Environmental Forensic Studies and Toxic Towns

Rob White*

Abstract

This article presents an overview of how social science methodologies can be mobilised as part of environmental forensic investigations. The article begins by providing an introduction to the field of environmental forensics and the types of approaches and methods generally utilised in this area of work. It then describes one particular approach to the study of toxicity, using the example of contaminants to air, water and land in residential areas. From a social science perspective, a key consideration in research on toxic towns is to provide critical interpretation of the conflicts and controversies surrounding such towns. The concern of the present article is to map out a methodological approach that can provide insight into, and analysis of, stakeholder interests that raises questions regarding the criteria used to assess the quality and robustness of evidence in relation to toxicity.

Introduction

The phenomenon of toxic towns periodically makes headlines as local residents and businesses come to the realisation that where they live and work is replete with environmental risks and harms. In Queensland, for example, chemical poisoning was recently discovered at a Noosa fish hatchery. It was subsequently alleged that pesticides used at nearby macadamia farms were the main reason for this. It was pointed out that even when regulations are followed by macadamia plantation farmers in their use of agrichemicals, there is frequently spray drift. To compound matters for the fish farmers, there was also evidence of chemical toxins in the nearby river, which was affecting source fish for the fish hatchery. In responding to the allegations, the Chair of the Noosa Fish Health Investigation Taskforce commented: 'The investigation by the taskforce requires a range of scientific skills….No single scientist covers all the expertise needed. [and] … There will be different views from different groups… . It is very difficult to get definitive data' (quoted in ABC TV 2010; see also Dayton 2010).

Meanwhile, there have also been allegations of 'dirty business' in the upper Hunter Valley of New South Wales, initially signalled by the rise in illnesses such as asthma and cancers among local people. Visits to the region by journalists uncovered regular incidences of toxic gas in the form of a yellowy orange cloud (ie nitrous oxide), the origins of which were linked to local mines and especially the large open cut mines. More generally, yearly statistics show a total of 108 tonnes of toxic metals, including arsenic, cadmium, cobalt and lead, being poured into the air of the Upper Hunter from mines and power stations, along

* Professor, School of Sociology and Social Work, University of Tasmania, Australia.

with 122,000 tonnes of sulphur dioxide. Not surprisingly, there have been calls for an independent inquiry, comparative health research, and identification of the content and danger levels for each substance. However, there have also been allegations of state-corporate collusion in dealing with the issue and, in particular, that the Department of Environment knows about the problem, but is not formally acting upon it (Fowler 2010).

Similar types of issues and allegations are apparent in many other places across the country. One need only think here of contaminated water in St Helen's, Tasmania; lead poisoning in Mt Isa in Queensland and Port Pirie in South Australia; and excessive dioxin levels in the waters around Homebush in New South Wales. These places have all attracted public attention at some time or another in regards to issues of toxicity and contamination. The experience is not new, nor is it confined to any one particular geographical area. Given this and given the health and wellbeing implications stemming from such environmental harms, it is important that criminology take an interest in these matters. How it might do so is the subject of this article.

Toxic towns are residential areas — small villages, towns or suburbs of larger cities — that are either located near contaminated physical sites (such as polluted waterways or hazardous landfill) and/or affected by polluted air and water that enter into their specific geographical locations. There is scope for criminology to provide useful and critical interpretation of the conflicts and controversies surrounding toxic towns generally. The purpose of this article is to demonstrate how social science methodologies can be mobilised as part of investigations into such environmental harms. The main concern, therefore, is to map out a conceptual approach that provides insights into and analysis of stakeholder interests, and that raises questions regarding the criteria used to assess the quality and robustness of evidence in relation to toxicity.

The intended outcome of research that looks at toxic towns is twofold: first, to create a unique opportunity for social scientific participation in applied forensic studies; and second, to draw upon grounded case studies in order to develop intervention strategies for toxic town issues more generally. The first relates to the importance of environmental forensic studies as part of investigation into the nature and dynamics of environmental harm. It is about the here and now. The second relates to the importance of environmental crime prevention and thinking now about how best to deal with over-the-horizon issues involving toxic waste and human exposure to air, water and soil contaminants. It is about precaution, risk and potential harms.

The article begins by briefly describing the usual contributions of environmental forensics. This is followed by discussion of the politics of forensic investigation and, in particular, the specific need for environmental forensic *studies*, rather than forensic *science* as such. We then return to questions of method, and the application and benefits of analyses of the knowledge/discourses surrounding toxic towns.

Environmental forensic science

The use of forensic techniques in dealing with environmental crime is an expanding and evermore sophisticated area of work within environmental law enforcement agencies and networks (including for example, environmental protection agencies, wildlife protection and natural resource management bodies, and the INTERPOL Environmental Crime groups). Typically, at an applied level, international environmental crime refers to such things as the trans-border movement and dumping of waste products, the illegal traffic in real or

purported radioactive or nuclear substances, and the illegal traffic in species of wild flora and fauna. These concerns are reflected institutionally as well. For example, INTERPOL has two key working groups that are actively involved in investigatory and operational work in regards to environmental crime: pollution and wildlife. The Pollution Crimes Working Group, for instance, is an active forum in which criminal investigators from around the globe meet to discuss issues such as determining the role of organised crime in environmental crime, and identifying trends and patterns in trans-border shipments of hazardous waste.

The area of wildlife forensics deals with the application of scientific knowledge to a range of species protection, law enforcement and wildlife verification challenges that face policy-makers, investigation and enforcement officers, and commercial stakeholders. These challenges include: the illegal capture or killing of animals, birds, reptiles and plants in contravention of domestic or international law; the illegal harvest of living resources from protected areas and the trade in those resources, a problem of particular relevance for fisheries and forestry sectors; and the illegal trade in raw and processed parts of protected animals, birds, reptiles and plants and in goods manufactured from such parts (see for example, Alacs and Georges 2008).

There are major and continuing challenges to the undertaking of environmental forensic investigations. Consider, for example, the complexities involved in environmental crime scene investigation. Issues here include: first responder safety in regards to hazardous waste and pollutants; the scientific skills and knowledge of environmental crime scene investigators and forensic specialists; the availability of environmental forensic technologies to crime scene investigators; and emerging technologies that may assist with investigations (Ramer 2007).

Acknowledgement of the complexities of the issues is but a first step in recognising the limitations of such work. For example, in one study, it was found that investigation of environmental pollution situations in Brazil is a complex environmental contamination situation, but few analytical resources were available to accomplish the necessary comprehensive evaluation and, thus, to provide material proof for the situation and to determine whether it was an environmental crime according to the law (Barbieri, Schwarzbold and Rodriguez 2007). The methods included:

- data from quarterly monitoring reports sent to authorities as part of the landfill operation permit requirements;
- monitoring lead and chromium exposure of nearby residents;
- testing of fish in nearby artificial pond;
- groundwater analysis;
- sediment analysis.

Putting the pieces together (of pollution, of perpetrators) is both the problem and the basis for achieving suitable outcomes. Moreover, there are always additional considerations to take into account when attempting to determine wrongdoing when it comes to specific types of environmental harm such as pollution. These include, for example, the issue of background values:

> ‘Before jumping to conclusions related to contamination sources, we should always consider evaluating background values and remember that high contamination values are not necessarily associated with spilled product. Natural sources are less obvious and yet ubiquitous and sometimes significant’. (Petrisor 2007)

There is now a broad spectrum of activity associated with the doing of environmental forensic studies. In drawing upon multiple scientific studies and knowledge production techniques, composite socio-ecological accounts of harm can be compiled, although the questions 'compiled by whom, and for what purposes?' remain of major interest and contention. Recent technical developments in the area are discussed below.

DNA testing

Illegal fishing and illegal logging can be tracked through the employment of DNA testing at the point of origin and at the point of final sale. Work done on abalone DNA, for example, demonstrates that particular species within particular geographical locations can be identified as having specific (and, thus, unique) types of DNA (Roffey et al 2004; see also Ogden 2008). The use of phylogenetic DNA profiling as a tool for the investigation of poaching also offers a potential deterrent in that regular testing allows for the linking of abalone species and/or subspecies to a particular country of origin. This increases the chances of detection and, thus, may have relevance to crime prevention as such. The use of DNA testing to track the illegal possession and theft of animals and plants can, thus, serve to deter would-be offenders, if applied consistently, proactively and across national boundaries.

Satellite surveillance

Illegal land clearance, including cutting down of protected trees, can be monitored through satellite technology. Compliance with or transgression of land clearance restrictions, for example, can be subjected to satellite remote sensing in ways that are analogous to the use of closed circuit television (CCTV) in monitoring public places in cities. Interestingly, the criminalisation of land clearance, which primarily affects private landholders, was due in part to images of extensive rates of land clearance provided through satellite remote sensing studies. Use of such technologies also embed certain notions of 'value' and particular relations between nature and humans, issues that warrant greater attention in any further development of this kind of technological application (Bartel 2005).

Automated video monitoring

New software and digital hardware technologies combined with utilisation of Ethernet, the Internet Protocol, and wireless mesh based networks provides the opportunity for monitoring activity in almost any location in the world from any other location in the world (Hayes, Porteous and Zhou 2008). Intelligent video monitoring embraces automation of much of the monitoring activity and the archival of only those incidents identified to be of interest — for example, motion detection. Intelligent video analysis can facilitate the audits of large-scale, 24/7 monitoring operations, contributing to both deterrence and evidence gathering in environmentally sensitive locations.

Contamination forensics

The contamination of land, water and air can be prevented by proactive testing of specific sites, movement routes and currents, by the establishment and collection of benchmark data, and by regular monitoring. To do this requires utilisation of methods that might include: chemical analysis; study of documentary records; use of aerial photographs; and application of trend techniques that track concentrations of chemical substances over space and/or time (Murphy and Morrison 2007; Brookspan, Gravel and Corley 2007). Bearing in mind that some contaminations, such as nuclear radiation, are not easily visible to human detection, both alternative methods of science and communal reflexivity over potential risks are needed (Macnaghten and Urry 1998).

A vast array of techniques and approaches to environmental forensics are now available (see United States Environmental Protection Agency 2001). For example, forensic sciences are now able to track the chemical signature of oil spills (Pasadakis et al 2008) and to use sophisticated chemical and biological analyses to track such spills (as well as illegal disposal of waste) to their source (Mudge 2008). As well, the forensic sciences are now actively turning their attention toward climate change, with a view to contributing to monitoring efforts and identifying emerging environmental issues (Petrisor and Westerfield III 2008).

Other methods of investigation include such specific techniques as: identification of wildlife through footprints, scats (faeces), bones, fur, claws, blood; use of chemical analysis in relation to certain benchmark data and established allowable thresholds (which is used in relation to toxic outfalls, water and land sites); creation of topographic (elevation) maps and thematic maps (eg land disposal activity, population distribution, vegetation communities, land use); monitoring of relevant internet sites for exposure of wrongdoing and illegal activity (eg Facebook, YouTube, MySpace, Twitter, activist sites); and surveillance of local markets through to eBay (eg sites and places where ivory, antlers, rare plants, etc are bought and sold).

Environmental forensic studies

'Forensic science' generally refers to specific areas of technical and vocational expertise. Training in chemistry, ballistics, fingerprint analysis, DNA testing, computer forensics and so on can be highly specialised. So too, crime scene investigation (including specific types of crime scene, such as arson and bush fire arson cases) demands the development of particular skills, capacities and expertise. Dealing with the human element of crime that can draw upon the expertise of biology, bio-mechanics, psychology and social work, likewise is oriented toward hands-on or practical types of intervention.

'Forensic studies', on the other hand, refers to the study of forensics as a social phenomenon. Typically, the question here is less to do with 'how to' (eg laboratory science and crime scene techniques), than with the overall implications of forensics for society as a whole. In this respect, the concern is to learn about how science and technology shape the work of the justice system (Fradella, Owen and Burke 2007). The main emphasis of forensic studies is on providing a generalist understanding of the field as a whole, including how developments across the field might feed into particular criminal justice processes (such as, in combating environmental crimes). The intent, as well, is to provide space for critical reflection on specific forensic practices (for example, the expanded use of DNA testing), and to inquire into the effectiveness or otherwise of forensics in regards to how the police, the courts and corrective services undertake their basic roles. A key element of this is how 'evidence' itself is socially constructed within legal and scientific discourses (for example, see Taylor 2004 in regard to sex abuse cases), and how different players within the criminal justice system conceptualise the nature of criminal investigation, criminal procedure, criminal evidence and courtroom practices.

The methodological approach for the study of toxic towns detailed below is informed by a general interest in environmental forensic studies. However, rather than viewing forensic studies solely through the lens of sociological examination of how harms are viewed and subjected to scientific scrutiny (ie critical analysis of forensic science), the intention is to illustrate potential application of social science methods *as part of* forensic examination (ie the incorporation of social science methods directly into the investigative process). At the heart of this is a combination of stakeholder analysis and examination of the social

construction of knowledge. The concern is to undertake research that involves: identification of stakeholders and specific stakeholder interests (eg worker and jobs; residents and amenity); scrutiny of the narratives around 'risk' and 'harm' from the different stakeholders (eg medical risk viz health department; loss of livelihood viz oyster farmers; limited problems viz miners); and the types of knowledge produced about toxicity in specific circumstances. Before outlining the contours of such an approach, it is useful to appreciate why this is important in the first place.

The theoretical framework that underpins the present approach to environmental forensic studies is that of green criminology (Beirne and South 2007). 'Green criminology' refers to the study by criminologists of environmental harms (that may incorporate wider definitions of crime than that provided in strictly legal definitions), environmental laws (including enforcement, prosecution and sentencing practices) and environmental regulation (systems of civil and criminal law that are designed to manage, protect and preserve specified environments and species, and to manage the negative consequences of particular industrial processes) (White 2008). Within this rapidly establishing field, the specific area of environmental justice is concerned with the health and wellbeing of individuals, groups and communities in regards to toxic environments (Bullard 2005a, 2005b; Pellow 2007).

Green criminology provides an umbrella under which to theorise and critique both illegal environmental harms (that is, environmental harms currently defined as unlawful, and therefore, punishable) and legal environmental harms (that is, environmental harms that are currently lawful, but which are, nevertheless, socially and ecologically harmful). Specific types of harm as described in law include: illegal transport and dumping of toxic waste; the transportation of hazardous materials such as ozone depleting substances; the illegal traffic in real or purported radioactive or nuclear substances; the proliferation of e-waste generated by the disposal of tens-of-thousands of computers and other equipment; the safe disposal of old ships and airplanes; the illegal trade in flora and fauna; and illegal fishing and logging. However, within green criminology there is also a more expansive definition of environmental crime or harm that includes (White 2011):

- transgressions that are harmful to humans, environments and non-human animals, regardless of legality per se; and
- environmental-related harms that are facilitated by the state, as well as corporations and other powerful actors, insofar as these institutions have the capacity to shape official definitions of environmental crime in ways that allow or condone environmentally harmful practices.

Due to the fact that identification and responses to toxicity may be influenced by the political process, including state collusion in creating the environmental harm in the first place, researchers generally adopt the more expansive definition of environmental harm in studying toxic towns. Whether or not such collusion ought to be considered a 'state crime' or 'state corporate crime' is debatable (Michalowski and Kramer 2006). Nonetheless, for many green criminologists the biggest threat to environmental rights, ecological justice and non-human animal wellbeing are system-level structures and pressures that commodify most aspects of social existence, that are based upon the exploitation of humans, non-human animals and natural resources, and that privilege the powerful over the interests of the majority (Lynch and Stretesky 2003; White 2008). It is for this reason that assessment of environmental injustice requires critical scrutiny of how states themselves intervene with regard to specific environmental harm issues.

According to critical green criminology, the global capitalist political economy determines the ways in which production and consumption occur, with attendant evils of

environmental degradation and human exploitation that also include instances of contamination of local communities (White 2011). As extensive work on specific incidents and patterns of victimisation demonstrates, some people are more likely to be disadvantaged by environmental problems than others. This is evident with respect to the siting of toxic waste dumps, extreme air pollution, chemical accidents, access to safe clean drinking water and so on (see Chunn, Boyd and Menzies 2002; Saha and Mohai 2005; Williams 1996). It is the poor and disadvantaged who suffer disproportionately from such environmental inequalities, whether this is in the United States (Bullard 1994), Canada (Rush 2002), India (Engel and Martin 2006) or Australia (Walker 2006). Moreover, it is these communities that also suffer most from the extraction of natural resources. For example, in many places around the globe where minority or Indigenous peoples live, oil, timber and minerals are extracted in ways that devastate local ecosystems and destroy traditional cultures and livelihoods (Brook 2000; Gedicks 2005; Schlosberg 2007).

Green criminology is not only concerned with exposure, critique and radical action toward system transformation. Also of concern are matters pertaining to social and environmental justice in the context of present institutional arrangements. Interrogation of how knowledge is constructed constitutes one strategy in pursuit of broader justice issues that may be both pragmatic and transitional in character. For instance, the environmental justice framework seeks to prevent environmental threats and is premised upon a series of interlinked propositions and principles (see Bullard 2005b). These principles emphasise values such as social equity (in which all individuals should have a right to be protected from environmental degradation) and harm prevention (that focuses on eliminating a threat before harm occurs). Each of these areas requires that considerable resources be devoted to measuring things such as human exposure to environmental chemicals, and sociological analysis of harm and risk distributions among diverse population groups.

An important part of the environmental justice framework is ideological and practical support for the adoption of the precautionary principle. From a social movement perspective, the preferred emphasis when it comes to precaution is to err on the side of human safety and wellbeing, rather than industrial development. As Bullard (2005b:28) observes:

> It asks "How little harm is possible?" rather than "How much harm is allowable?" This principle demands that decision makers set goals for safe environments and examine all available alternatives for achieving the goals, and it places the burden of proof of safety on those who propose to use inherently dangerous and risky technologies.

Moreover, the environmental justice framework requires that:

> '[those] parties applying for operating permits for landfills, incinerators, smelters, refineries, chemical plants, and similar operations must prove that their operations are not harmful to human health, will not disproportionately affect racial and ethnic minorities and other protected groups, and are nondiscriminatory' (Bullard 2005b: 28–9).

Taking precaution is not only about risk assessment. It is about marshalling requisite expertise in order to best understand the specific problem at hand. Science can and must be a major tool in deliberations over human interventions and human impacts. But this is only one sort of knowledge. Expertise is also developed from the ground up, not simply on the basis of experiment and scientific method. Farmers on the land, and fishers of the sea, for example, have generations of expertise built up over time and under varying environmental conditions. Indigenous peoples frequently have knowledge and understandings of their environments that go back to time immemorial. The fact that some Indigenous people have

survived for thousands of years, and thrived, in extremely hostile environments (the frozen lands of the north, the deserts of the dry continents) is testimony to human practices that are positively connected to immediate environs (see Robyn 2002). A public participatory process of deliberation needs to incorporate all of these kinds of voices. It also needs to be able to challenge the 'wisdom' and 'truth' of each, without prejudice and without fear.

Forensics as contested knowledge: Toxic towns

The following discussion is based upon preliminary work undertaken by the author on six different sites in Tasmania where allegations of harmful toxicity have been made:

- Roseberry (contaminated land and air);
- Lutana, Hobart (contaminated land and air);
- Wentworth Park, Hobart (contaminated land);
- Royal George (contaminated water);
- King River (contaminated water);
- Saint Helens (contaminated water).

Rather than reporting on the research project findings as such, the purpose of the present discussion is to indicate how social science methods are being employed in the course of this study.

We start from the premise that, ideally, there should be wide-scale community involvement in risk assessment processes and in after-the-fact diagnosis of alleged harms. If evaluation of toxic towns is to be free from corrupted processes, then a wide range of stakeholder interests and views need to be incorporated into the investigation of alleged harms. From a positive affirming perspective, for example, research has demonstrated that participation is important not only from the point of view of the legitimacy of environmental decision-making, but also because it can enhance problem-solving (Steele 2001; Scott 2005a, 2005b). If sustainability is the goal, if precaution requires thinking about multiple courses of action, and if community involvement is to be of benefit, then it is clear that citizens ought to be engaged as deliberators and contributors in their own right.

However, when environmental harm is contested — conceptually and evidentially — and there are major specific social interests at play (governments, companies, workers, consumers, environmentalists, residents), then those with the power to do so tend to shape public debate in ways that diminish participation and deliberation. This has certainly appeared to be the case with respect to the six Tasmanian communities. It is in regards to this point that the present suggested approach finds its purchase, since its key concern is to forge more robust investigatory methods into alleged environmental harms and toxic towns.

For the purposes of this study, the main consideration was to focus on human populations, at the local level, living in urban or semi-rural environments. The question of temporal issues deserves special mention, however, as they are especially pertinent in regard to toxic towns in the light of:

The past: legacy issues in relation to storage of toxic materials (eg radioactive and hazardous waste) and long-term presence of substances such as mining sludge.

The present: current claims to injury and harm arising from contemporary practices, such as pesticide spraying and mining procedures that pollute the air, water and land.

The future: potential transference issues (eg as a result of floods) and accumulation issues (eg increases in toxicity hazard over time as with the stockpiling of car and truck tyres).

Importantly, we envisage that unexpected weather events linked to climate change will impinge upon toxic towns and surrounding areas in particularly damaging ways, in that they increase the possibility of transference of harm across physical boundaries and regardless of ordinary preventive barriers.

The methods of research that our research team adopted for investigation included: historical mapping of the sites and their contamination over time; mapping interconnectedness between people, places and substances; gathering photographs and general information to contextualise the activities and substances; and analysing media treatment of the issues in each town/site. Data collection involved web and library searches of publicly available information from many different sources (eg government departments, local councils, academic research, activists, victims/survivors). It also involved field visits and general observation of each site, as well as site analysis (eg geology, history). It has included informal conversations with 'locals' about their experiences in living in the area and, in future, work will include formal interviews with a cross-section of stakeholders.

Stakeholders and stakeholder discourses

A key tool of the approach we adopted for this study is analysis of specific discursive universes. This method does not necessarily include 'discourse analysis' as such, by which is meant specific procedures and epistemological approaches to the study of language and reality (see Walter 2010). The primary concern has been with how different groups use different language and concepts to express their views and interests. This is important for several reasons.

For instance, at the heart of investigations of environmental harm is the question of whose knowledge of 'wrong' is right? In other words, whose voices are going to be heard and which kinds of evidence are to be given credibility? It is rare that scientific evidence is uncontested and that proof of environmental harm is simply a matter of 'let the facts decide'. For example, what counts as 'science', what counts as 'evidence', who counts as being a 'scientific expert' and what counts as 'sensible' public policy are all influenced by factors such as economic situation, the scientific tradition within a particular national context, the scientific standards that are used in relation to specific issues, and the style and mode of government (White 2008).

Knowledge is always tied to someone and somewhere. It is not socially neutral, but reflects particular interests and relations of power. There are several different types of knowledge including scientific, common-sense, experiential, and technical. There are many different sources of knowledge in addition to scientific disciplines, including: the knowledge of the layperson; the knowledge of workers such as farmers, fishers, and loggers; the knowledge of Indigenous peoples in diverse settings; and the knowledge of technicians who use particular instruments to measure and appraise aspects of the world around them.

Accordingly, one task for this research project has been to identify the diverse and multiple discourses that individually and collectively describe the particular issues pertaining to each toxic town. These discourses are varied and many, and in many cases are in competition. They include, for example, legal discourses (eg liability), scientific discourses (eg toxicology), community and lay discourses (eg victimisation), media discourses (eg sensationalist claims) and activist discourses (eg toxic action).

Key questions in relation to these discourses have included whose voices are heard, how and when the voices are heard, and the gender (class, race etc) bias in those voices. The study of discourses has direct investigatory implications. For instance, the nature of participation and engagement is relevant in respect to several different considerations:

- *intervention strategy* (eg taskforce approach versus specific experts);
- *methodologies* (eg multiple forensic methods and testing regimes, such as testing of soils, site histories, testing of local residents, flora and fauna analysis);
- *context bias* (eg objective or subjective approaches depending upon whether we need to know local context, or whether the science demands that we do not know local disputes or context); and
- *determining expertise* (eg questioning of the credentials of the expert; questioning of the findings of the expert).

In our study we are interested in who is saying what and why, as well as who the audience is and why. Fundamentally, however, the focus of research is on the ways in which debate occurs over what constitutes evidence.

Evidence and the investigation context

The analysis of stakeholder discourses is providing interesting insights into the social construction of 'evidence' according to specific understandings and the meanings given to particular ways of knowing. Indeed, our approach to environmental forensic studies has had an intrinsic interest in unpacking the evidence assessment process. Specifically, we wished to consider matters of evidence from the point of view of definitions (eg how is 'risk' or 'harm' defined?), thresholds (eg at what point does 'risk' or 'harm' occur to an extent warranting action or intervention?), burden of proof (eg who has the responsibility for proof?) and nature of the evidence (eg what is acceptable as evidence?).

Based upon analysis of the findings so far, we have been able to distinguish three sources of error and/or limited knowledge that impinge upon the assessment of alleged toxicity. These are the problems associated with *partial* knowledge (ie knowledge that is incomplete since it is limited to only one kind of domain expertise, such as soil testing); *skewed* knowledge (ie knowledge that is in some way biased, even if accurate within its own terms of reference, such as reliance upon patient records from one medical practice); and *distorted* knowledge (ie knowledge that is more akin to propaganda, being ideologically based, as in *ad hominem* attacks against specific protagonists). Each sort of knowledge presents problems vis-à-vis the accumulation of necessary and sufficient knowledge to assess the relevant contamination issues. However, they also suggest relatively straightforward solutions, revolving around, for example, the combining of different knowledge sources, deployment of diverse forms of sampling, and emphasising substantive empirical evidence over ideological statement.

Future work associated with this research project involves examination of factors that affect investigation generally. Amongst others, these include:

Resources

- number of agents available from particular government and non-government agencies (eg staffing);
- expertise of those carrying out the investigation (eg training, credentials);
- ability and capacity to use multi-methods (eg resources, funding and expertise);
- leadership and accountability structures (eg management).

Potential limitations of investigation

- testing of local areas (eg epidemiological testing when those who are ill or die are no longer part of the tested community; geographical concentration of illness);
- testing of human subjects (eg age-related differences in susceptibility);
- testing for environmental harm (eg tipping points; accumulation of harm over time, such as dioxins in fish).

Complicating factors

- multiparty sites, sites with previous uses and users to current parties, and sites in which wastes are commingled over a period of time (eg assigning liability);
- threat of lawsuit by powerful protagonists (eg companies suing researchers who conclude with negative findings);
- politicisation of issues (eg politicians, local residents, media).

Values and valuations

- need to be able to provide a dollar value of costs of commission/omission (with possible regulation through fines) (ie costs of crime);
- cost-benefit analysis of investigation and intervention in relation to compliance costs (that require agency resources, formation of expertise, and monitoring work) and environmental benefits (eg what is protected and preserved) (ie costs of crime control);
- issue of how to put a value on specific species, environments and human-related outcomes (eg value of destruction of fish hatchery).

Evidence gathering and analysis also has other technical sides as well, and these, too, will be considered. For example, Mandiberg (2009:1185–6) describes the difference between technology-based limits, and quality-based limits in the context of pollution regulation and notions of environmental harm:

> Technology-based limits focus on pollution emerging from a particular source. They require a source to adopt the best mechanisms practically available to reduce or eliminate the pollution … These limits do not, however, reflect an assessment of how the pollutants in question affect a particular water body or air quality control region.
>
> Quality-based limits, on the other hand, are more stringent and do focus on the health of the water body or air quality control region in question. In setting these limits, the agency begins with quality goals and works backwards to impose limits on all sources contributing pollution to that water body or air quality control region.

Each approach implies a different starting point for analysis, and each has different implications for any conclusions that are made in relation to the extent and nature of harm. While there is benefit to be gained in drawing upon each approach, the nature and extent of environmental harm, nonetheless, requires a contextual interpretation based upon specific trends and incidents:

> 'For example, a discharge that is slightly over a water-quality-based limit might not actually harm the health of the water body, depending upon discharges from other point sources. On the other hand, a discharge that is significantly over a technology-based limit might cause substantial environmental harm'. (Mandiberg 2009:1186)

Hence, the importance of 'thresholds' vis-à-vis the level of environmental harm acceptable or allowable.

Research into toxic towns involves extraordinary complexities. Yet, it is precisely these complexities that demand an approach based upon synthesis of knowledge and interpretation from many different sources. This is the intended outcome of the approach described in this article.

Conclusion

The basic argument of this article is that social science methodologies can be mobilised as part of the applied study of environmental harm. In so doing, there is scope to develop environmental forensic studies in a way that not only provides critical evaluation of forensic science in terms of effectiveness and social context, but that contributes directly to the investigation itself.

At the outset of the Tasmanian research, the intention has been to interrogate the ways in which 'evidence' surrounding toxic towns is gathered, presented and mobilised by diverse stakeholders. In this respect, it initially shares similarities with work done on disputes that are characterised by multi-layered conflict about knowledge, rights and development, as evident for example in the multidimensional character of the aquaculture controversy in Canada (Young and Matthews 2010). What we have found in the Tasmanian study to date is that from an investigatory point of view, the quality of decision-making and of policy responses has been undermined by reliance upon sole expert opinion and decision-making by government fiat. Contrary views and alternative types of evidence have generally been ignored or downplayed, something that stakeholder analysis has helped to highlight.

Environmental issues may be socially constructed (see Hannigan 2006); but 'truth' is comprised of interlinked and multidimensional layers that collectively ought to determine whether or not precaution is taken, preventative measures enacted and compensation granted. In other words, there is a need not only to acknowledge and discuss social divisions in regards to 'evidence' of environmental harm, but to utilise such discursive frames as the basis for informed decisions about what to actually do about perceived or alleged environmental harms. The risks and harms in fact may well be real, and it is the role of social science to contribute to judgements about how this might be determined in a practical, concrete manner and how best to respond in each case.

Toward this end, the substantive contribution of environmental forensic studies is to identify knowledge that is partial, skewed and distorted, with a view to assembling the most robust evidence possible in assessing toxic towns. This implies several things on the part of the researcher. First, that we accept that some knowledge is more reliable and valid than other kinds (the question of 'truth'); and second, that the contest over knowledge is not socially neutral (the question of 'interests'). As the history of the environmental justice movement shows (see for example, Pellow 2007; Bullard 2005a), research into toxic towns is inevitably political and contentious, especially in that it brings into play powerful actors and major industries (such as, forestry, mining and agriculture in the case of Tasmania). For the researcher this demands not only integrity of method, but integrity of purpose. Criminological investigation into toxic towns inevitably means locating oneself within wider struggles for social and environmental justice.

References

ABC TV (2010a) 'Two-headed fish raise chemical concerns', *7.30 Report*, 20 April 2010 (McCutcheon P)

ABC TV (2010b) 'A Dirty Business', *Four Corners*, 12 April 2010 (Fowler A)

Alacs E and Georges A (2008) 'Wildlife across our borders: a review of the illegal trade in Australia', *Australian Journal of Forensic Sciences* 40(2), 147–60

Barbieri C, Schwarzbold A and Rodriguez M (2007) 'Environmental Crime Investigation in Arroio do Meio, Rio Grande do Sul, Brazil: Tannery and Shoe Factory Waste Landfill Case Study', *Environmental Forensics* 8, 361–9

Bartel R (2005) 'When the Heavenly Gaze Criminalises: Satellite Surveillance, Land Clearance Regulation and the Human-Nature Relationship', *Current Issues in Criminal Justice* 16(3), 322–39

Beirne P and South N (eds) (2007) *Issues in Green Criminology: Confronting Harms Against Environments, Humanity and Other Animals*, Willan Publishing, Devon

Brook D (2000) 'Environmental Genocide: Native Americans and Toxic Waste', *American Journal of Economics and Sociology* 57(1), 105–13

Brookspan S, Gravel A and Corley J (2007) 'Site History: The First Tool of the Environmental Forensics Team' in Murphy B and Morrison R (eds) *Introduction to Environmental Forensics* (2nd ed), Elsevier Academic Press, London

Bullard R (1994) *Unequal Protection: Environmental Justice and Communities of Color*, Sierra Club Books, San Francisco

Bullard R (2005a) 'Introduction' in Bullard R (ed) *The Quest for Environmental Justice: Human Rights and the Politics of Pollution*, Sierra Club Books, San Francisco

Bullard R (2005b) 'Environmental Justice in the Twenty-first Century' in Bullard R (ed) *The Quest for Environmental Justice: Human Rights and the Politics of Pollution*, Sierra Club Books, San Francisco

Chunn DE, Boyd SC and Menzies R (2002) '"We all live in Bhopal": Criminology Discovers Environmental Crime' in Boyd SC, Chunn DE and Menzies R (eds) *Toxic Criminology: Environment, Law and the State in Canada*, Fernwood Publishing, Halifax

Dayton L (2010) 'Fears linger in rural paradise', *Health*, *The Weekend Australian* (Sydney), 13–14 March 2010

Engel S and Martin B (2006) 'Union Carbide and James Hardie: Lessons in Politics and Power', *Global Society* 20(4), 475–90

Fradella H, Owen S and Burke T (2007) 'Building Bridges Between Criminal Justice and the Forensic Sciences to Create Forensic Studies Programs', *Journal of Criminal Justice Education* 18(2), 261–82

Gedicks A (2005) 'Resource Wars against Native Peoples' in Bullard R (ed) *The Quest for Environmental Justice: Human Rights and the Politics of Pollution*, Sierra Club Books, San Francisco

Hannigan J (2006) *Environmental Sociology* (2nd ed), Routledge, London

Hayes L, Porteous G and Zhou T (2008) 'Technological Developments for Environmental Monitoring', Paper submitted to INECE [International Network for Environmental Compliance and Enforcement] 8th International Conference, Cape Town, South Africa, 5–11 April 2008

Lynch M and Stretesky P (2003) 'The Meaning of Green: Contrasting criminological perspectives', *Theoretical Criminology* 7(2), 217–38

Macnaghten P and Urry J (1998) *Contested Natures*, Sage, London

Mandiberg S (2009) 'Locating the Environmental Harm in Environmental Crimes', *Utah Law Review* 4, 1177–222

Michalowski R and Kramer R (2006) *State-Corporate Crime: Wrongdoing at the Intersection of Business and Government*, Rutgers University Press, New Brunswick, NJ

Mudge S (2008) 'Environmental Forensics and the Importance of Source Identification', in Hester R and Harrison R (eds) *Issues in Environmental Science and Technology*, No 26 Environmental Forensics, Springer/Royal Society of Chemistry, London

Murphy B and Morrison R (eds) (2007) *Introduction to Environmental Forensics* (2nd ed), Elsevier Academic Press, London

Ogden R (2008) 'Fisheries Forensics: the use of DNA tools for improving compliance, traceability and enforcement in the fishing industry', *Fish and Fisheries* 9, 462–72

Pasadakis N, Gidarakos E, Kanellopoulou G and Spanoudakis N (2008), 'Identifying Sources of Oil Spills in a Refinery by Gas Chromatography and Chemometrics: A Case Study', *Environmental Forensics* 9, 33–9

Pellow D (2007) *Resisting Global Toxics: Transnational Movements for Environmental Justice*, The MIT Press, Cambridge

Petrisor I (2007) 'Background in Environmental Forensics: "Raising the Awareness?"', *Environmental Forensics* 8, 195–8

Petrisor I and Westerfield III W (2008) 'Hot Environmental and Legal Topics: Greenhouse Gas Regulation and Global Warming', *Environmental Forensics* 9, 1–5

Ramer J (2007) *Environmental Crime Forensics*, Florida Department of Law Enforcement

Robyn L (2002) 'Indigenous Knowledge and Technology', *American Indian Quarterly*, 26(2), 198–220

Roffey P, Provan P, Duffy M, Wang A, Blanchard C and Angel L (2004) 'Pyhlogenetic DNA Profiling: A Tool for the Investigation of Poaching', Paper presented at Australian Institute of Criminology Outlook Conference, Melbourne, 29–30 November 2004

Rush S (2002) 'Aboriginal Resistance to the Abuse of Their National Resources: The Struggles for Trees and Water' in Boyd SC, Chunn DE and Menzies R (eds) *Toxic Criminology: Environment, Law and the State in Canada*, Fernwood Publishing, Halifax

Saha R and Mohai P (2005) 'Historical Context and Hazardous Waste Facility Siting: Understanding Temporal Patterns in Michigan', *Social Problems* 52(4), 618–48

Schlosberg D (2007) *Defining Environmental Justice: Theories, Movements, and Nature*, Oxford University Press, Oxford

Scott D (2005a) 'When Precaution Points Two Ways: Confronting "West Nile Fever"', *Canadian Journal of Law and Society* 20(2), 27–65

Scott D (2005b) 'Shifting the Burden of Proof: The Precautionary Principle and Its Potential for the "Democratization" of Risk' in Law Commission of Canada (eds) *Law and Risk*, UBC Press, Vancouver

Steele J (2001) 'Participation and Deliberation in Environmental Law: Exploring a Problem-solving Approach', *Oxford Journal of Legal Studies* 21(3), 415–42

Taylor C (2004) *Court Licensed Abuse: Patriarchal Lore and the Legal Response to Intrafamilial Sexual Abuse of Children*, Peter Lang, New York

United States Environmental Protection Agency (US EPA) (2001) 'Report prepared for 13th INTERPOL Forensic Science Symposium', Lyon, France, 16–19 October 2001, US EPA Office of Criminal Enforcement, Forensics and Training Environmental Crime

Walker C (2006) 'Environmental Racism in Australia', *Chain Reaction* 96, Autumn 2006, <http://www.foe.org.au/media>

Walter M (ed) (2010) *Social Research Methods*, Oxford University Press, South Melbourne

White R (2008) *Crimes Against Nature: Environmental Criminology and Ecological Justice*, Willan Publishing, Devon

White R (2011) *Transnational Environmental Crime: Toward an Eco-Global Criminology*, Routledge, London

Williams C (1996) 'An Environmental Victimology', *Social Justice* 23(4), 16–40

Young N and Matthews R (2010) *The Aquaculture Controversy in Canada: Activism, Policy, and Contested Science*, University of British Columbia Press, Vancouver