CHAPTER FIVE

THE INJURY ICEBERG: AN ECOLOGICAL APPROACH TO PLANNING SUSTAINABLE COMMUNITY SAFETY INTERVENTIONS

This journal article was co-authored with colleagues, Jan Hanson, Paul Vardon, Kathryn McFarlane, Jacqui Lloyd and my doctoral supervisors, Reinhold Müller and David Dürrheim. The article further develops the concept of ecological safety promotion and applies these principles to provide a scientific foundation for the design of sustainable safety promotion interventions. While interventions targeting individual behaviour are undoubtedly important, the desired behaviour is unlikely to be sustained unless it is well grounded in the social and physical environment that reinforces and maintains this behaviour.

From the outset, there was a conscious effort to design sustainability into Mackay Whitsunday Safe Communities by utilising and developing local resources where ever possible.

A literature review regarding intervention and coalition sustainability was undertaken by me and in collaboration with Paul Vardon and Jacqui Lloyd, was published as a chapter entitled “Becoming Queensland’s First Safe Community: Considering Sustainability from the Outset”, in “Reducing Injury in Mackay North Queensland” edited by Reinhold Müller and published by Warwick Educational Publishing in 2002 (Hanson et al., 2002c). It became clear that sustainability is an ecological concept. To be sustainable an ecological system must have access to the resources necessary to maintain the desired outcome and the ability to mobilise these resources. The key to designing sustainable, safe communities is a comprehensive socio-ecological analysis of the target community, the environmental and social determinants of injury in that community and the natural, man made, financial, human and social resources that community will need to mobilise to maintain its safety and wellbeing.

I therefore undertook a further literature review into the ecological foundations of sustainability in environmental systems and subsequently drafted the manuscript that forms the basis of this chapter. After comment from my co-authors the paper was refined and submitted to the Health Promotion Journal of Australia. As this was the first time the ecological principles of sustainable community safety was published in a hard copy health promotion journal, it was necessary to restate many of the key concepts previously published, but not widely circulated, in Chapter Four, Safe Communities: An Ecological Approach to Safety Promotion, as this provided the conceptual foundation for the ideas developed in the article.

PUBLICATIONS:

Hanson, D, Vardon, P & Lloyd, J 2002c, 'Becoming Queensland's first safe community: considering sustainability from the outset', in R. Müller (ed.), *Reducing injuries in Mackay, North Queensland,* Warwick Educational Publishing, Warwick, Queensland, Australia, pp. 35-52, see Appendix 22

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Article

The injury iceberg: an ecological approach to planning sustainable community safety interventions

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Introduction

William Haddon, the father of modern injury prevention, introduced the concept of ecological injury prevention with his foundation paper *On the Escape of Tigers: an Ecological Note*.[1] He was seeking to emphasise a comprehensive approach to injury causation in response to the prevailing paradigm of accident prevention. While human behaviour was perceived to be the pre-eminent cause of an accident, Haddon argued it did not follow that changing behaviour was the most effective way to prevent injury. He highlighted opportunities for harm reduction through redesign of the physical environment. By preventing or dissipating the adverse release of energy, it was possible to minimise the chance of injury without necessarily preventing the accident.[2] Haddon precipitated a major paradigm shift from accident prevention to injury prevention. Much has been achieved on the strength of this fundamental change.

Now, 30 years later, health promotion has embraced an ecological understanding of health, realising the importance of both the physical and social environment. A number of recent studies have emphasised the importance of the social determinants of injury.[3,4] It is time to revisit Haddon's original thesis and reappraise the best opportunities for harm reduction within an ecological system. Can we capitalise on what has been achieved through re-engineering the physical environment by simultaneously re-engineering the social environment?

Method

A literature review was undertaken of English-language articles addressing the topics of 'ecological injury prevention or safety promotion', 'ecological health promotion', 'sustainable economic, health or ecological systems' and 'steady state' using Medline, Sociological Abstracts, Social Service Abstracts and the Web of Science, Social Science Citation Index and Science Citation Index, with 143 articles retrieved and reviewed.

Abstract

Issue addressed: A systematic ecological framework in which to design sustainable, community-based, safety promotion interventions is presented.

Method: A literature review was undertaken of English-language articles addressing the topics of 'ecological injury prevention or safety promotion', 'ecological health promotion', 'sustainable economic, health or ecological systems' and 'steady state', with 143 articles retrieved and reviewed.

Results: Injury prevention is a biomedical construct, in which injury is perceived to be a physical event resulting from the sudden release of environmental energy producing tissue damage in an individual. This reductionist perspective overlooks the importance of psychological and sociological determinants of injury. Safety has physical, psychological and sociological dimensions. It is inherently an ecological concept. Interventions aiming to achieve long-term improvements in community safety must seek to develop sustainable safety promoting characteristics within the target community.

Conclusion: To reduce a community's risk of injury and sustain this lowered risk, the community 'ecological system' must have access to the resources necessary to maintain the desired outcome and the ability to mobilise these resources.

Key words: Safety promotion, injury prevention, sustainability, ecological health promotion.

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Safety promotion

'Injury prevention' is a biomedical construct, based on a reductionist view that injury is a physical event resulting from a sudden release of environmental energy producing tissue damage in an individual.[2] This approach underestimates the importance of the psychodynamic and social determinants of injury.[3,5] Is there benefit in reframing the issue in more holistic terms?

Park and Burges[6] first coined the term *human ecology*, extrapolating the theoretical paradigm of plant and animal ecology to the study of human communities. Last[7] defines *ecology* as "the study of relationships among living organisms and their environment", while *human ecology* refers to the "study of human groups as influenced by environmental factors, including social and behavioural factors".

In 1986, the First International Conference on Health Promotion, held in Ottawa,[8] emphasised the environmental and social determinants of health, redefining health promotion as the "process of enabling people to increase control over, and to improve, their health. To reach a state of complete physical, mental and social well-being, an individual or group must be able to realise aspirations, to satisfy needs, and to change or cope with the environment". The Ottawa Charter (see Figure 2) advocates a co-ordinated, intersectoral approach that empowers individuals to adopt healthy lifestyles through the creation of supportive environments and health promoting public policy, facilitated by effective community action in collaboration with a proactive, outward looking health sector.

Maurice et al. define safety as "a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community".[9] It is as much concerned with the subjective dimension – the perception of safety – as it is with the objective dimension – the absence of injury. It is as much concerned with the community in which individuals reside as it is with the individuals that make up the community. It is evident that safety is a psychological, sociological and environmental phenomenon, as much as it is physiological. It is inherently an ecological concept.[10]

'The injury iceberg' – an ecological approach to safety promotion

Green and Kreuter propose a socio-ecological model of health promotion where health and safety are interpreted in the context of the whole (ecological) system.[11] We propose a visual metaphor, the 'injury iceberg', to assist understanding of the important characteristics of this model (see Figure 1).

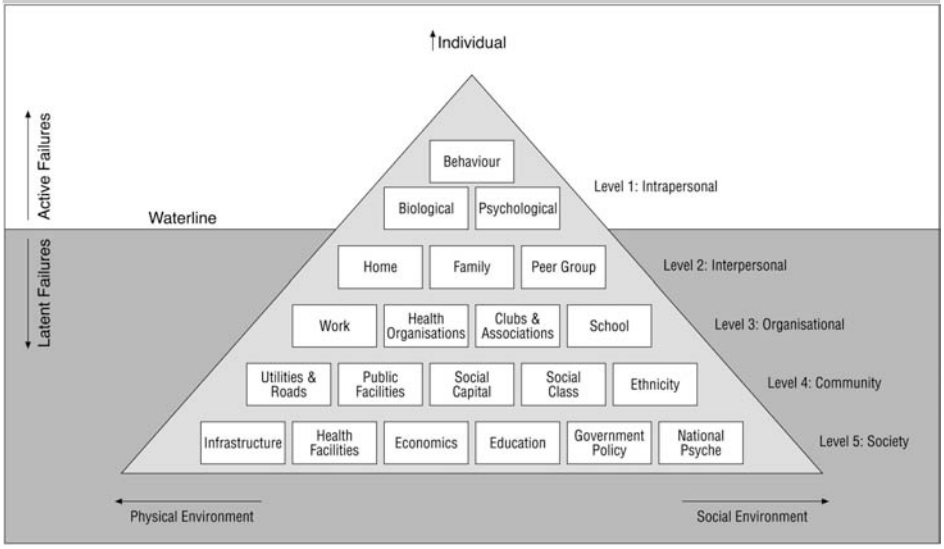
Three dimensions to this system can be identified:

1. The individual and their behaviour.
2. The physical environment.
3. The social environment.

Each dimension can, in turn, be analysed at five levels:[11]

1. The *intra-personal* level is concerned with characteristics of the individual, their knowledge, skills, life experience, attitudes and behaviours as they interface with the environment and society.
2. The *inter-personal* level refers to the immediate physical

Figure 1: The injury iceberg



environment and social networks in which an individual lives (family, friends, peers and colleagues).

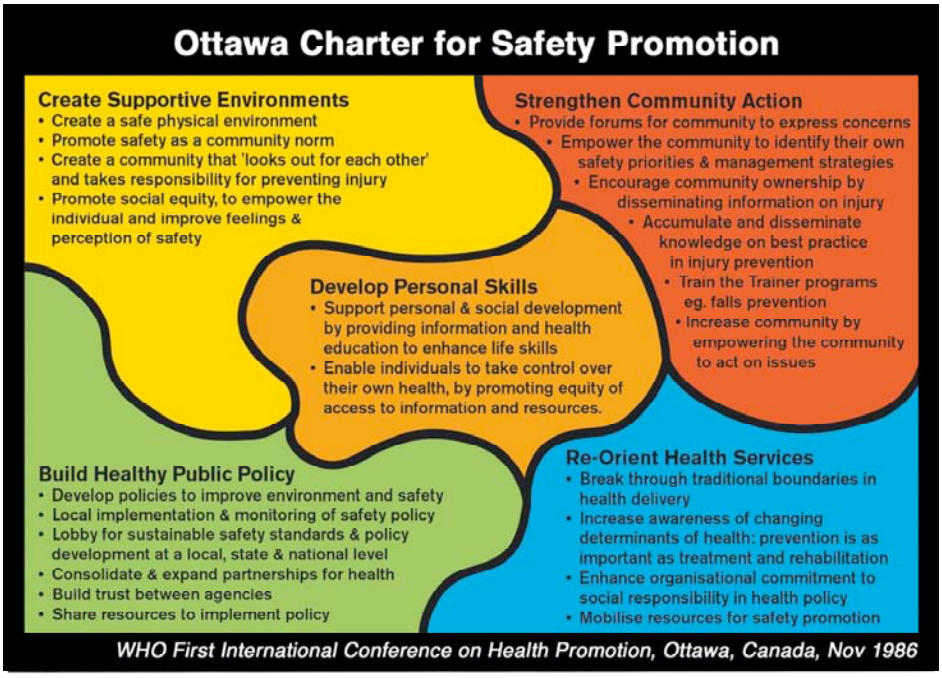
3. The *organisational* level refers to commercial organisations, social institutions, associations and clubs. They have structures, rules and regulations enabling them to pursue specific objectives and have direct influence over the physical and social environments maintained within their organisation.
4. A *community* may be defined in both structural and functional terms. Structurally, a community can be defined within geographic or political boundaries. Functionally, a community may share demographic, cultural, ethnic, religious or social characteristics with its members "having a sense of identity and belonging, shared values, norms, communication and helping patterns".[11]
5. *Societies* are larger systems, often defined along political boundaries, possessing the means to distribute resources and control the lives and development of their constituent communities.

The individual is, metaphorically speaking, the 'tip of the iceberg', just one part of a complex ecological system. While they may be the most visible component of this system, important determinants of their behaviour and environmental risk are 'hidden below the waterline'. Attempts to modify injury risk at one level in isolation (e.g. individual behaviour) will be resisted by the rest of the system, which will attempt to maintain its own internal stability (homeostasis). Syme[12] observes that health and behavioural change "is difficult and unlikely to be successful when many forces in the social, cultural and physical environment conspire against such change".

The socio-ecological paradigm emphasises the *dynamic interface* between the three dimensions – the individual, the physical environment and the social environment – acting at five levels: intrapersonal, interpersonal, organisational, community and societal. They provide the ecological context in which the individual behaves. Each level is built on the foundation of a 'deeper' level. As these deeper levels are larger and exercise more inertia, they are harder to change, but once changed are more likely to sustain the desired outcome.[13]

An injury event rarely occurs as a consequence of an isolated failure at one level of the system. Reason[14] argues that a critical combination of latent system failures, unmasked by a local triggering event, exacerbated by active behavioural failures, conspire together to create an injury event. *Latent failures* may be environmental, organisational or social. They have their origin in decisions taken by designers, builders, managers and politicians. These system flaws lie dormant for long periods until they are unmasked by a *triggering event*. *Active failures* are the counterproductive behavioural responses of individuals to a

Figure 2: The Ottawa Charter for Safety Promotion.



triggering event. In this systems approach to injury causation, individuals are the inheritors rather than the instigators of the injury sequence. Identifying and rectifying latent weaknesses within an ecological system has the potential to improve deeper level system defences, making the system more resilient and therefore reducing the risk of injury.

Cohen et al. observe that, "complex problems require comprehensive solutions".[15] It is important for coalition members to think strategically about their sphere of influence.[13,16] More will be achieved if each group concentrates on those components of the problem under their direct sphere of influence.[13] Community coalitions are best placed to engage the local community. Organisations have control over internal policy. Bureaucrats and politicians can implement safe public policy. By forming a coalition of like-minded members who between them have strategic influence over multiple levels of the socio-ecological system, it is possible to create a suite of interventions in which the "overall strategy results in a whole that is greater than the sum of its parts".[15] This ecological model provides a complex web of causation and creates a rich context for intervention. It can be used to map the key links in an accident sequence, identifying upstream latent failures along with the more obvious active failures. Identifying the most strategic links (leverage points) will ensure effective action.

Sustainable safety promotion

Sustainable safety promotion programs deliver lasting improvements in the health status of individuals or the communities they target.[17] Sustainability has been a neglected area of safety promotion research. Sadly, many promising initiatives do not survive.

Failure to sustain desirable project outcomes is counterproductive. Not only is it a waste of the human and financial resources invested in the project,[17,18] it also erodes community trust in the responsible organisations.[17-19]

Sustainability is an attractive concept to political and administrative systems that are anxious to achieve long-term outcomes from their social investments. While 'sustainability' is at present a mandatory piece of politically correct rhetoric, it is less often achieved. In 1998, the World Bank conducted a review of 550 projects it had funded and found that 48% had sustainability problems.[20] Rissel et al., in their study of 78 projects funded under the Minnesota Heart Health Program, found that only 52% of these project were still functioning after six years.[21] Yate reported that 50% of community-based coalitions became inactive after they had performed initial simple tasks.[22] Prestby and Wandersman studied 17 community-based coalitions and found that only eight were still functioning after one year.[23]

There is an urgent need to move beyond the rhetoric and deliver sustainable outcomes.

Sustain – a definition

The Oxford Dictionary defines sustain as "(1) to maintain or keep going continuously, (2) to support or bear the weight of especially for a long period, or (3) to give strength to encourage or support".[24] The concept is one of *assuming responsibility* to expend *sufficient resources* to maintain the *desired outcome*. Three key questions are evident:

1. What is the desired outcome?
2. Are there sufficient resources?
3. Who is responsible?

Sustain what?

It is important to be clear about the ultimate objective. What needs to be sustained?[13] The project itself? The outcome the project sought to achieve? The ability of the target community to maintain this outcome? Is the ongoing survival of interventions implemented by the project necessary to maintain this outcome? Is it possible to embed safety-promoting characteristics in the physical and social environment so that these interventions become superfluous?[13,16] While answers to these questions will vary from project to project, intervention to intervention, a clear definition of the desired outcome is imperative when trying to identify and mobilise the resources required.

Sufficiency

Sustainability is an ecological concept. Lowe suggests a system is ecologically sustainable "when it has at its disposal an amount of land that supplies all the resources it consumes and absorbs all the waste it produces".[25] The essential idea is that the system must have access to the energy necessary to be self-sustaining in the long term and to deal with any adverse by-products it produces while utilising this energy.

This concept has been adopted by public health practitioners. McMurray suggests, "a community can be viewed as an ecosystem, with resources, opportunities and threats to health and healthy lifestyles".[26] Sustaining a process to enhance community safety depends not only on the community having the resources necessary to maintain a safe physical and social environment,[27-29] but also the ability to identify and rectify any features of the environment that compromise safety.[30-32]

Interventions dependent on external resources are vulnerable. In an age of financial accountability, economic rationalism and aggressive competition for funding, short-term funding is the norm in Australia. Interventions come and go depending on their ability to secure ongoing funding. The solution is to maximise the ability of a community to maintain an outcome within its own 'ecosystem'.

Capacity building is the process by which a project attempts to enhance a community's capacity to identify, mobilise, co-ordinate and develop local resources to solve local issues.[30,33-36] Bush

et al. define *community capacity* as "a collection of characteristics and resources which, when combined, improve the ability of a community to recognise, evaluate and address key problems".[36] While at face value a project may mobilise local resources to achieve a specific health objective, it can also be a vehicle to develop sustainable, health-promoting qualities (capacity) within the community itself.[30,33,35,36]

The dynamic quality of community capacity cannot be overstated. What we do today affects the capacity of the ecological system we are working with tomorrow. Projects that develop capacity and enhance self-efficacy activate an important amplifying effect on the community's ability to implement and sustain desirable safety outcomes in the future.[30]

While building local social and physical capacity is undoubtedly important, it is not necessarily sufficient to ensure sustainability. Sustainability is not directly determined by the resources invested during the development phase of the project, but rather by the resources available to maintain the desired outcome. Rarely are the key questions asked.[13,37,38] Are there sufficient resources within the ecological system to *maintain* the desired outcome? What resources are required? Does the community have access to these resources and the authority to mobilise them? If there is a gap between the resources required and the resources available then the situation is, by definition, unsustainable.

Sustainable ecological systems must adapt to constantly changing internal and external environment.[18,30,36,38] Olsen[37] identifies three important factors that determine sustainability:

1. Community capacity.
2. Contextual factors. These external environmental, social or political factors are not under the control of the community.
3. Activity. The greater the activity, the greater the resources required to maintain this activity.

An important characteristic of sustainable health promotion networks is their capacity to reinvent themselves in the face of changing environmental, social and political contextual factors. Rissel et al.[21] in their review of 78 projects funded under the Minnesota Heart Health Program found that of the 41 projects that had been successfully sustained, 57% had required substantial modification since implementation.

Who is responsible?

Who is responsible for mobilising these resources? Partnerships cannot be sustained unless all partners contribute. This principle applies equally to horizontal partnerships (within a community system) and vertical partnerships (between state-based political administrative systems and communities).

Those planning community interventions need to actively build self-sufficiency into projects using local resources as far as possible while developing the local advocacy skills necessary to mobilise external resources where required.

External sponsors also need to seriously consider their responsibilities. Professionally driven, externally initiated projects have the potential to exacerbate community dependency if they do not build community capacity, encourage self-sufficiency and foster self-efficacy in the target community. When the external investment is withdrawn there is no local ownership or infrastructure to maintain the project. Administrative and political systems have responded by attempting to engage local communities in the development of their projects, ultimately delegating responsibility to the community after a period of infrastructure and social investment.[17,37-40] However, to delegate responsibility for sustaining an outcome to a community under the guise of capacity building without ensuring that the community has access to the resources and expertise required to maintain the desired outcome and the authority to mobilise these resources is both ineffective and unethical.

Ecological sustainability

There are a number of important implications of this ecological approach to sustainability. First, while interventions targeting individual behaviour are undoubtedly important, the desired behaviour is unlikely to be sustained unless it is well grounded in a social and physical environment that reinforces and maintains this behaviour. Second, for outcomes to be sustained, the community must have access to the human, physical, social and financial resources necessary to maintain these outcomes. Finally, projects must be able to adapt to a constantly changing internal and external environment if outcomes are to be sustained. This requires careful forward planning based on a sound understanding of the ecological system and the resources required to implement and maintain change.

Given the prevailing focus on individual accountability for injury, central control of financial resources, and a system of short-term funding, most interventions concentrate on what is achievable within a short time frame. Few have the inclination, much less the time required for the strategic planning necessary to produce change grounded deeply within an ecological system. Few have control over the resources they need to sustain community action, but are dependent on the patronage of external agencies. In this pressured environment, sustainability becomes an afterthought precipitated by the crisis of funding withdrawal. Sadly, if the ecological foundations for sustaining the outcome have not already been laid, it is often too late to rescue the situation.

Conclusion

Haddon's original thesis should be expanded to embrace a socio-ecological view of injury causation and prevention. Safety has physical, psychological and sociological dimensions. It is intrinsically an ecological concept.

We propose a visual metaphor, 'the injury iceberg', as an ecological metaphor of injury causation. In this system the individual is only the 'tip of the iceberg'. The most enduring way to reduce an individual's risk of injury is to systematically address the environmental and sociological issues 'hidden beneath the water line'.

Sustainability is also an ecological concept. To be sustainable an ecological system must have access to the resources necessary to maintain the desired outcome and the ability to mobilise these resources. Interventions dependent on external resources are vulnerable. The solution: build sustainability from the outset by maximising a community's capacity to maintain safety initiatives within their own resources.

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CHAPTER SIX
SOCIAL NETWORKS: FROM METAPHOR TO METHODOLOGY

> "For the last thirty years, empirical social research has been dominated by the sample survey. But as usually practiced, using random sampling of individuals, the survey is a sociological meat grinder, tearing the individual from his social context and guaranteeing that nobody in the study interacts with anyone else in it. It is a little like a biologist putting his experimental animals through a hamburger machine and looking at every hundredth cell through a microscope; anatomy and physiology get lost, structure and function disappear, and one is left with cell biology. … If our aim is to understand people's behaviour rather than simply record it, we want to know about primary groups, neighbourhoods, organisations, social circles, and communities; about interaction, communication, role expectations, and social control" (Barton, 1968, p1).

6.1. THE CASE FOR NETWORKS

If we are to understand why populations experience different injury rates, then research techniques that focus on individuals will not be effective. The individual is only the "tip of the injury iceberg" (Hanson et al., 2000b and 2005). A host of interdependent environmental and social contextual determinants "hidden below the water line" interact with the physiology and psychology of individuals to determine the incidence of injury experienced by a population.

While this comprehensive, wholistic, model of injury causation suggests many opportunities to address a community's injury problem, it also offers special challenges. Green and Kreuter (1999) observe that:

> If the ecological credo that everything influences everything else is carried to its logical extreme, the average health practitioner has good reason to do nothing, because the potential influence of or consequences on other parts of the ecological system lie beyond comprehension, much less control (Green and Kreuter, 1999, p25).

An ecological model of injury causation is necessarily a "complex" model of injury causation. However, "complex" does not just mean "complicated", but rather a system of interrelated mutually interdependent causal determinants (Buckley, 1998; Byrne, 1998, Lewis, 2005). Complex systems are resistant to

investigation by traditional reductionist scientific methods that seek to understand system function by disaggregating the system into its component parts. Not because the system does not have components, but rather because the components are so mutually interdependent that isolating a component from its contextual influences may seriously misconstrue how the system works (Ackoff, 1974; Buckley, 1998; Byrne, 1998).

Ackoff (1974, p 21) argued that "no problem ever exists in complete isolation" and coined the term "messy problem" to describe a complex system of interrelated problems (Ackoff, 1974; Chisholm, 1996; Hill, 2002; Keast et al., 2004). Rittel and Webber (1973) independently proposed the term "wicked problems" to describe a challenging set of interrelated problems (Clarke and Stewart, 1977; Keast et al., 2004). Ackoff (1974) observed that:

> In the machine age messy problematic situations were approached analytically. They were broken down into simpler discrete problems that were often believed to be capable of being solved independently of one another. We are learning that such a procedure not only usually fails to solve the individual problems that are involved, but often intensifies the mess. The solution to a mess can seldom be obtained by independently solving each of the problems of which it is composed (Ackoff, 1974, p21).

The highly complex, dynamic, multi-causal, multi-level, multi-sectoral nature of contemporary social problems also mean that they are resistant to interventions designed by any single profession or government agency (Rittel and Weber, 1973; Clarke and Stewart, 1997; O'Toole, 1997). Cohen and Swift (1999) observe that "complex problems require comprehensive solutions (p203)". No single professional group, community group, organisation, or government sector possesses the expertise or resources to design or implement a comprehensive multi-level and multi-sector solution (Cohen et al., 2003). The USA Institute of Medicine (Bonnie et al., 1999) report "Reducing the Burden of Injury: Advancing Prevention and Treatment" observes:

> The determinants of health are beyond the capacity of any one practitioner or discipline to manage. … We must collaborate to survive as disciplines and as professionals attempting to help our communities and each other (Bonnie et al., 1999).

In this regard, complex problems have been characterised as "problems of cooperation" (O'Toole and Montjoy, 1984). If a sufficiently comprehensive definition of the problem and its key sub-components can be established by pooling the expertise of different professional groups, and if a socially acceptable solution can be negotiated by politicians, bureaucrats and the community, then the problem can be productively addressed (Rittel and Weber, 1973; Clarke and Stewart, 1997; O'Toole, 1997). Stone et al. (1999) suggested that:

> Social forces (and societies most vexing problems) are characterised by a lack of coherence .... *In this type of situation, the main concern is how to bring about enough cooperation among disparate community elements to get things done. This is a 'power to' that, under many conditions of ultracomplexity, characterises situation better than 'power over'. (Stone et al., 1999, p354).*

Contemporary literature on societal governance and public health argues that this has profound implications for the way complex problems should be addressed (Rittel and Weber, 1973; Clarke and Stewart, 1997; O'Toole, 1997; Agranoff and McGuire, 2001; Lasker and Weiss, 2003; Mandell and Steelman, 2003; Keast et al., 2004).

6.2. NETWORKS: A METAPHOR FOR COLLABORATIVE COMMUNITY ACTION

Organisational theory suggests that the design and structure of an organisation, or inter-organisational network, must reflect the complexity of its operating environment (Hill, 2002). Hierarchical organisations are efficient structures for addressing problems which can be reliably broken down into a predictable sequence of independent sub-tasks for which the required human, technical and resource inputs can be dependably accessed (Rittel and Weber, 1973). It is possible, and indeed efficient, for a hierarchy to design structures, policies and processes to address problems of this nature (Powell, 1990). However, hierarchical mono-organisational structures have difficulty responding to situations where the underlying problem evades clear definition, is rapidly changing, or the required inputs and outputs are unpredictable (Rittel and Webber, 1973, Clarke and Stewart, 1977; Agranoff and McGuire, 2001).

It has been proposed that non-hierarchical patterns of organisation are better suited to complex operational environments (Jones et al., 1997; Lasker et al., 2001; Agranoff and McGuire, 2001; Keast et al., 2004). Through networking, the knowledge, expertise and resources of different professional groups and organisations can generate the critical mass of activity, resources and expertise necessary to solve multifaceted complex problems (Bonnie et al., 1999; Cohen et al., 2003; Lasker et al., 2001). Networks are believed to be more innovative, more responsive and better positioned to rapidly generate comprehensive solutions than mono organisational "silo" approaches (Leavitt, 1951; Guetzkow and Simon, 1955; Granovetter, 1973; Granovetter, 1985; Powell, 1990; Jones et al., 1997; Bonnie et al., 1999; Lasker et al., 2001; Agranoff and McGuire, 2001; Keast et al., 2004).

Networks have therefore emerged as a favoured form of social organisation in the postmodern era (Lipnack and Stamps, 1994; Alter and Hage, 1993; Castells, 2000). Lipnack and Stamps (1994) observe:

> The network is emerging as the signature form of organisation in the information age, just as bureaucracy stamped the industrial age, hierarchy controlled in the agricultural era, and the small group roamed in the nomadic era (Lipnack and Stamps, 1994, p3).

6.3. NETWORKS, COLLABORATIONS AND PARTNERSHIPS

It is illustrative that the nomenclature describing this social process is itself complex. Many different professional groups offer their own classifications using the same terms to describe different things, and different terms to describe the same thing (Mignus, 2001).

The terms "networks", "collaborations" and "partnerships" are frequently used interchangeably to describe the overall process by which organisations or people work together for mutual benefit (Mandell and Steelman, 2003). All authors agree that within this spectrum of activity there are some important distinctions:

- Intra-organisational systems versus inter-organisational systems (Mandell and Steelman, 2003; O'Toole and Montjoy, 1984).
- Hierarchical systems versus non-hierarchical systems (Powell, 1990; O'Toole, 1997; Jones et al., 1997; Nutbeam, 1998; Agranoff and McGuire, 2001).

- Formal systems vs informal systems (Lasker and Weiss, 2003; Mandell and Steelman, 2003).
- Systems with a high degree of mutual dependence versus systems with a low degree of mutual dependence (Gilroy and Swan, 1984; Swan and Morgan, 1992; Cigler, 2001; Himmelman, 2001; Mandell and Steelman, 2003).

Organising effective shared action within an organisation is logistically different to organising effective shared action involving people or organisations that are politically or organisationally autonomous (Powell, 1990; O'Toole, 1997; Jones et al., 1997; Agranoff and McGuire, 2001). Within an organisation compliance can generally be expected by virtue of its hierarchical structure. This is an efficient mechanism to facilitate shared action, assuming the managers have the administrative, technical and leadership skills to provide effective direction to their subordinates. However, once the bureaucratic boundaries of an organisation are crossed, it is no longer possible to assume the compliance of other actors, except by mutual consent (Powell, 1990; O'Toole, 1997; Jones et al., 1997; Agranoff and McGuire, 2001). In this circumstance, intra-organisational hierarchical methods of ensuring cooperation are neither possible nor appropriate.

On occasion, autonomous organisations or people may decide to enter into formal partnerships to share resources and to cooperate for mutual benefit. More commonly, organisations or people cooperate informally, unrestrained except by social convention and general legal statute.

Both within and between organisations there can be more intense patterns of shared work, depending on the strength, formality and history of relationships, and the extent and duration of resource sharing. There is general agreement that there is a continuum between forms of shared action in which actors are more independent and autonomous and those that involve increasing levels of commitment, trust and mutual interdependence (Gilroy and Swan, 1984; Swan and Morgan, 1992; Cigler, 2001; Himmelman, 2001; Mandell and Steelman, 2003). However, different authors use different classifications to describe this continuum (Figure 6.1).

Swan and Morgan (1992)	Gilroy and Swan (1984)	Himmelmann (2001)	Mandell and Steelman (2003)
	Networking Partnership Usually existing for information exchange. Members join or disconnect with ease, … Informality governs procedural and structural patterns: member organisations can maintain their organisational autonomy.	**Networking** Exchanging information for mutual benefit: it does not require much time or trust or the sharing of turf.	**Intermittent coordination** The policies and procedures of two or more organisations are adjusted mutually to accomplish an objective. Members may cooperate on a number of activities, but the commitment to each other is at arms length.
Interagency Cooperation A process of working together to achieve the day to day goals of the organisation.	**Cooperative Partnership** Relatively low levels of intensity in linkages and agreements that can range from informal to somewhat formal. Organisations can cooperate on one or more activities but do not generally have marginal costs.	**Coordinating** Exchanging information for mutual benefit and altering activities for a common purpose: it requires more time and trust but does not include sharing turf.	**Temporary Task Force** Ad hoc activity among organisations to accomplish a purpose. It is set up to work on a specific and limited purpose and will disband that purpose is accomplished.
Interagency Coordination A process of engaging in various efforts that alter or smooth the relationships of independent organisations, staffs, or resources.	**Coordinating Partnership** Require commitment of resources beyond information sharing and generally entail specific shared, common goals established by the member units. Membership is more stable.	**Cooperating** Exchanging information, altering activities, and sharing resources for mutual benefit and common purpose: it requires significant amounts of time, high levels of trust, and a significant sharing of turf.	**Regular coordination** Two or more organisations agree to engage in limited activity to achieve a common purpose. This requires commitment of resources beyond information sharing.
Interagency Collaboration Is more jointly planned and intensive.	**Collaborative Partnership** Strong linkages among members. The purpose is specific, often complex, and usually very stable. Formal process and structural patterns of collaboration are usually expressed in writing … each member unit has delegated considerable autonomy to the collaboration.	**Collaborating** Exchanging information, altering activities, sharing resources and a willingness to enhance the capacity of others for mutual benefit and a common purpose: it requires the highest level of trust, considerable amounts of time, and extensive sharing of turf.	**Coalition** Occurs when interdependent actions are taken, but the purpose is narrow in scope. All actions occur within the participant organisations themselves or involve sequential or simultaneous activity of participant organisations. The purpose is specific and involves long term commitment.
			Network Typified by a broad mission and joint and strategically interdependent action. The structural arrangement takes on broad tasks that reach beyond the simultaneous actions of independently operating organisations.

Figure 6.1 Comparison of different classifications of inter-organisational networks

The definitions authors offer for a "network" is illustrative (Table 6.1). Most authors suggest network is a generic term to describe any reasonably stable group of actors and the relationships that link them (Wasserman and Faust, 1994; Moore, 1997; Borgatti and Forster, 2003; Goodwin et al., 2004). Nutbeam (2001) and O'Toole (1997) specify that networks are necessarily non-hierarchical. Himmelman (2003) and Cigel (2003) specify that a network implies relatively loose linkages between members who do not share significant resources. In contrast Mandel and Steelman (2003) argue that a network implies a "strong commitment to overriding goals and members agree to share significant resources over a long period of time". To overcome this confusion it is worth returning to the dictionary definition and linguistic derivation of some key terms.

A group of people who exchange information, contacts, and experience for professional or social purposes (Moore, 1997, p899).
A social network consists of a finite set or sets of actors and the relation or relations defined on them. The presence of relational information is a critical and defining feature of a social network (Wasserman and Faust, 1994, p20).
Any moderately stable pattern of ties or links between organisation and individuals, where those ties represent some form of recognisable accountability (however weak and however often overridden) whether formal or informal in character, whether weak or strong, lose or tight, bounded or unbounded (Goodwin et al, 2004, p13).
Networking is defined as exchanging information for mutual benefit, it does not require much time or trust nor the sharing of turf. It is very useful strategy for organisations that are in the initial stages of working relationships (Himmelman, 2001, p277).
Organisations working together with very loose linkages are networking partnerships, usually existing for information exchange. Members join or disconnect with ease, without threatening the partnership's existence. Informality governs procedural and structural patterns; member units can maintain their organisational autonomy. Resource sharing primarily involves the exchange of ideas news and reports (Cigler, 2003, p 74).
A grouping of individuals, organisations and agencies organised in a non-heirachical basis around common issues or concerns, which are pursued proactively and systematically, based on commitment and trust (Nutbeam, 1998, p361).
Structures of interdependence involving multiple organisations or parts thereof, where one unit is not merely the formal subordinate of the others in some larger hierarchical arrangement (O'Toole, 1997, p 45).
A Network structure is typified by a broad mission and joint and strategically interdependent action. The structural arrangement takes on broad tasks that reach beyond the simultaneous actions of independently operating organisations (i.e. action that may include, but reaches beyond, coordination, task force or coalition activity. There is a strong commitment to overriding goals and members agree to commit significant resources over a long period of time (Mandel and Steelman, 2003, p 197).

Table 6.1: Literature definitions for "network"

6.4. DEFINING NETWORKS

The Oxford dictionary defines a network as *"a group of people who exchange information, contacts and experience for professional or social purposes" (Moore, 1997, p 899).* Network is a derivation of "*net"* which emphasises the interlaced pattern of interaction between people and organisations. This is consistent with the definition of network offered in social network analysis *"a finite set or sets of actors and the relation or relations defined on them"* (Wasserman and Faust, 1994, p20). This thesis adopts "network" as the general term for any reasonably stable group of actors that interact or exchange information or resources around a specific relationship or set of relationships. No particular type or structure of these relationships is implied. Networks may be intra-organisational or inter-organisational, hierarchical or non hierarchical, formal or informal, depending on the type of relationship studied and the social structure in which the relationship is embedded.

6.5. INTRA-ORGANISATIONAL NETWORKS

Intra-organisational networks may be classified as either:

- **hierarchical (vertical) networks:** Hierarchical networks are common in organisations. They are efficient for managing clearly specified tasks that can be facilitated by central co-ordination of a management team, and through the drafting of formal written policies and procedures (Powell, 1990; O'Toole, 1997).
- **non-hierarchical (horizontal) networks:** In domains of rapid technological change and uncertain inputs and outputs, organisations are increasingly using non-hierarchical (horizontal) networks to respond to their complex operational environment (Jones et al., 1997; Pedler, 2001; Hill, 2002). In these circumstances, the efficiency gained by centralised hierarchical coordination may become a bottleneck when the speed, amount and type of information processing necessary to complete a designated task exceeds the expertise and capacity of the centralised management system. Non-hierarchical networks are more flexible and innovative in these circumstances (Leavitt, 1951;

Powell, 1990; Jones et al., 1997; Lasker et al., 2001; Keast et al., 2004).

6.6. FORMAL INTER-ORGANISATIONAL NETWORKS: COALITIONS, ALLIANCES AND PARTNERSHIPS

Formal inter-organisational networks can be classified in terms of the degree and scope of the ongoing commitment to work together:

- **Coalition:** The Oxford Dictionary defines a coalition as *"a temporary alliance for combined action, especially of distinct parties forming a government or of nations"* (Moore, 1997, p 245) and implies a formal agreement between parties. However, no long term relationship is necessarily assumed.
- **Alliance:** An alliance is defined as *"a union or agreement to cooperate, especially of nations by treaty or families by marriage"* (Moore, 1997, p 34). Members of an alliance typically act independently, except under the terms specified by the alliance agreement.
- **Partnership:** A partner is defined as *"a person who shares or takes part with another or others, especially in a business firm with shared risks or profits",* or "*either member of a married couple, or an unmarried couple living together" (Moore, 1997, p978).* It is a derivation of the Middle English *parcener* – "*joint heir*". Based on this derivation, a partnership implies a longstanding relationship between partners with mutual obligations mandated by contractual agreement or by common law that relates to most aspects of their shared work.

6.7. INFORMAL INTER-ORGANISATIONAL NETWORKS: KNOWLEDGE NETWORKS, CO-OPERATING NETWORKS, CO-ORDINATING NETWORKS, COLLABORATIVE NETWORKS

Inter-organisational networks are frequently based on informal relationships. They can be classified in terms of the degree of commitment of time, expertise and resources shared to maintain network activities. *Knowledge networks* share information but there is no commitment of resources beyond the exchange of information, brochures and reports. The terms *co-operate*,

co-ordinate and *collaborate* imply that actors are actively working together. However, *co-ordinate* implies that this co-operation results in the improved *order* of network activities, while *collaborate* implies sharing the burden ("labour" or toil") as well as the benefits of working together (Moore, 1997).

Based on the this analysis, this chapter adopts the following classification to describe the continuum of informal inter-organisational network activities:

- **Knowledge Networks** exchange information for mutual benefit. Members maintain organisational autonomy. Resource sharing is limited to the exchange of information, brochures and reports.

- **Co-operative Networks** exchange information and members acknowledge and accommodate the overall objectives of the network and other network members.

- **Co-ordinating Networks** exchange information and members adopt common objectives after negotiation between network members. Membership is more stable, with attention given to who joins and who leaves. Network members pool resources to meet shared objectives, but maintain autonomous control over the assignment of their organisation's resources.

- **Collaborating Networks** display ongoing commitment to other network members and the shared objectives of the network. The purpose is specific, often complex and typically long term. Membership is stable and the addition or loss of network members may have significant detrimental effects on the network. Members share resources to meet network objectives and are willing to delegate some responsibility for the assignment of these resources to the network itself. There may be attempts to formalise network activities through written objectives, policies and reporting processes, however these do not necessarily imply binding legal agreements between network members.

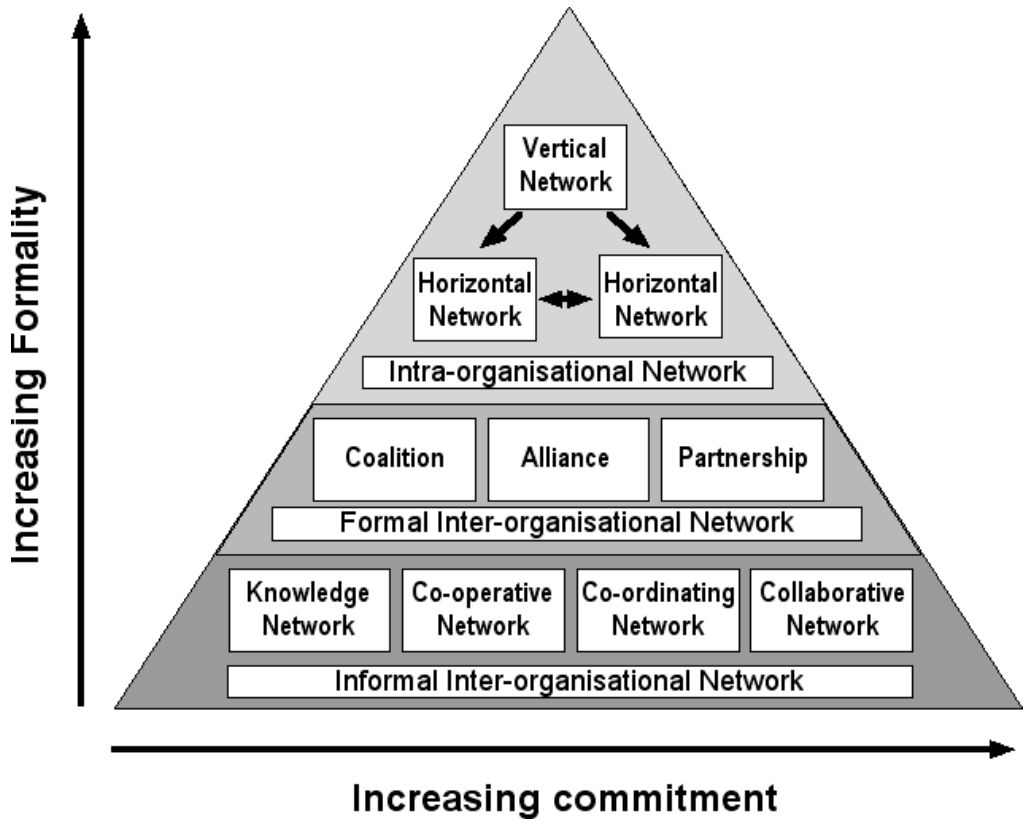


Figure 6.2: The network pyramid - a model of intra-organisational and inter-organisational networks

6.8. A CLASSIFICATION OF NETWORK ORGANISATION: THE NETWORK PYRAMID

In an attempt to provide some clarity to this perplexing area, this chapter proposes the "Network Pyramid" (See Figure 6.2), a typology to facilitate dialogue when discussing different types of networks and to dispel the myth that there is a single network type that is ideal in all circumstances. Different network structures are useful for different purposes, and the type of network that can be mobilised is dependent on the history and social structure of a community.

All human networks are built on a foundation of informal social structure and convention. While organisational hierarchies, coalitions, alliances and partnerships may formalise this social structure, they cannot supersede it. Whether enforced by intra-organisation structure or by inter-organisational contractual agreement, formalised patterns of network interaction cannot breach the deeply embedded social conventions of the social network or the common law principles of their society. A manager, despite their

organisational authority, is not entitled to expect a subordinate to undertake illegal or fraudulent activity, or act in a way that intentionally harms other employees or the community. Similarly, a contract between organisations is not legally enforceable if it breaches the common law statutes of a society. Social convention whether informal (social expectations) or formal (common law) are the foundation on which all other patterns of interaction are built.

Provided formal networks do not breach underlying social convention and are organisationally capable of meeting their objective they can be efficient. Most actors will comply with reasonable direction within the legitimate domain of organisational authority or inter-organisational agreement. In contrast, informal social systems require more “on the go” negotiation to achieve sufficient consensus to act. However, networks that have a history of successful interaction and a shared understanding of the problem may be able to develop sufficient consensus to act in an efficient and timely manner.

Within any network at any specific time, the pattern of social relationships may vary substantially between different individuals, subgroups and organisations. While certain individuals, groups or organisations may collaborate very closely, others may cooperate but maintain their autonomy, others merely exchange information, while others may not interact at all. Relationships within a network may be formal or informal. Networks may also change over time. In particular, informal networks can rapidly remodel themselves in response to their environment.

While acknowledging the fluidity of human social networks, this typology is proposed as a tool to characterise the general pattern of relationships observed within a network.

6.9. FROM METAPHOR TO METHDOLOGY: SOCIAL NETWORK ANALYSIS

If indeed networks are important vehicles for the promotion of community safety, it is necessary to develop methodolgies able to describe and analyse how these social systems work (Wellman, 1988; Wasserman and Faust, 1994).

The standard approach of epidemiology and sociology was to define a population and study a representative sample of individuals within this

population. A key assumption was that the attributes and behaviour of these individuals were independent (Wasserman and Faust, 1994). When researchers were confronted with interdependent observations they sought to remove these "confounding variables". At best they were a nuisance, at worst they undermined the validity of their models. However, in human systems, the interdependence of actors and their environment (the capacity of individuals to influence each other, modify their environment and be influenced by their environment) is not just a methodological inconvenience, but an essential characteristic of social interaction (Robins and Pattison, 2005b).

Social Network Analysis (SNA) takes a structural perspective of social interactions, arguing that behaviour is not solely influenced by the beliefs, attitudes and capabilities of individuals, but also by their socio-ecological context. There has been a recent growth of interest in SNA. Published studies have grown exponentially since the 1970's (Figure 6.3).

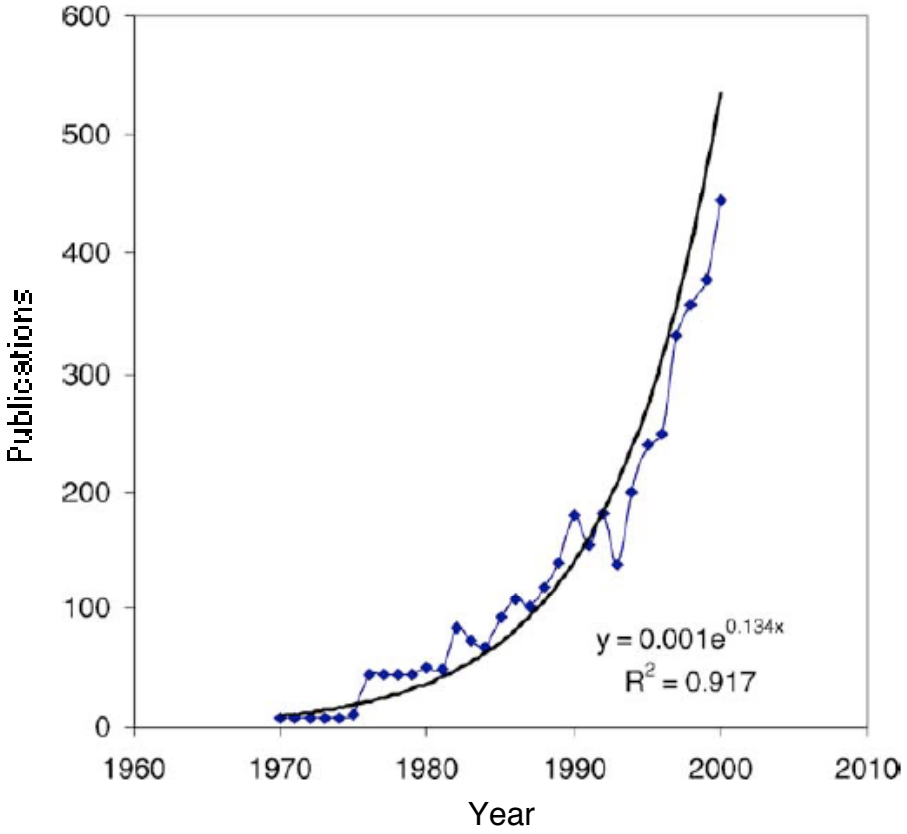


Figure 6.3: Growth of publications indexed by sociological abstracts containing "social network" in the abstract or title (Borgatti and Foster, 2003)

6.10. SOCIAL NETWORK ANALYSIS: A SHORT HISTORY

The importance attributed to social structure as a determinant of the behaviour of social systems and individuals embedded within these social systems has a history dating back to the genesis of sociology. Auguste Comte (1798-1857), the founder of modern sociology, argued there were two key elements to the study of sociology, statics and dynamics (Abercrombie et al. 1994; Freeman, 2004). While dynamics studied the "general laws of social development", statics studied the "anatomy" of society or the "laws of social interconnection". Émile Durkheim (1858 – 1917) insisted that society was more than the sum of its parts. In contrast to utilitarian tradition of British social thought which concieved of society as nothing more than an collection of individuals united by self interest, Durkheim argued that individuals were moulded and constrained by social phenomenon. These "social facts" could not be explained in terms of the actions and motivation of individuals (Abercrombie et al. 1994). Georg Simmel (1858 – 1918) argued "*Society exists where a number of individuals enter into interaction*" and went on to specify that:

> A collection of human beings does not become a society because each of them has an objectively determined or subjectively impelling life content. It becomes a society only when the vitality of these contents attains a form of reciprocal influence; only when one individual has an effect, immediate or mediate upon another, is mere spatial aggregations or temporal succession transformed into society. If therefore, there is to be a science whose subject matter is society and nothing else, it must exclusively investigate these interactions (Simmel 1908, cited Freeman 2004, p 15).

In the 20th century, a number of diverse strands independently shaped the development of present day SNA.

The "gestalt" school of psychology had a critical influence on the genesis of SNA. At the beginning of the century a number of German pyschologists became interested in the way the human mind transformed sensory stimuli into perceptions. They were intrigued by the tendency of the mind to impose form on sensory stimuli, especially visual stimuli (Bootzin et al., 1986). It became clear that the brain recognised overall patterns of sensory stimuli, or "gestalts" (the German word for "form", "shape" or "whole"). A gestalt may

have properties that cannot be inferred from observation of its component parts. In social psychology, this school of thought emphasised the importance of social context (the whole) on the behaviour of individuals (a component part).

In the 1930's many leading gestalt theorists fled Nazi Germany for the United States of America. Jacob Moreno, Kurt Lewin and Fritz Heider became important proponents of gestalt social psychology (Scott, 2000).

Many identify a 1934 publication by Jabob Moreno's (1889-1974) "Who Shall Survive" as the signal event in the history of SNA (Wasserman and Faust, 1994; Freeman, 2004). Moreno argued the importance of social structure or "psychological geometry", which he later called "sociometry". Along with his collaborator, Helen Jennings, he conducted a number of systematic studies of social systems in the 1930's. He "invented", the sociogram (a graphic representation of a social system) to describe and interpret his results (Wasserman and Faust, 1994; Freeman, 2004).

Kurt Lewin (1890-1947) established a research centre at Massachusetts Institute of Technology (MIT) that focused on "field theory", the internal and external "forces" that impact on individual behaviour. A social field consisted of a combination of "points" (individuals) connected by "paths" (interactions), a concept not dissimilar to Moreno's sociometry (Scott, 2000). Lewin's advocacy of mathematical modelling of group relationships, provided a critical foundation for later work (Scott, 2000).

Fritz Heider researched how "cognitive balance" impacted on interpersonal relationships. Heider was especially interested in "interpersonal balance", in which there was congruence in the attitudes held by members of an individual's immediate social environment.

After Lewin's unexpected death in 1947, most of his research group moved to the University of Michigan, where Dorwin Cartwright collaborated with mathematician Frank Harary to develop a formal mathematical model of Heider's "cognitive balance" theory (Cartwright and Harary, 1956). Together they pioneered the application of "Graph Theory" to group behaviour (König, 1936 cited in Scott, 2000; Cartwright and Zander, 1953; Harary and Norman,

1953) an innovation that formed the mathematical foundation of modern SNA. Graph theory isn't necessarily concerned with the representation of mathematic relationships diagrammatically, but rather with the mathematical description of the properties of a set of points (nodes) connected by a set of lines (edges). Using graph theory it became possible to mathematically describe and analyse group structure (Scott, 2000).

Before moving to the University of Michigan, Cartwright supported Alex Bavelas, one of Lewin's graduate students, in the completion of his doctoral dissertation (Scott, 2000; Freeman, 2004). Bavelas remained at MIT and went on to design a landmark study in SNA, which demonstrated the importance of an actor's network centrality (the degree to which they are central to network communication) to their personal influence and to overall network function (Bavelas, 1950).

At the beginning of the 20th century, Alfred Radcliffe-Brown (1881-1955) was an eloquent advocate for a structural perspective of social systems. Based on his anthropological studies of indigenous people in the Andaman Island in the Bay of Bengal and in Western Australia he emphasised the importance of kinship and social subgroups (cliques) within social systems. He travelled extensively and taught in Cape Town, Sydney, Chicago, Birmingham and Oxford and in so doing influenced the development of two early schools of Social Network Analysis at Harvard University and Manchester University (Freeman, 2000).

The main intellectual thrust for the study of social structure at Harvard University came from W. Lloyd Warner (1898-1970). Warner worked with Radcliffe-Brown in the anthropological study of Australian Aborigines and returned to the United States keen to apply ethnographic field methods to the study of industrial communities (Freeman, 2004). Warner moved to Harvard where he collaborated with Australian psychologist Elton Mayo on a number of important studies of factory and community life in America and attempted to apply the structural ideas of Radcliffe-Brown.

The Western Electrical Company enlisted Mayo's support and subsequently Warners's, to study determinants of worker productivity. The so called

”Hawthorne Study” used ethnographic methods to study the effect of group dynamics on worker productivity (Freeman, 2004). Later, the “Yankee City Study” confirmed the critical importance of social subgroups on social structure (Scott, 2000). In the “Deep South Study” Warner studied the effect of social class and race on social stratification. These studies are notable for their use of sociograms to report group structure (Scott, 2000; Freeman, 2004). Their strong focus on the effect of subgroups or cliques on social interaction laid the foundation for an important new domain of SNA research (clique identification and block modelling). Unfortunately, when Warner and his students moved on to other universities, the initial Harvard thrust was lost (Freeman, 2004).

The Manchester Group were even more strongly influenced by the structural ideas of Radcliffe-Brown than the Harvard group. However, instead of emphasising social integration and cohesion they were interested in the effect of conflict, power and change on social structure. While pursuing this interest, they managed to integrate concepts relating to the impact of social network structure with important contemporary sociology theory, especially the impact of personal values of actors, internalised from the norms and values of their social context (Scott, 2000).

In the 1960s, Harrison White precipitated a renaissance of social network research at Harvard University. White had studied mathematics and science at MIT, obtaining his PhD in theoretical physics in 1955. However, within one year of completing his PhD he pursued a longstanding interest in the social sciences, ultimately obtaining a second PhD in sociology in 1960. His dissertation was a social network study that involved the application of algebra in modelling organisational behaviour. White moved to Harvard in 1963 armed with exemplary training in physics, mathematics and structural sociology. Reza Azarian notes:

> It is the schooling in theoretical physics rather than in classical sociology which, at least initially, provides the main frame of reference in his analysis of social phenomena (Azarian, 2000 cited Freeman, 2004, p 124).

His research regarding the algebraic description of actor roles resulted in a number of notable papers on block modelling (Lorraine and White, 1971;

White et al., 1976; Boorman and White, 1976; Heil and White, 1976), a suite of mathematical techniques used to analyse social structure (Wasserman and Faust, 1994). However, it was White's outstanding skills as an educator that made him such a critical catalyst for the development of modern SNA. Abbott (1994, cited in Freeman, 2004, p127) described White "as a man who has started sociological revolutions, introduced new techniques, and trained one of the finest groups of students in the discipline". Freeman (2004) comments:

> A list of White's students is a virtual who's who in social network analysis. … From the beginning, White saw the broad generality of the structural paradigm, and he managed to communicate both that insight and his own enthusiasm to a whole generation of outstanding students. Once this generation started to produce, they published so much important theory and research focused on social networks that social scientists everywhere, regardless of their field, could no longer ignore the idea. By the end of the 1970s, then, social network analysis came to be universally recognised among social scientists (Freeman, 2004, p 127).

Under White's tutelage, SNA had finally come of age. As his students pursued their international careers, the work of White and his British counterparts were united into a complex but increasingly coherent framework that formed the basis of modern SNA (Scott, 2000). However, it is important to understand that "social network analysis is not, in itself, a specific theory or set of theories" but rather "a series of mathematical concepts and technical methods" (López and Scott, 2000). The field is essentially defined by a suite of methodological techniques utilised by its proponents to quantitatively analyse social systems. Freeman (2004) suggests that four key concepts together define the field:

1. Social network analysis is motivated by a structural intuition based on ties linking social actors.
2. It is grounded in systematic empirical data.
3. It draws heavily on graphic imagery.
4. It relies on the use of mathematical and/or computational models.

6.11 CONCLUSION

Networks have been proposed as an effective response to the complex problems that plague modern society. Health practitioners, researches and administrators have enthusiastically embraced the network metaphor. By networking, sharing knowledge, expertise and resources, it is argued communities can be empowered to comprehensively and effectively promote their own health and safety. If this is indeed the case, it is important to move beyond the network metaphor to develop methodologies able to describe and analyse how this social process works.

Social Network Analysis is a suite of quantitative sociological research tools which analyse how individuals interact to create the structure and function within social systems, and just as importantly, how the contextual social characteristics of a social system determine the behaviour of individuals. This thesis seeks to test whether SNA could be used to describe the growth and structure of the Mackay Whitsunday Safe Communities, the mobilisation of human and other resources utilised by the network, and offer insight into how the coalition functions.

CHAPTER SEVEN

SOCIAL NETWORK ANALYSIS OF MACKAY WHITSUNDAY SAFE COMMUNITIES: METHODOLOGY

7.1 SOCIAL NETWORK ANALYSIS

Social Network Analysis (SNA) in a quantitative sociological technique that seeks to map and analyse the patterns of relationship observed in a social network. In SNA the unit of analysis is not an individual actor but rather the relational ties that link a pair of actors, or dyad (Scott, 2000). By collating the set of relationships observed at a dyad level it is possible using graph theory (König, 1936 cited Scott, 2000; Cartwright and Zander, 1953; Harary and Norman, 1953) to mathematically describe a social system.

Social Network Analysis (SNA) takes a structural perspective of social interactions, arguing that behaviour is not solely influenced by the beliefs, attitudes and capabilities of an individual, but also by their socio-ecological context. Wasserman and Faust (1994) suggest four underlying theoretical principles that distinguish SNA from other research paradigms:

- Actors are interdependent, rather than independent autonomous units.
- Relational ties between actors are channels for the transfer or flow of information and resources (either material or nonmaterial).
- The social structure created by the pattern of relationships linking actors provides opportunities and constrains individual action.
- Network models conceptualise structure as lasting patterns of relations among actors.

However, the field of SNA is more accurately defined as a suite of mathematical concepts and techniques used to describe, quantify and analyse social systems, rather than a specific theory.

7.2 MATHEMATICAL FOUNDATIONS

A network can be represented as a *graph G* = *(*N,E*)* comprised of a set of social actors or *nodes* (N) and a set of relationships or *edges (*E*)* that connect a pair of nodes, where:

1. N = {1,2, ….. g} denotes a set of nodes. These actors can be persons, teams, organisations, countries, machines, or concepts.
2. E = {a,b, …. g} denotes a set of edges. Each edge represents a particular relationship linking a pair of actors. Data is collected in pairs or *dyads*. e_{ij} indicates the presence or absence of an edge or relational *tie* linking a pair of actors (i,j). When e_{ij} = 1, this indicates the presence of a tie, whereas if e_{ij}= 0, no tie was observed. Ties represent channels of information, resources, social exchange or associations connecting actors in a network (Wasserman and Faust, 1994). While typically these "ties" are relational, any type of interaction can be measured, including financial, informational or conceptual associations (Borgatti and Foster, 2003).

Depending on the type of relationship, ties can be:

- *Directed* – in directional ralationships the reporting of a relationship e_{ij} by actor n_i does not necessarily imply that actor n_j will report the reciprocal relationship e_{ji} ($e_{ij} \neq e_{ji}$). For example, the fact that actor n_i gives advice to actor n_j does not imply n_j gives advice to n_i ,
- *Undirected* – in undirected relationships the reporting of a relationship by one member of a pair of actors (dyad) n_i implies actor n_j has the same relationship ($e_{ij} = e_{ji}$). For example, the observation that n_I is married to actor n_j implies that n_j must also be married to n_I ,
- *Binary* or *dichotomous* - a relationship is either observed to exist (e_{ij} = 1) or not to exist (e_{ij} = 0),
- *Valued* – in which the strength or frequency of an interaction is assigned a numerical value,
- *Signed* - the relationship is observed to either be positive ($e_{ij} = {}^{+}1$), or negative ($e_{ij} = {}^{-}1$).

Data can be displayed graphically. A line indicates the presence of a relational tie linking two nodes or actors. Arrows are used if the relationship is directional. In social networks this graph is called a *sociogram* (Figure 7.1). A sociogram provides a spatial representation of the relationships identified by respondents.

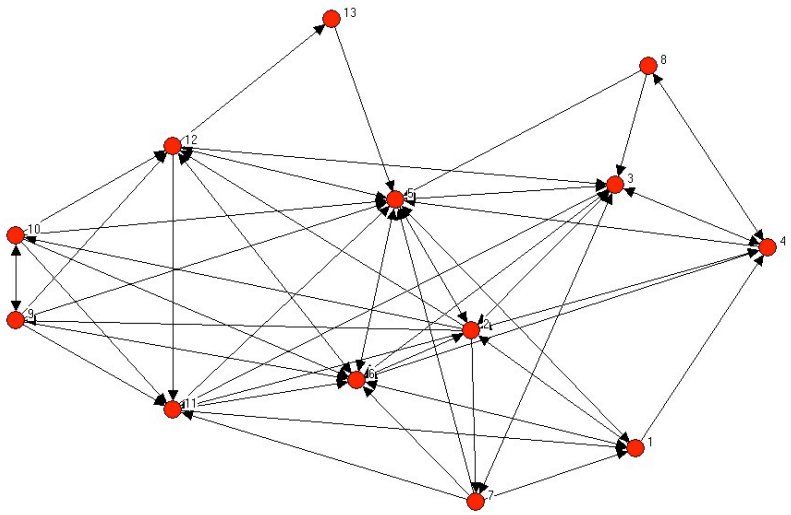


Figure 7.1 Sociogram: Mackay Whitsunday Safe Communities Network Support Group, 2004

A network of social interactions can also be represented by a g x g *adjacency matrix* (Figure 7.2). In this matrix (M), the rows and columns correspond to individual actors or nodes (N) of the network graph (G). Each entry (m_{ij}) in the matrix, indicates whether a relationship is directed from an individual actor (n_i) to another actor in the network (n_j). The entry equals 1 if the pair of actors (i,j) is a member of the set of edges or ties (E) observed in the network. In a dichotomous graph:

$m_{ij} = 1$ if $(i,j) \in E$ (i.e. a tie is observed directed from i to j)

$m_{ij} = 0$ if $(i,j) \notin E$ (i.e. no tie is observed directed from i to j)

The rows in the adjacency matrix represent the outgoing ties emanating from each actor, whereas the columns represent incoming ties. If the relationship is undirected, the matrix will be symmetrical.

	Actor 1	Actor 2	Actor 3	Actor 4	Actor 5	Actor 6	Actor 7	Actor 8	Actor 9	Actor 10	Actor 11	Actor 12	Actor 13
Actor 1		1	0	1	1	1	0	0	0	0	0	0	0
Actor 2	0		1	1	1	1	1	0	1	1	1	1	0
Actor 3	0	1		1	1	1	1	0	0	0	1	1	0
Actor 4	0	1	1		1	1	0	1	0	0	0	0	0
Actor 5	1	1	1	0		1	0	0	0	0	0	0	0
Actor 6	1	1	1	1	1		0	0	0	0	1	1	0
Actor 7	1	0	1	0	1	1		0	0	0	1	0	0
Actor 8	0	0	1	1	1	0	0		0	0	0	0	0
Actor 9	0	0	0	0	1	1	0	0		1	1	1	0
Actor 10	0	0	0	0	1	1	0	0	1		1	1	0
Actor 11	1	0	0	0	1	1	0	0	0	0		0	0
Actor 12	0	0	1	0	1	1	0	0	0	0	1		1
Actor 13	0	0	0	0	1	0	0	0	0	0	0	0	

NB. Data is directional and binary (0 = no relationship, 1 = relationship)

Figure 7.2 Directional Adjacency Matrix: Mackay Whitsunday Safe Communities Network Support Group

When attention is focused on an individual actor, the actor is referred to as *ego* and the actors who have ties with ego are called *alters*. The ensemble of ego, their alters, and all the relationships that link them is called an *ego network*.

This mathematical representation can be used to calculate the effect of social interactions at the interpersonal level on the structure and characteristics of larger social systems. Conversely, it can also be used to calculate the effect of larger social systems on the individual and their interpersonal relationships.

While SNA is characterised by the collection of relational data, it is also possible to collect individual actor attribute data.

7.3 METHODOLOGICAL ISSUES

A critical decision during the design phase of any study, including a SNA, is defining the population under study. Two questions are of particular importance:

1. How will members of the social network be identified?
2. How will the boundary of the social network be defined?

Lauman et al (1983) reviewed strategies used to define a network. They distinguished between *realist approaches (*where the study population is empirically defined based on the network's perception of itself), and *nominalist approaches* (where investigators determine the study population based on theoretical considerations or the analytic purpose of the study). The network could be defined using one of three essential network characteristics: actors, relationships or activities (Lauman et al., 1983; Marsden, 1990).

1 Actors. Network membership may be defined by the group itself (for example, schools, clubs, workplace, department, organisations, or community group). Alternatively, network members may occupy a defined role within an organisation or social system (for example, professional communities or elites).

2 Relationships. Social relationships may themselves be used to identify the network (for example, friendship networks, support networks or snowballing procedures).

3 Activities. Participation in a shared activity (for example, attendance at an event, participation in a forum or publication in a specific journal) may be used for defining the network.

Networks do not exist in isolation and depending on the purpose of the study, relationships with external actors may be an important part of network function. Laumann et al. (1983) suggest that the partial system fallacy (omitting important actors from the study population) is potentially one of the most serious flaws in SNA study design.

If the purpose of this study was to investigate community affairs, or the relational or structural characteristics of Mackay Whitsunday Safe Communities (MWSC), then a "closed" design which investigated a network defined by a group of actors who were formal members of the MWSC would be meaningful. As the aim was to investigate how MWSC achieved its objectives, interaction with external actors was considered a critical part of its activities so a closed design was considered to have serious limitations. Given that important, in-kind, human and financial resources were likely to be accessed through both internal and external

relationships, it was decided that a network defined by the chain of relationships used to access and distribute these resources within MWSC would be more meaningful.

Snowballing is a methodology that progressively follows a chain of relationships emanating from an initial sample of key informants (Wasserman and Faust, 1994; Scott, 2000). This methodology was selected as it allowed respondents to delineate a network of relationships they believed made a significant contribution to the function of MWSC. Snowballing methodologies are traditionally used to identify “hidden populations”. Typically these are hard to reach sub-populations of a larger study population; for example, criminal networks or illicit drug users (Thompson, 1997; Atkinson and Flint, 2001; van Meter, 1990; Petersen and Valdez, 2005; Kossinets, 2006). However, snowballing lends itself to identifying the “hidden population” of external actors who make a significant contribution to MWSC. As some of these actors may not even reside in Mackay Whitsunday, they may not be discovered using traditional population survey techniques.

A number of authors argue that SNA is especially vulnerable to bias introduced by missing data (van Meter, 1990; Griffiths et al., 1993; Scott, 2000; Atkinson and Flint, 2001; Chattoe and Hamill, 2005; Kossinetts, 2006). Missing data may be of two types, missing actors or missing relationships, and may occur in three ways:

1. Selection bias,
2. Non-participation bias,
3. Recall bias.

Kossinets (2006) demonstrated that network-level statistics can be dramatically affected by selection bias related to boundary specification issues. He conducted a sensitivity analysis of an empirical dataset (a scientific collaborative network) and demonstrated that failure to identify all members of a network would result in overestimation of network parameters, while failure to identify all relationships would result in an underestimation of network parameters.

Borgatti (2004, personal communication) suggests that participation rates of at least 80% are necessary for network attribute calculations to be representative. Conscientious follow up of all network members is imperative if one is to conduct a successful SNA, particularly as non-participants may not arise randomly. Less engaged members of the network may either be less motivated to participate in the study or more difficult to contact.

The third source of bias is recall bias. Self reporting of relationships with other members of the network is the most common method used to collect network data. A number of researchers (Bernard and Killworth, 1977; Bernard et al., 1980, 1982 and 1984; Hammer, 1984; Sudman, 1985; Freeman et al., 1987; Sudman, 1988; Marsden, 1990; Feld and Carter, 2002) have reported marked discrepancies between the number of relationships respondents report during interviews (typically 20 or less) and their true network (typically hundreds of relationships), as estimated by daily logs of social contact, intensive probing techniques, extrapolation from indirect contacts, or “small world” studies. Importantly, there are systematic rather than random discrepancies between self reported and observed network data (Freeman et al., 1987; Marsden, 1990). Recognition methods (in which participants are offered a list of network members and asked to nominate who they know) are more complete than recall methods in which participants must actively recall other network members without prompting (Sudman, 1985, Sudman, 1988; Marsden, 1990). Network data that concern relationships that are frequent, closer or stronger are more likely to be accurately reported than relationships that are infrequent, distant or weak (Hammer, 1985; Marsden, 1990). While participants may struggle to accurately report social interactions within a specific time frame or context (Bernard and Killworth, 1977; Bernard et al., 1980, 1982 and 1984), they are able to report their “typical” social interactions with other network members (Freeman et al., 1987; Marsden, 1990). It is therefore meaningful to report participants’ perceptions of their network. However, this does pose a challenge to researchers attempting to calculate network parameters based on this type of data.

There are significant theoretical disadvantages to snowball samples:

1. Snowballing follows a chain of *memorable* relationships emanating from the key informants used in the initial sample. It may therefore overlook less connected members at the periphery of the network (van Meter, 1990; Griffiths et al., 1993; Scott, 2000; Atkinson and Flint, 2001) and thereby overestimate network parameters (Kossinets, 2006).
2. Snowball samples use a *recall* method. The network is defined by following the chain of relationships participants recall, rather than by a predetermined list of network members used to prompt participants. Given recall methods have been shown to systematically under-report network relationships (Sudman, 1985, Sudman, 1988; Marsden, 1990), they may underestimate network parameters (Kossinets, 2006).
3. Snowball samples may give undue prominence to the personal networks of the key informants used in the initial sample (van Meter, 1990; Griffiths et al., 1993; Scott, 2000; Atkinson and Flint, 2001).

In light of the advantages of a snowballing approach but also these important disadvantages, a hybrid technique was adopted. MWSC members who had not been identified during the first snowball survey wave were added to the wave two sample. A MWSC member was defined as anyone minuted as having attended one or more meetings of one of the project's action groups. This ensured that all members of the MWSC were included; yet allowed respondents to identify external relationships they considered relevant to the function of MWSC. This methodology identified MWSC and its Support Network (MWSC and SN), a network of relationships involving community and external actors who cooperated to promote safety in the region.

This study seeks to assess the utility and validity of SNA as a tool to describe and analyse the function of MWSC and SN.

7.4 METHOD

The initial sample was conducted by surveying members of the MWSC Network Support Group (NSG). This phase of the study was undertaken in November 2003. Network members nominated by the NSG were surveyed during wave one of the study. This phase of the study was conducted in the first half of 2004. New actors nominated by wave one respondents were surveyed during wave two. The final phase of the study was conducted in the second half of 2004. At this stage, MWSC members not identified by wave one respondents were also surveyed. New actors nominated by wave two respondents were recorded, but not included in the study population.

Respondents were asked to actively recall and name individuals with whom they interacted in their work of promoting safety in the community. These people did not necessarily need to be members of the MWSC. This allowed all contacts within the sphere of influence of the MWSC to participate in the survey.

Participants were reassured that their participation was voluntary and all personal identifying information was kept confidential.

Network members who did not respond to the original mail survey were followed up in writing and if necessary a minimum of two attempts were made to contact them by telephone. Network members contacted by telephone were offered the opportunity to complete the survey over the telephone.

After the initial data collection phase, actors were identified by organisational role rather than individual contribution. In those intances where a particular role was undertaken by more than one individual over the course of the study, relationships were recorded by organisational role, not individual identity.

Respondents were asked five questions in relation to the actors they identified as members of their personal MWSC & SN ego network (see Appendix Twenty-Three for sample questionnaire)

Q1. What relationship do you currently have with this person?

- *No contact (0).*
- *Some contact (1)* - you share flyers and advertising materials, ask questions or refer clients to each other.
- *Interagency meetings (2)* – you meet to share information and discuss mutual goals but work independently.
- *Working committee (3)* – you collaborate at committee level to meet shared objectives agreed by the group.
- *In depth collaboration (4)* – you collaborate to develop joint funding proposals, plans or projects, sharing time and resources to actively work together.

Q2. What relationship did you have with this person prior to your involvement with the Mackay Whitsunday WHO Safe Communities (Note: this data was being recorded retrospectively)?

- *No contact (0).*
- *Some contact (1).*
- *Interagency meetings (2).*
- *Working committee (3).*
- *In depth collaboration (4).*

Q3. Has this relationship changed as a *consequence* of the project?

- *Worse (-1)* - our relationship has deteriorated as a consequence of our involvement in the project.
- *Unchanged (0)* - our relationship remains unchanged, or any changes that have occurred are unrelated to the project.
- *Better(+1)* - our relationship has improved as a consequence of our involvement in the project.

Q4. What resources do you share with this person as a consequence of your involvement in the project?

- We *do not share* resources.
- We share *in kind resources* e.g. printing, photocopying written materials, library access, desk space, computer software or hardware.
- We share *human resources* to collaborate on joint projects. This does not include attendance at meetings unless your involvement in the group requires you to commit extra time to meet shared objectives set by the group.
- We share *financial resources* to collaborate on joint projects. That is, your organisation shared significant financial resources (> $100) that once given are no longer under your direct control.

Q5. On balance have you found this relationship?

- *Unhelpful (-1)* – the benefit obtained by working together does not justify the extra effort and resources required to maintain the relationship.
- *Neutral* (0) – the extra effort and resources required is balanced by the benefit obtained by working together.
- *Beneficial (+1)* - the benefit obtained by working together outweigh any extra effort and resources required to maintain the relationship.

Respondents were also asked to identify the type and extent of resources they shared, or shared on behalf of their organisation with Mackay Whitsunday Safe Communities as a whole.

a. In kind resources
    i. Photocopying (> 25 copies).
    ii. Printing or resource materials(> 25 copies).
    iii. Access to computing equipment.
    iv. Desk space.
    v. Office space.

b. Staff time:
    i. None.
    ii. < 5 hours per week.
    iii. 5 to 15 hours per week.
    iv. 15 to 25 hours per week.
    v. 25 to 35 hours per week.
    vi. > 35 hours / week.

c. Financial resources
    i. None.
    ii. < $100.00 per annum.
    iii. $100.00 to $500.00 per annum.
    iv. $500.00 to $1000.00 per annum.
    v. $1,000.00 to $5,000.00 per annum.
    vi. $5,000 to $10,000.00 per annum.
    vii. $10,000 to $50,000 per annum.
    viii. $50,00.00 to $100,000 per annum.
    ix. > $100,000 per annum.

Directional adjacency matrices and sociograms were constructed for each question:

Q1. Relational matrix and sociogram for 2004 (valued),

Q2. Relational matrix and sociogram for 2000 (valued),

Q3. Changed relationship matrix (signed),

Q4. Resource sharing matrices and sociograms,

a. In-kind resources (2004) matrix and sociogram (binary),

b. Human resources (2004) matrix and sociogram (binary),

c. Financial resources (2004) matrix and sociogram (binary),

Q5. Beneficial relationship matrix and sociogram, 2004 (signed).

7.5 INDIVIDUAL NETWORK ATTRIBUTES

These matrices were used to calculate the following network attributes of individual actors and their relational ties using UCINET 6.74 software (Borgatti et al., 2002):

1. *Degree*. The degree of an individual actor (ego) is the number of ties linking them to other actors in the network (Scott, 2000). In directed networks *in degree* can be distinguished from *out degree*. *In degree* is the number of ties directed towards ego by other actors in the network (i.e. the sum of the column for an individual actor in the adjacency matrix). *Out degree* is the number of ties directed from ego to other actors in the network (the sum of the row for that actor).

2. *Path*. A path is a sequence of ties joining two actors in a network. A number of different paths may be possible. The path length d_{ij} is the number of ties traversed to connect the two actors (Degenne and Forsé, 1999).

3. *Geodesic path*. The shortest path connecting two actors (Degenne and Forsé, 1999).

4. *Distance*. The geodesic *distance* is the length of the geodesic path (Degenne and Forsé, 1999).

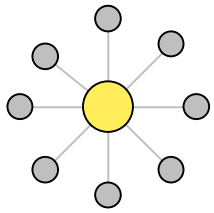
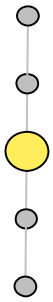
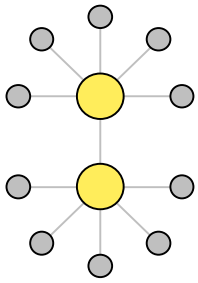
	Diagrammatic Representation	Description
Degree Centrality		The absolute count of the number of relationships maintained by an actor. It is a measure of an actor's immediate sphere of influence. In directional matrices "in-degree centrality", the number of times ego is nominated by other actors, can be distinguished from "out-degree centrality", the number of relationships nominated by ego.
Closeness Centrality		The "farness" of an actor is the sum of the shortest path (geodesic) between this actor (ego) and all other actors within the network. The reciprocal of farness is closeness centrality. Actors with higher scores are closer to the rest of the network and can thereby communicate more efficiently. Closeness can be normalised by dividing the maximum closeness score (n-1) by absolute closeness. It is then expressed as a percentage of the maximum possible closeness score.
Betweeness Centrality		The number of occasions an actor is situated on a geodesic pathway connecting two other actors in the network. Actors with high betweeness scores are therefore in a better position to control the flow of information. They can either act as brokers (facilitators of information exchange) or as gatekeepers (i.e. they selectively prevent the passage of information).

Table 7.1 Freeman's (1979) Measures of Actor Centrality

5. *Centrality*. Centrality is one of the most important and widely used conceptual tools for studying the prominence of individual actors within a network (Everett and Borgatti, 2005). Empirical studies have confirmed theoretical suspicions that the most "central" actors are also the most powerful actors (Markovsky et al., 1988; Brass and Burkhardt,1993). They possess the greatest leadership potential in a social network. Freeman (1979) proposed three measures of actor centrality: degree centrality, closeness centrality and betweeness centrality (Table 7.1).

6. *Isolate*. Actors who do not have a relationship with any other network members (Scott, 2000).
7. *Local Clustering Coefficient* C_i of an actor is the proportion of dyads to whom actor i is connected that are connected to each other (Robins et al, 2005a).

7.6 GLOBAL NETWORK CHARACTERISTICS

Global network characteristics were also calculated using UCINET 6.74 software (Borgatti et al., 2002):

1. *Density* is a commonly calculated measure of network cohesion. The density of a group is defined as the number of edges or relationships observed divided by the total number of possible relationships. For a directed graph (Scott, 2000):

$$\text{Density} = \frac{l}{N \times (N-1)}$$

Where l = the number of ties or *lines* joining all actors in the network

N = total number of actors in a network

2. *Average Degree* Some authors (Friedkin, 1981) have questioned the value of density as a measure of cohesion given that it is logarithmically dependent on the size of the network (large networks typically demonstrate very low densities). *Average Degree* is another commonly cited measure of cohesion. *Degree* is the number of ties observed for an individual actor. Average degree is therefore the average number of relationships observed for each actor in the network (Scott, 2000).

$$\text{Average Degree} = \frac{l}{N}$$

3. *Average distance*. The average geodesic distance between all nodes.
4. *Distance weighted fragmentation.* The average of the reciprocal of the distances between all actors, which ranges between 1 and 0. Larger values indicate more fragmentation of the network (Borgatti et al., 2002).

5. *Distance based cohesion.* Equals 1 minus the *distance weighted fragmentation.* Larger values indicate the network is more cohesive (Borgatti et al., 2002).

6. *Clustering Coefficient C* is the average value of the local clustering coefficient across all nodes (Robins et al, 2005a ; Watts 1999; Borgatti et al., 2002).

7. *Centralisation*. A measure of how tightly a network is organised around its most central point, i.e. a central actor or group of actors (Scott, 2000). For a given binary network with vertices $v_1....v_n$ and maximum degree centrality c_{max}, the network degree centralization measure is $\sum(c_{max} - c(v_i))$ divided by the maximum value possible (n – 2), where $c(v_i)$ is the degree centrality of vertex v_i (Borgatti et al, 2002).

8. *Core periphery structure*. The tendency of a network to form around a core group of central actors who themselves have cohesive (i.e. dense) relationships with each other (Borgatti and Everett, 1999).

9. *Triad Census*. A *Triad* is a (sub-) network consisting of three nodes and the ties that connect them (Scott, 2000). While the dyad represents an interpersonal interaction between two actors, the triad is the first and most basic manifestation of social interaction in which the presence of a third actor may influence the interaction between the other two actors in the triad. It is argued that triadic structures are the building blocks of larger social systems (Scott, 2000). Thus, the balance of social interactions observed at the triad level may be used to predict the structure and properties of the overall network (Degenne and Forsé, 1999). The *Triad Census* is the frequency distribution observed for the sixteen possible permutations of relationships connecting any group of three actors (de Nooy et al., 2005). The Triad census was calculated using Pajek 1.02 (Batagelj and Mrvar, 2004; deNooy et al., 2005).

Sociograms were drawn using NetDraw 1.45 software (Borgatti et al., 2002). A block-model of MWSC & SN was drawn by modelling the known membership of network action groups actors. Where an actor was active in more than one group they were assigned to the group with which they had the greatest number of relationships. Action group members who were simultaneously members of the NSG were assigned to the NSG.

7.7 CONCLUSION

Social Network Analysis was used to describe, quantify and analyse the MWSC social system. It was considered an appropriate methodology for this study because it takes a structural perspective of social interactions, arguing that behaviour is not solely influenced by the beliefs, attitudes and capabilities of individuals, but also by their socio-ecological context.

The network was delineated using a snowballing technique to follow up the chain of relationships emanating from the Network Support Group through three survey waves between November 2003 and December 2004. Respondents were asked to actively recall actors with whom they interacted in their work of promoting community safety, including people who were not members of Mackay Whitsunday Safe Communities, thus allowing all contacts within the sphere of influence of the coalition to be identified and importantly, allowing assessment of the mobilisation of resources, whether in kind, human, social or financial resources mobilised by Mackay Whitsunday Safe Communities.