01/08	1	1	15/04/10	1	1
11/01/08	3	1	24/04/10	1	1
17/01/08	1	1	01/09/10	2	1
19/01/08	1	1	27/12/10	1	1
20/01/08	2	2	31/12/10	2	1

Table 2: MFB Fire Incidents and UE Fire Starts on Common Dates

The Correll and Field report has refined this estimate further by matching fire starts/incidents on addresses etc. I confirm that I got the same numbers and similar common records as in the report. The results in section 2.3 of the Correll and Field(2011) report show that the number of fire starts over the five year period *cannot be less than 1253*, the sum of 567 and 686.

2.3 Methodology

2.3.1 Summary

In this section, formulae for the well-known Lincoln-Petersen estimator and the Schnabel estimator are given. Some of the assumptions of the method are discussed and harmonic regression is described to take into account seasonal effects.

2.3.2 My Comments

Using the same notation as in the report, the variance of the Lincoln-Petersen estimator is (see, for example, Agresti, 2002, p.511)

$$\frac{n_1 n_2 (n_1 - m)(n_2 - m)}{m^3}.$$

Similarly, the variance of the Schnabel estimator is (Seber, 1982)

$$\frac{(n_1+1)(n_2+1)(n_1-m)(n_2-m)}{(m+1)^2(m+2)}$$

.

The Schnabel estimator has less bias than the Lincoln-Petersen estimator and smaller variance.

Kadane et al. (1999) quote the key assumptions of the capture-recapture method.

> "The simplest capture-recapture experiment involves two lists of samples and has four key assumptions; that the population is closed, that individuals can be matched from capture to recapture, that capture in the second sample is independent of capture in the first sample, and that capture probabilities are homogeneous across all individuals in the population" (International Working Group 1995).

The first assumption is satisfied. The second is largely satisfied. The third and fourth assumptions are discussed later in this review.

2.4 Results

2.4.1 Summary

Estimates using the Lincoln-Petersen estimator; and the Schnabel estimator based on all data as well as monthly and seasonal data are obtained. The estimate using the Schnabel estimator is 1453 fire starts per year with a 95% confidence interval of 1036 to 1870.

2.4.2 My Comments

I used the `RCapture` package (Baillargeon et al., 2007) in the R environment for statistical computing and graphics (R Development Core Team, 2011). The `closedp.t` command with method "Mt" gives exactly the same results and standard errors as the Lincoln-Petersen estimator; while the Schnabel estimator and standard error is given by `closedp.bc` command. I confirm that all the calculated results are correct.

The 95% confidence intervals are given in the report by the mean plus or minus two standard errors and hence are symmetric. Profile Likelihood methods give asymmetric confidence intervals where the lower bound is closer to the estimate than the upper bound. Figures 1 and 2 give the profile likelihoods for the number of fire starts in the CFA and MFB areas respectively. For the five-year period as a whole, the 95% confidence interval for the CFA area is 3329 to 8149 and the 95% confidence interval for the MFB area is 1952 to 3142. Annualised, the 95% confidence interval for the CFA area is 666 to 1629 and the 95% confidence interval for the MFB area is 411 to 661. The 95% confidence interval[3] for the total number of fire starts in both areas is 1175 to 2020 fire starts per year. These profile likelihood calculations show that the lower bounds of the confidence intervals given in the report are conservative.

2.5 Comments

2.5.1 Summary

Heterogeneity in the data was addressed by examining the recording frequency depending on the damage recorded in the MFB data set. This analysis shows that the larger the damage the more likely it is that a fire start will be recorded in both databases. The use of the damage function presented problems, however, since there was an increasing trend of fires being recorded with zero damage.

[3]Obtained by combining the end points of the 84.2% confidence intervals since $(1 - .842)^2 = 0.025$, giving a confidence level of 0.95.

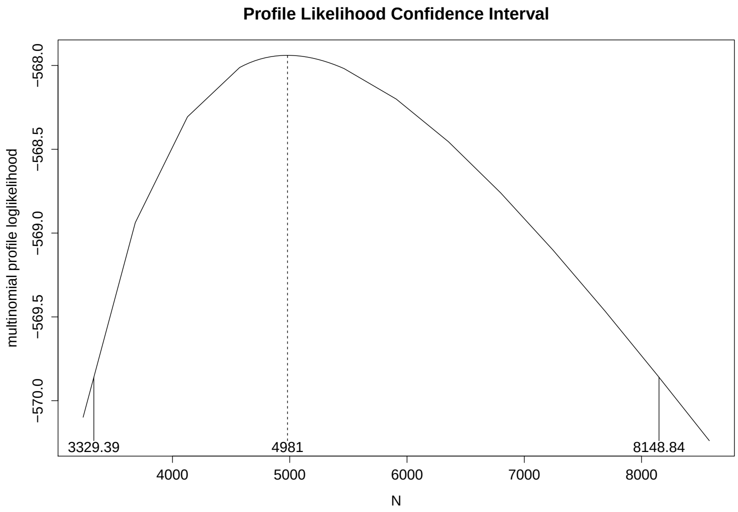

Figure 1: 95% confidence interval for number of fires in UE CFA area based on profile likelihood. Time period of coverage: 2006 to 2010.

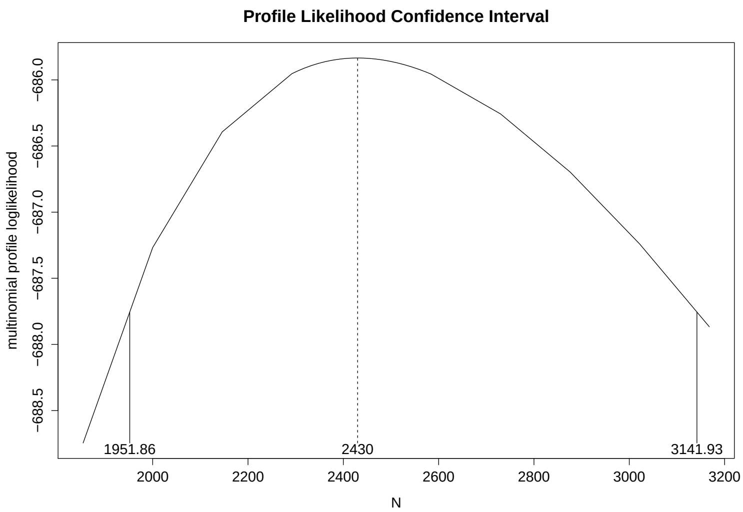

Figure 2: 95% confidence interval for number of fires in UE MFB area based on profile likelihood. Time period of coverage: 2006 to 2010.

Area	No years	Reporting period estimates		Annualised estimates	
		fires	stderr	fires/year	stderr
UE/CFA	5	5015.5	1145.6	1003.1	229.1
UE/MFB	4.75	2806.0	352.0	590.7	74.1
Total				1593.8	240.8

Table 3: Results using Chao's lower bound

A simulation study was carried out to determine whether bias of the Schnabel estimator might have a material effect on the results. The simulation study found that this was not the case.

The report concluded by recommending the use of the Schnabel estimator based on all the data.

2.5.2 My Comments

The Schnabel estimator and the other estimators used in the report are based on the assumptions that the lists are independent and that the samples are obtained homogeneously. If the lists are positively dependent, then the estimate of the population size will be understated while the reverse will occur if the lists are negatively dependent. To examine what the effects of these assumptions would be, I carried out Chao's lower bound estimation (see, Brittain et al. 2009), which does not rely on these assumptions. Chao's lower bound estimate is

$$N \geq (n_1 + n_2 - m) + \frac{f_1^2}{4f_2}$$

with variance

$$\frac{f_1^2}{4f_2}\left(\frac{f_1}{2f_2} + 1\right)^2$$

where $f_1 = n_1 + n_2 - 2m$ and $f_2 = m$. Table 3 gives the results of applying these formulae to the overall data. There are only comparatively minor differences from the values given in Table 5 of the Correll and Field(2011) report.

3 Some Additional Comments

3.1 Probability Modelling

In Diamond (2011), I applied a probabilistic model developed by Neubauer et al. (2011). The model assumes that the number of fire starts per month that are reported follows a binomial distribution with a constant probability of a fire start being reported, π, but with a poisson distributed number of fire starts occurring where the mean of the poisson distribution is allowed to vary from month to month.

When more than one list is available, there is less of a requirement to use probabilistic methods, although probability models still have some merit. Capture-recapture methods are preferred when there are two or more lists. In the present case, the results from the application of the Neubauer et al. (2011) method can be seen to be conservative since we now have a direct measure of the number of observed, distinct fire starts using the UE, CFA, and MFB data bases.

3.2 Dependence between lists

One of the assumptions of the Capture-Mark-Recapture methodology is that the lists are independent.

According to Chao (2001)[4]

> Dependence among samples leads to a bias for the usual estimator derived under independence. We use a two-sample experiment to explain intuitively the direction of the bias. Assume that a first sample of n_1 animals is captured. Therefore, the marked rate in the population is n_1/N. A second sample of n_2 animals is subsequently captured and there are m_2 previously marked. The capture rate for the marked (recapture rate, overlap rate) in the second sample can be estimated by m_2/n_2. If the two samples are independent, then the recapture rate in the sample should be approximately equal to the marked rate in the population. Therefore, we have $m_2/n_2 = n_1/N$, which yields an estimate of the population size under independence of $N_P = n_1 n_2/m_2$ (the well-known Petersen estimator or dual system estimator). This estimator has been justified and modified under various statistical models (see Seber 1982, Chapter 3). If the two samples are positively correlated due to heterogeneity or a trap-happy response, then those animals captured in the first sample are more easily captured in the second sample. The recapture rate in the second sample tends to be larger than the marked rate in the population, i.e., we would expect that $m_2/n_2 > n_1/N$, which gives $N > n_1 n_2/m_2 = N_P$. Thus, the Petersen estimator underestimates the true size if the two samples are positively dependent. Conversely, it overestimates for negatively dependent samples that may be due to trap-shy responses to capture.

[4]Chao uses m_2 for the recaptured animals while the report uses m.

Positive dependence means that the odds[5] of a fire start being recorded in the CFA database given that it is recorded in the United Energy database is higher than the odds of a fire start being recorded in the CFA database given that it is not recorded in the United Energy database.

Negative dependence means that the odds of a fire start being recorded in the CFA database given that it is recorded in the United Energy database is lower than the odds of a fire start being recorded in the CFA database given that it is not recorded in the United Energy database.

Independence means that the odds of a fire start being recorded in the CFA database is unaffected by whether it is recorded in United Energy database.

Similar considerations apply to the MFB data base.

3.3 Heterogeneity

Dependence between lists can be induced by heterogeneity. As the report shows in section 5, as the severity of the fire increases the more likely it is to be reported in both the MFB and UE databases. Although there is no direct evidence we might assume that this was also the case for the CFA database. If the particular finding did indeed hold for CFA data, then that would lead to positive dependence between the CFA and UE databases.

Kadane et al. (1999) studied the effect of heterogeneity on Capture-recapture estimates. They assumed that there were r strata[6] and that for each of the strata, k_i was (in this context) the odds of a fire start being counted by both UE and CFA databases given that it was recorded in the UE database; and c_i was the odds of a fire start being counted by both UE and CFA databases given it was recorded in the CFA data base. They then reordered the strata so that $k_1 \geq k_2 \geq \cdots \geq k_r$. They showed that if $c_1 \geq c_2 \geq \cdots \geq c_r$, which they called the assumption of *monotone relative catchability*, then the overall population size would be under-estimated. They also explained that this assumption would usually be a reasonable one to make. There is no need to actually construct the strata, because an assumption can simply be made that different types of fire starts will be subject to varying probabilities of being reported. If there are changing probabilities, and if the assumption of monotone relative catchability holds, then the capture-recapture estimate will usually be on the low side.

[5]The odds of an event is the probability of the event divided by $1 -$ the probability of the event. Note that probabilities can range from 0 to 1, while odds range from 0 to ∞.

[6]A division of the population so that every individual in the population is in one and only one stratum.

4 Conclusions

- Based on a direct examination of the records in the UE, CFA, and MFB data bases, the number of fire starts over the fire year period must be greater than 1253, i.e greater than 250.6 fire starts per year.
- Probability Methods based on the generalised Poisson distribution, but using only the UE records, give results that are conservative.
- Capture-recapture methods based on the separate lists give more reliable results.
- The estimate of 1453 fires per year with a 95% confidence interval of 1036 - 1870 based on the Schnabel estimator is the most reliable estimate found to date.
- Capture-recapture methods assume independence of lists and homogeneity. Positive dependence is likely to lead to over-estimation while negative dependence could lead to under-estimation. Heterogeneity is likely to lead to under-estimation.
- Application of Chao's lower bound estimate, which does not depend on list independence and which allows for heterogeneity, gives comparable results to the Schnabel estimates.

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Career History

1977-78	Statistician, ICI Explosives Factory, Deer Park
1979-86	Research Officer, Research Scientist, Senior Research Scientist And Statistics and Computing Team Leader, ICI Central Research Laboratories, Ascot Vale
1987-1989	Lecturer, Department of Mathematics, Computing and Operations Research, Footscray Institute of Technology
(1989)	Visiting Scientist, Center for Quality and Productivity Improvement, University of Wisconsin-Madison, USA.
1990-2003	Senior Lecturer, Department of Computer and Mathematical Sciences, Victoria University of Technology
(1995)	Visiting Fellow, Center for Quality and Productivity Improvement, University of Wisconsin-Madison, USA.
2003-2004	Senior Statistician, Insureware
2004-2006	Senior Lecturer and Deputy Director of Consulting, Department of Econometrics and Business Statistics, Monash University.
2007-	Senior Lecturer and Director of Consulting, Department of Econometrics and Business Statistics, Monash University.
2011-	Associate Professor and Co-ordinator of Statistical Support, Office of Pro-Vice Chancellor (Research and Research Training), Victoria University

Teaching Experience

Monash University

- Business Statistics (First Year), Marketing Research Analysis (Second Year), Survey Data Analysis (Third Year-Clayton and Caulfield).
- Expert Stats Seminars on Software Packages for Statistics, Questionnaire Design, Analysis of Survey Data, and Multivariate Statistics.
- Introduction to Statistics for Pharmacy-five session course:
  - Data handling, exploration, and graphical summaries
  - An overview of basic statistical methods
  - Regression Analysis and extensions
  - Designing experiments and power analysis
  - An overview of more advanced statistical methods

Victoria University of Technology
- Applied Statistics (First Year), Linear Statistical Models, Sampling and Data Analysis (Second Year), Experimental Design (Third Year).
- Statistics for Engineers, Statistics for Nurses, Statistics for Occupational Health.
- Forecasting (Graduate Diploma in Business Science)

Sessional Teaching
- Monash University (1996-2003) Design of Experiments for Masters Students of the Australian Pulp and Paper Institute.
- RMIT (1991, 1996-2002) Design of Experiments for Masters in Quality Management.
- AGSM (1993-1997): Total Quality Management for Graduate Management Qualification.
- Various other: The University of Melbourne, Enterprise Australia, Swinburne Institute of Technology.

Supervision

Principal Supervisor

Gregory Simmons (1994-1997). M.Sc. completed. "Properties of some minimum run resolution IV designs."

Tony Sahama (1995-2003). Ph.D. completed. "Some practical issues in the design and analysis of computer experiments."

Ewa Sztendur (1999-2005). Ph.D. completed. "Precision of the path of steepest ascent in response surface methodology." [As a result of this thesis, Ewa was awarded the 2006 Victoria University Vice-Chancellor's Peak Award for Research and Research Training-Research Degree Graduate.]

Co-supervisor

Keith Hart (1996-1997). M.Sc. completed. "Mean reversion in asset prices and asset allocations in funds management."

Jyoti Behera (1999-2000). M.Eng. completed. "Simulation of container terminals."

Ray Summit (2001-2004). Ph.D. completed. "Analysis of warranty data for automobile data."

Rob Moore (2001-2007). Ph.D. completed. "Computer recognition of musical instruments.

M.Sc. Minor Theses

Milena Shtifelman (1999). Completed. (Monash University Accident Research Centre). "Modelling interactions of factors influencing road trauma trends in Victoria."

Rohan Weliwita (2002). Completed. "Modelling road accident trauma data."

Theses Examination

One M.Sc. major thesis (University of Melbourne) and one M.Sc minor thesis (Victoria University).

Industry Projects

Over 30 projects for the following companies and organisations:

Gas and Fuel Corporation	Ford Australia
Mobil Australia	Fibremakers
ICI Australia	Western General Hospital
Data Sciences	Keilor City Council
AMCOR	Composite Buyers
Davids	Email Westinghouse
Craft Coverings	Australian Wheat Board
CSL	Holding Rubber
Viplas Olympic	Melbourne Water
Federal Airports Corporation	

Research and Consulting Experience

- Ten years with ICI Australia as an industrial statistician initially with the Explosives group and eventually with the research group.
- A Ph.D. from the University of Melbourne entitled "Two-factor interactions in non-regular foldover designs."
- Two six month periods at the Center for Quality and Productivity Improvement at the University of Wisconsin-Madison.
- Extensive consulting and training on behalf of the Centre for Applied Computing and Decision Analysis based at VUT for the following companies:

Data Sciences	Initiating Explosives Systems
Analytical Science Consultants	Saftec
Glaxo Australia	Datacraft Australia
Enterprise Australia	ICI Australia
The LEK partnership	Kaolin Australia
BP Australia	AMCOR
Melbourne Water	Kinhill Group
Australian Pulp and Paper Institute	

- Operated the Statistical Consulting Service at Victoria University of Technology from 1992-2002.
- From 2002-2004 worked as a Senior Statistician with Insureware on the analysis of long-tailed liability data.
- From December 2004 to December 2006 Deputy Director of Consulting of Monash University Statistical Consulting Service based in the Department of Econometrics and Business Statistics.
- From January 2007 Director of Consulting of Monash University Statistical Consulting Service based in the Department of Econometrics and Business Statistics.
- Extensive consulting and training on behalf of the Monash University Statistical Consulting Service for the following companies and organisations:

Australian Tax Office	Department of Human Services
J D McDonald	IMI Research
Port of Melbourne Corporation	Incitec Pivot
Agricola, Wunderlich & Associates	Parks Victoria
Australian College of Consultant Physicians	ANZ
Department of Justice	CRF(Colac Otway)
United Energy	AFLPA

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Professional Service

- President, Victorian Branch, Statistical Society of Australia, 2001-2002.
  - Terms as Council Member, Vice-President, and Past President.
- Referee: *Australian and New Zealand Journal of Statistics*, *Biometrika*, *Journal of Statistical Software*

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2nd December 2011

Our Reference: UE.ED.07.02

By email: Neil.Diamond@buseco.monash.edu.au

Dr Neil Diamond
Room 674, Building 11E
Department of Econometrics and Business Statistics
Monash University
CLAYTON VICTORIA 3800
Australia

Dear Dr Diamond,

PEER REVIEW OF A REPORT ON THE APPLICATION OF CAPTURE, MARK AND RECAPTURE METHODS TO ESTIMATE THE NUMBER OF FIRE STARTS IN THE UNITED ENERGY DISTRIBUTION REGION

Background

The Australian Energy Regulator is responsible for the administration and operation of the f-factor scheme, and has recently released a draft determination, which is to apply over the period from 2012 to 2015[1]. The scheme aims to provide incentives for Distribution Network Service Providers (DNSPs) to reduce the risk of fire starts, and to reduce the risk of loss or damage caused by fire starts[2]. The scheme was developed by the Victorian Government.

An f-factor target has been set, which has been based, in part, on the historical occurrence of fire starts in each distribution network (including the United Energy distribution network) over the period from 2006 to 2010. United Energy has examined its data and has become aware that there was systematic under-reporting of fire starts over the five years from 2006 to 2010. The distribution management system used by the business was aimed at gathering information on faults, with a lesser degree of effort directed towards the gathering of data on fire starts.

An examination of the records in the distribution management system shows that evidence of fires and fire starts was reported in an *ad hoc* fashion. Inconsistent terminology has been used,

[1] AER, Draft determinations and Explanatory statement for the draft determinations, F-factor scheme determinations 2012-15 for Victorian electricity distribution network service providers, Australian Energy Regulator, 5th October 2011.
[2] Energy and Resources Legislation Amendment Bill 2010, Explanatory Memorandum, page 10.

spelling is inaccurate, and the descriptions in the text field are sometimes incomplete. The questions posed by SKM in relation to specific records in the UE Distribution Management System (DMS) are indicative of some of the problems with the historic recording of information pertaining to fire starts[3].

We are aware that linesmen were not fully briefed on the methods for reporting fire starts, although this situation began to change in 2010. Considering the 2006 to 2010 period as a whole, field personnel appear to have recorded the evidence for fire starts somewhat sporadically. Linesmen were not obliged to note down fire-related symptoms.

Previously, United Energy had formed the view that the reporting of pole and cross-arm fires from 2006 to 2010 was reasonably rigorous and well-founded. However, from a detailed examination of the records, and from discussions with field staff, we are confident that there were a number of pole fires that occurred which have not been documented.

In future, we expect more rigorous reporting of fire starts, because additional effort has been expended on re-training linesmen, and a new and enhanced reporting template has been created. The new template provides for answers to be chosen from among a menu of responses. Hence, there will be less reliance on the direct comments provided by linesmen.

Report on the use of Capture, Mark and Recapture methods, prepared by Rho Environmetrics Pty Ltd and John Field Consulting Pty Ltd.

A statistical analysis has recently been undertaken for United Energy to determine an accurate, historical benchmark for the number of fire starts which occurred in the UE distribution region from 2006 to 2010. The work was performed by consultants, Dr Ray Carroll and Dr John Field, who chose to apply capture, mark, release, and re-capture methods. The authors analysed the number of fire starts recorded by United Energy, and also considered the number of cases reported in the databases of the Country Fire Authority (CFA), and the Metropolitan Fire Brigade (MFB). The authors have concluded that the best estimate of the number of fires which took place in each year from 2006 to 2010 is 1,453. This figure for the average annual number of fire starts has been derived using a Schnabel estimator, and is associated with a symmetric, 95% confidence interval which runs from 1036 to 1870[4].

In this context, we would like you to critically assess and appraise the study which was conducted by Dr Ray Carroll and Dr John Field. Specifically, would you please carry out the following tasks:

- Carefully review the written report which was prepared by Rho Environmetrics Pty Ltd and John Field Consulting Pty Ltd.

- Examine the underlying data sources, which will be made available to you. You will receive copies of the databases and other data files which were provided to Ray Carroll and John Field.

[3] See AER – Guide to Questions – F-Factor Data Verification, questions posed by Terry Krieg, Sinclair Knight Merz, 2nd September 2011.

[4] Using capture-mark-recapture methods to estimate fire starts in the United Energy distribution area, prepared for Jeremy Rothfield, United Energy, 2nd December 2011. Report authored by Rho Environmetrics Pty Ltd together with John Field Consulting Pty Ltd; see section 5.

- Evaluate and comment on the methods which the authors have applied. Compare the application of these methods with your own experience of applying capture, mark, release and recapture techniques to the databases of the CFA and the MFB, and to the data on fire starts held internally by UE.
- Examine the data matching which has been undertaken by Ray Carroll and John Field.
- Assess whether the main results reported by the authors are reproducible.
- Comment on the conclusions reached by the authors.
- Compare the usefulness of capture, mark, release and recapture methods with other methods of measuring or compensating for under-reporting in historical data. These other methods will include probabilistic methods, such as the Bernouilli sampling approach that you have previously applied.
- Compare the results obtained by Ray Carroll and John Field with the results which you obtained and documented in Diamond (2011)[5].
- Prepare a review report of your findings.

Guidelines in preparing your report

Attached are Expert Witness Guidelines issued by the Federal Court of Australia. Although this brief is not in the context of litigation, United Energy is seeking a rigorously prepared independent view for use in the context of regulatory decision making and you are requested to follow the Guidelines to the extent reasonably possible in the context.

In particular, please:

Identify your relevant area of expertise and provide a curriculum vitae setting out the details of that expertise:

1.1.1. only address matters that are within your expertise;

1.1.2. where you have used factual or data inputs please identify those inputs and the sources;

1.1.3. if you make assumptions, please identify them as such and confirm that they are in your opinion reasonable assumptions to make;

1.1.4. if you undertake empirical work, please identify and explain the methods used by you in a manner that is accessible to a person not expert in your field;

1.1.5. confirm that you have made all the inquiries that you believe are desirable and appropriate and that no matters of significance that you regard as relevant have, to your knowledge, been withheld from your report; and

1.1.6. please do not provide legal advocacy or argument and please do not use an argumentative tone.

[5] Diamond, N.T. (2011). "Under-reporting of Fire Starts," A report for United Energy, 20th November 2011.

United Energy Distribution Pty Limited
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Yours sincerely,

Jeremy T. Rothfield

Jeremy Rothfield
Network Regulation and Compliance Manager

FEDERAL COURT OF AUSTRALIA

Practice Note CM 7

EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

1. Rule 23.12 of the Federal Court Rules 2011 requires a party to give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see **Part 3.3 - Opinion** of the *Evidence Act 1995* (Cth)).

2. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence[1], and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

__Guidelines__

1. General Duty to the Court[2]

1.1 An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.

1.2 An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential.

1.3 An expert witness's paramount duty is to the Court and not to the person retaining the expert.

2. The Form of the Expert's Report[3]

2.1 An expert's written report must comply with Rule 23.13 and therefore must

- (a) be signed by the expert who prepared the report; and
- (b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and
- (c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and
- (d) identify the questions that the expert was asked to address; and
- (e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and

[1] As to the distinction between expert opinion evidence and expert assistance see *Evans Deakin Pty Ltd v Sebel Furniture Ltd* [2003] FCA 171 per Allsop J at [676].

[2] The "*Ikarian Reefer*" (1993) 20 FSR 563 at 565-566.

[3] Rule 23.13.

(f) set out separately from the factual findings or assumptions each of the expert's opinions; and

(g) set out the reasons for each of the expert's opinions; and

(h) comply with the Practice Note.

2.2 The expert must also state that each of the expert's opinions is wholly or substantially based upon the expert's specialised knowledge[4].

2.3 At the end of the report the expert should declare that "[the expert] has *made all the inquiries that* [the expert] *believes are desirable and appropriate and that no matters of significance that* [the expert] *regards as relevant have, to* [the expert's] *knowledge, been withheld from the Court.*"

2.4 There should be included in or attached to the report the documents and other materials that the expert has been instructed to consider.

2.5 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court[5].

2.6 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.

2.7 The expert should make it clear if a particular question or issue falls outside the relevant field of expertise.

2.8 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports[6].

3. Experts' Conference

3.1 If experts retained by the parties meet at the direction of the Court, it would be improper for an expert to be given, or to accept, instructions not to reach agreement. If, at a meeting directed by the Court, the experts cannot reach agreement about matters of expert opinion, they should specify their reasons for being unable to do so.

PA KEANE
Chief Justice
1 August 2011

[4] *Dasreef Pty Limited v Nawaf Hawchar* [2011] HCA 21.
[5] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565
[6] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565-566. See also Ormrod *"Scientific Evidence in Court"* [1968] Crim LR 240