

Monitoring Settlement Sustainability – a review of practice

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Abstract

The paper reports on the first stage of a research project which aims to construct tools for effective liveability, environmental performance and settlement form monitoring. This project forms part of the FRST funded Learning Sustainability Programme, a six year programme of research being undertaken to help make the form of New Zealand settlements more sustainable.

In this paper I review the methods and tools currently used in New Zealand to establish and monitor settlement sustainability, particularly in regard to urban form. This includes an examination of monitoring by territorial local authorities, including both RMA and LTCCP monitoring, as well as a review of what is happening nationally through MfE and Statistics NZ on the development of indicators.

The paper then explores the similarities and differences in the approach to monitoring used by different local authorities and how they compare to international best practice. The paper concludes with recommendations on how monitoring can be used most effectively to not only measure but also contribute to settlement sustainability.

Introduction

The purpose of this paper is to discuss the importance of monitoring urban form as part of settlement sustainability monitoring and review approaches to monitoring urban form at the national and local levels in New Zealand.

There is now a well developed body of research¹ that, while not conclusive, shows that urban form is an important contributor to the environmental, social and economic performance of cities and importantly their sustainability. This research evidence is beginning to paint a clearer picture about the dynamic nature of urban systems, in which the built environment (urban form and design) interacts with the social, cultural and natural aspects of the city. As such changes in one aspect of the system, for example, the built environment, can have profound effects on other aspects of the system. Better understanding how this system operates in a particular context should be a key goal for urban planners and policy makers.

In this paper, I will first discuss the importance of monitoring urban form as part of urban sustainability monitoring. I will then explore how urban form has been characterised and measured in the research literature previously. I will then use this as a benchmark to review how urban form is currently monitored in New Zealand both nationally and at the local level, based on a review of national and local authority monitoring reports and strategies. The paper will conclude with a discussion on how the measurement of urban form in New Zealand might be improved.

¹ There is no room in this paper to overview this in any detail but see for instance: Williams, Burton and Jenks, 2000; van Diepen and Voogd, 2001; Burchell *et al.*, 2002; Camagni, Gibelli, and Rigamonti, 2002; Ministry for the Environment, 2005.

The importance of measuring urban form

The term settlement form, used here interchangeably with the more common term "urban form", refers to the spatial arrangement of settlements/cities as well as their 'look and feel'. This includes:

- The shape of a settlement as seen from the air or on a map, including: the overall pattern and compactness of development (for example single vs. multi-centred, nodal development, ribbon development, or continuous 'sprawl') and how different settlements are connected.
- How people/homes and activities (jobs, industry, agriculture, recreation, services) are distributed in an urban area.
- The design of urban commercial precincts and residential neighbourhoods, for example a car-centred design or a pedestrian and/or public transport-oriented design.
- The design of transportation systems, for example traditional car-oriented systems to systems designed to support integrated public transport and walkability.

The importance of urban form to the sustainability of cities is recognised throughout the planning literature (see for example, Camagni, Gibelli, and Rigamonti, 2002; Ministry for the Environment, 2005; van Diepen and Voogd, 2001; Williams, Burton and Jenks, 2000). Urban form, at all spatial scales, has been linked to the environmental and social performance of cities, although the evidence is inconclusive about the exact nature of the relationships (causes, consequences, or indirect relationships). It is also widely recognised that "the physical environment is only one element in a more complex whole" (Alberti, 1996, p.390) with socioeconomic conditions as well as the culture and values of urban communities having an important effect on environmental, social, and economic outcomes and perceptions of "quality of life"².

At the metropolitan level, much of the discussion about urban form has focused on the concerns about "urban sprawl".

Urban sprawl, has been described as urban form characterised by:

- Low density residential development
- Leapfrog residential development (residential areas separate from the main part of city by tracts of rural or other land uses)
- Large residential areas without good access to employment, services
- Dispersion of employment,
- Ribbon development (along road corridors)
- Large lot, single family residential areas
- Radial discontinuity
- Physical separation of land uses (Galster *et al.* (2001); Burchell *et al.* 2002)

Urban Sprawl has been seen to contribute to a number of negative environmental, social and economic effects, including:

- Increased travel miles and costs, traffic congestion, and air pollution
- Human health effects (for example, obesity due to lack of exercise)
- Economic decline
- Income and racial segregation of neighbourhoods
- A mismatch between the location of jobs and housing
- Inefficient land conversion and the loss of productive farmland
- Increased costs of infrastructure
- Decline in civic life and social capital³.

² See footnote 7.

³ See for example: Galster *et al.* (2001); Burchell *et al.* 2002; Camagni, Gibelli, Rigamonti (2002)

For example, Ewing *et al.* (2002a/b) looked at the relationship between cities characterised by "sprawl" and transport behaviour. They found that urban "sprawl" was correlated with higher rates of driving and vehicle ownership, increased levels of ozone pollution, and depressed rates of walking and alternative transport use.

On the other hand, research studies have shown that good urban form is associated with positive impacts such as:

- Social equity
- Sustainable use of land
- Vitality and liveliness
- Economic benefits
- Reduction in CO2 emissions
- Reduction in vehicle miles travelled, time spent travelling, and overall transport energy savings
- Ecosystem viability
- Access to services and facilities (Cervero, 1991, Boarnet and Crane, 2001 cited in Knaap *et al.*, 2006; Williams, Burton and Jenks, 2002)

Despite the lack of agreement on how exactly urban form relates to the environmental, social and economic performance of cities, it is clear that urban form is an important thing to measure as part of urban sustainability monitoring in order for policy makers and planners to:

- Evaluate the effectiveness of any planning or other policy instruments aimed at creating a particular urban form
- Systematically monitor urban environmental changes and provide early warning on any trends in urban form which may support or hinder their broader planning and policy goals
- To better understand, in their particular context, the potential links between urban form and positive and negative environmental, social, or economic effects.

For example, as Bertraund (2001, p.22) argues:

Because of the impact of a city spatial structure on its economic and environmental performance, urban planners should constantly monitor its evolution.... spatial indicators need to be constantly monitored to verify that the city is evolving in the spatial direction consistent with the municipal objectives.... Urban planning is not an exact science but has to proceed by trial and errors. That makes it all the more important to monitor the constantly evolving spatial organization of cities.

Likewise, Miller (2003, p.340) argues:

if planning and its outputs are to remain useful and meaningful for communities, then it is essential that in some way they demonstrate that they do produce outcomes that improve the quality of both life and the environment.

Monitoring requires the specification of:

- (1) key areas/ variables/ characteristics to be monitored, for example: urban form
- (2) identification of indicators that can be used to represent or understand the state or condition of the relevant characteristic(s), for example: population density as an indicator of urban form; and
- (3) Identification of ways of measuring those indicators⁴, for example: number of households per hectare as a way of measuring population density.

⁴ In some cases the indicators themselves are measures

The choice of key aspects of urban form to monitor and relevant indicators should be driven by a conceptual framework which is built from an understanding of the hypothesised relationships between the built environment and environmental, social, economic, and cultural outcomes (as identified through the academic and policy research introduced above), as well as the policy/planning and environmental/social context of the area being studied. This is supported by Wong who states "one of the major problems encountered in developing indicators is the need to have a well-established conceptual framework to underpin the choice of indicators and their interpretation" (Wong 1998, p.231).

The next section will discuss various approaches to measuring urban form, including the key characteristics and indicators⁵ of urban form that have been identified, based on a review of a selection of papers from the research literature, international indicators systems, and New Zealand local authority monitoring.

Approaches to measuring urban form

The measurement of urban form occurs at different spatial levels, for a variety of purposes, using various types and sources of data. In this section, I will report on a review of key research papers that have specifically examined how to measure urban form. I will also examine how urban form has been measured in a selection of research papers that have looked at the relationship between urban form and environmental and social outcomes.

This growing body of research is an important source of information for better understanding, based on international research, (1) the most important elements of urban form (in terms of social, environmental, and economic performance) and (2) the most appropriate ways of measuring those elements (choice of indicators and measures).

This research is used in this research as a 'benchmark' to compare New Zealand practice against as well as to present recommendations for improved practice.

A summary of the key urban form characteristics and indicators identified in this review is reported in Table 1 in Appendix 1. Overall, 10 characteristics of urban form were identified, including "development trends" which includes indicators and measures of "pressures" on urban form e.g. new houses, which were directly related to understanding changes to urban form. The following sections summarise some of the key findings of the review of the literature and then compares this to how we are currently measuring urban form in New Zealand.

Approaches to measuring urban form in the research literature

At the metropolitan level, there is a significant body of academic and popular research which focuses on the development of measures of urban form. As might be expected much of the work on measuring urban form at this level is couched in the debate about "urban sprawl" and how to determine whether or not a city is suffering from it. There have been several attempts to develop indices of "urban sprawl".

The first approach reviewed is that of Galster *et al.* (2001) who sought to define "urban sprawl" and create a Sprawl Index based on eight distinct and measurable aspects of land use patterns: density, continuity, concentration, clustering, centrality, nuclearity, mixed use and proximity. These indicators primarily relied on US census data.

The second approach by Ewing, Pendall and Chen (2002) used principal components analysis to develop indices for 4 components of "sprawl" based on 4 indicators of urban

⁵ While measures were also reviewed in this research, they are not reported here due to space limitations.

form: (1) residential density; (2) neighbourhood mix of homes, jobs and services; (3) strength of activity centres and downtowns; (4) accessibility of the street network. A total of 22 measures are used to measure these 4 indicators. The data used for these indicators included US census data, annual Household Survey and Census Transportation Package.

The third approach reviewed is Bertaund (2001) who presented an approach to describing the dynamic "spatial structure of a city" based on (1) the spatial distribution of the population as recorded by census data and (2) the pattern of trips made by people when they go from their residence to other locations for work, school, shopping, social activity etc.

Bertaund's approach is to examine the spatial distribution of the populations in different cities by combining census data with land use maps to construct 3 dimensional maps of the cities population distribution based on density gradients. The result is a diagram based on a map of the area in the XY plane and the population density shown in the Z dimension. He uses this to calculate the centre of gravity of the city (point to which the average distance per person is the shortest) and compares this to the CBD for a monocentric city. He then develops and discusses a number of indicators and measures of the distribution of the population that are theoretically linked to performance of cities, particularly in terms of transport.

At the sub-metropolitan level, Song and Knaap (2004) developed a methodology for measuring urban form that they used to evaluate development patterns and trends of single-family residential neighbourhoods in the Portland, Oregon metropolitan area in order to examine changes in key characteristics in neighbourhoods built in various time periods. They focused on five key characteristics of neighbourhood form: street design and circulation system; density; land use mix; accessibility; and pedestrian access.

In addition to the studies above, an earlier review of urban form measures by Knaap *et al.* (2006) was also used in this review.

In addition to reviewing research which specifically dealt with how to measure urban form, a review was also undertaken of a selection of published research projects that have measured urban form as part of their methodology.

In terms of research at both the metropolitan level and sub-metropolitan level, one of the largest areas of work has been to understand how urban form affects transport behaviour. For example, Krizek (2003) examines the relationship between neighbourhood accessibility and transportation behaviour across the entire Seattle region using a composite indicator of neighbourhood accessibility based on housing density, land use mix (number of employees in neighbourhood retail) and street design. Another study by Hess *et al.* (1999) examined the relationship between site design (using block size and length and completeness of sidewalks as indicators) and pedestrian travel.

Research has also examined how urban form is related to (correlates with) other environmental, social, and economic outcomes (variables). For example, a study by Burton (2000) explored how density relates to social equity. She compared the compactness of settlements (based on 41 measures) with corresponding measures of social equity (based on 53 measures) to identify any significant relationships between the two sets of indicators. The key urban form characteristics she looked at were: density, mix of uses, and intensification.

Another area of research has tried to understand trends in urban form. This work is used by policy-makers to identify and attempt to control the drivers of change, as well as better understand the potential outcomes from different policy scenarios. For example, Fulton *et al.* (2001) looked at trends in how rapidly American metropolitan areas were

consuming land for urbanisation over the period of 1982-1997 and what population growth, urban form, and governance variables correlated with the rate of land consumption. At the sub-metropolitan level, Song and Knaap (2004) examined the performance of New Urbanist neighbourhoods compared to a 'typical' neighbourhoods in Portland, Oregon in order to reflect on the success of Portland's internationally recognised growth management policies.

As can be seen in Table 1, while there is variation in the key characteristics of urban form and the indicators and measures used in the research literature, the overall conceptual framework is the same. According to this framework, the key aspects of urban form that affect the environmental, social and economic performance are:

- how the population is distributed or where people reside (measured by density, distribution)
- in relation to where they need/want to go, for example: areas of employment, commercial activities, recreational activities, services etc (measured by diversity, mixed use; accessibility, composition, size, shape) and
- how they can get there in terms of the nature of transportation network, including: roads, walking and cycling facilities, and public transport,
- and how the design/ amenity levels of the built environment encourage different patterns of behaviour.

Therefore, in order to effectively monitor urban form, it is necessary to monitor each of these areas using the most appropriate (and potentially available) data, at the level of detail required for developing policy and actions. Determining appropriateness and cost effectiveness of different data choices will require more intensive exploration and trial of indicators and measures. However, as a starting point a good urban form monitoring system for New Zealand might be argued to include the following indicators:

- Population density
- Accessibility
- Centrality
- Eccentricity
- Mix
- Nuclearity
- Size
- Transportation network
- Urban design⁶.

Introduction to monitoring internationally and in New Zealand

Monitoring is an important part of urban planning and policy development. Generally speaking, monitoring involves the regular and systematic gathering and analysing of information and is used by planners, policy makers and decision makers to:

- assess 'progress' towards a vision or goals for example "sustainable development" (outcomes monitoring)
- assess the success of policies and actions (performance monitoring)
- identify areas of concern and decide priorities (trend analysis)
- better understand the connection between actions and impacts (policy research)

Monitoring as part of urban planning and policy development occurs at a variety of levels.

At a national level, policy makers and planners usually focus on measuring the 'big picture' of a nation's status, often referred to in terms of the "state of environment".

⁶ A more in-depth discussion of the arguments for choosing these indicators as a starting point for investigation will be available in the full research report.

Monitoring at this level is usually concerned with issues of sustainability⁷, liveability⁸ and/or "quality of life"⁹. Therefore, monitoring is focused on indicators of the environmental, social and economic performance of the country as a whole, with variations in performance across regions, districts and cities sometimes highlighted. A sample of international monitoring systems are reviewed and reported in Table 1.

At a regional and local level, policy makers and planners are usually more concerned with monitoring as part of policy and plan development cycles.

Monitoring has also been used in some countries as an important community engagement tool. In these cases indicators have been developed by community groups as part of consultative process to highlight key issues important to the community, to both raise community awareness and to spark local government action on the issues. See for example Sustainable Seattle¹⁰ or the LITMUS project¹¹.

In New Zealand, there is no legislatively prescribed role or responsibilities for central government in terms of sustainability, liveability or quality of life monitoring, though they do participate in a number of international reporting programmes e.g. UN framework on Climate Change and Kyoto Protocol. Nonetheless, they have been involved in producing a number of reports which cover sustainability, liveability or quality of life. These are reviewed below.

At a regional and local level in New Zealand, local authorities are required to undertake monitoring as part of their duties under both the Local Government Act 2002 (LGA) and Resource Management Act 1991 (RMA), both of these acts require outcomes monitoring and performance monitoring.

The LGA requires monitoring and reporting progress toward community outcomes - monitoring the progress that is being made by the community towards to outcomes identified in the Long Term Council Community Plan (LTCCP); as well as trying to understand how the activities of Council discussed in the LTCCP are contributing to community outcomes.

The RMA requires monitoring the State of the Environment i.e. understanding the state or quality of natural and physical resources in the District and detecting changes. It also requires monitoring and reporting on the Efficiency and Effectiveness District Plan to determine whether the Districts Plan's policies and methods are the most effective and efficient way of achieving the Plan's objectives and assessing if the Plan's objectives are appropriate in terms of the purpose and principles of the Resource Management Act.

Most councils have produced monitoring strategies and/or reports, as part of these obligations. A selection of these strategies and reports is reviewed below.

⁷ For the purposes of this discussion sustainability can be considered in term of the UNCED definition of sustainable development which is development that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (UNCED, 1987 Brundtland Report).

⁸ For the purposes of this discussion liveability can be defined as: "how well the city works for us, as well as how comfortable and enjoyable our neighbourhood and city are" (Southworth, 2003, p.344).

⁹ There is no agreed definition of quality of life, nonetheless there are a number of composite indices which include a variety of social, environment, and economic performance criteria which purportedly measure it and are often used to compare the performance of countries, see for example the Economist's Quality of Life Index http://www.economist.com/media/pdf/QUALITY_OF_LIFE.pdf

¹⁰ <http://www.sustainableseattle.org>

¹¹ <http://www.neweconomic.org>

Approaches to measuring urban form in New Zealand

National-level

At a national level in New Zealand, monitoring or indicator development work related to sustainability, liveability and/or quality of life in the last 5 years has included work by Ministry for the Environment (MfE), Statistics New Zealand (SNZ), Ministry of Social Development (MSD) and a consortium of local authorities as part of the *in New Zealand Largest Cities programme*. These systems were reviewed to identify which characteristics of urban form were being measured and how they were being measured and compare this to the international practice presented earlier (see also Table 1 Appendix A).

The Ministry for the Environment recently produced *Gentle footprints: boots 'n' all* (April 2006) – a report described as not a “state of the environment” report but rather a discussion piece which reports on a number of environmental indicators. MfE produced a “state of the environment” report in 1997 and another is planned in 2007.

In addition, MfE has been involved in the development of a set of national environmental indicators on a variety of themes, this began as identifying in-depth and multiple indicators for each theme. As part of this programme, a significant amount of background work was done in 2000 looking at urban amenity indicators, however, this was never formalised into a suggested set of urban indicators. In the last few years the Ministry’s indicator work changed focus to a search for a small set of core indicators to measure environmental priority areas. Recently, a draft set of 11 environmental priorities and 15 core indicators was produced¹².

Despite the large amount of work within the Ministry on urban issues and initial work on urban amenity indicators in 2000, urban amenity has not been identified as a priority area in the new set of environmental priority areas for monitoring and no urban form indicators have been identified in this set. As a result no indicators of urban form, urban amenity or urban design have been reported in the recent *Gentle Footprints* document.

Statistics New Zealand have been involved in indicators work related to the New Zealand government’s sustainable development agenda. As part of this they produced a 2002 report *Monitoring Progress Towards a Sustainable New Zealand*. More recently they have been involved in the *Linked Indicators* Programme whose purpose was to facilitate the monitoring of New Zealand’s sustainable development, though in other places they also discuss monitoring “well-being”. The published set of “linked indicators” is broken into 4 sets: economic, social, environmental and cultural. They were developed in consultation with MfE and representatives of local government.

No urban form indicators were included in the original *Monitoring Progress Towards a Sustainable New Zealand* report. The consideration of urban form in the Linked indicators project is limited to reporting on the “look and feel of city” from the *Quality of Life* project (see below) and reporting on land use categories.

The Ministry of Social Development produce the *Social Report* annually. This report presents data on 10 domains, or areas of people’s lives, to create an overall picture of “wellbeing” and “quality of life” in New Zealand. Interesting in the 2006 Social Report, under the heading of “physical environment”, the desired outcome is: *The natural and built environment in which people live is clean, healthy and beautiful. Everybody is able to access natural areas and public spaces*. This implies a concern with both urban amenity and accessibility to open spaces yet the indicators for this domain are limited to

¹² See MfE (October 1996) newsletter Reporting on our Environment

air quality and drinking water quality, which do not provide any indication of the state of these characteristics.

Quality of Life in New Zealand Largest Cities is a cooperative project amongst currently 12 territorial authorities that provides social, economic and environmental indicators of quality of life in cities/districts which are either primarily urban in nature or are facing high urban growth on the fringe of urban areas. Two reports have been produced so far (2001, 2003) with the next due in 2007.

Even the *Quality of Life* programme only gives a cursory treatment of urban form despite its importance to many of the other areas monitored. It collects and reports on data from a residents' survey which measures the "look and feel of city" based on "residents' rating of their sense of pride in the way their city looks and feels". It also reports on area of greenspace.

While this review indicates that practice is poor at the national level in New Zealand, as Table 1 indicates, a review of a selection of other international indicators systems shows that monitoring of urban form is also poorly practiced in many of these systems.

Overall, the Government in New Zealand still appears to be 'finding their feet' in terms of their role and a preferred approach to sustainability, liveability and quality of life monitoring and reporting nationally. The current monitoring reporting in these areas currently appears disjointed, only partly coordinated and lacking clear policy/plan linkages. Importantly across all the monitoring areas there appears to be a lack of a clear conceptual framework underpinning the monitoring work, rather these projects appear to be driven more by data availability.

At a national level monitoring needs to be more clearly aligned with Government policy and actions and used to better understand the effectiveness of current actions through measuring both actions and areas of intended impact. In terms of urban form this means measuring both the actions taken by government and local authorities to influence the form and design of our cities (e.g. design codes, urban growth boundaries etc.) and the outcomes. There also needs to be stronger linkages with local and regional authorities in order to identify shared needs and lead new data collection (discussed further below).

Local authority level

A selection of local authority RMA and/or LTCCP monitoring strategies was also reviewed (See Table 1 in Appendix A). The councils reviewed are not necessarily a representative selection of councils and they may have other monitoring programmes, for example around specific strategies or policy research programmes which were not documented. Nonetheless, this review presents a basic perspective on the scope of local authority monitoring in New Zealand. It is hoped that a more in-depth look at how councils are monitoring urban form and trying to understand, for their specific contexts, how urban form relates to the environmental, social, and economic performance and 'liveability' of their cities will progress in line with the other work being conducted as part of this research programme.

The review highlights the primary focus of local authorities on monitoring development trends (pressures) that affect urban form, particularly in terms of the location of new development or subdivision in reference to areas or zones of the city/district; changes to the composition (area of land in various zoning/ uses) of cities; and development density. This reflects the objectives in many District/City Plans to control the location of activities in reference to the zones set up¹³ and ensuring there is enough land to meet future needs.

¹³ I make this observation despite the intention of the RMA to provide for more "effects-based" planning.

Overall there was a lack of attention to other key aspects of urban form and design including: distribution, diversity, accessibility, urban design and key aspects of the transportation network. This is surprising considering the number of councils who have now signed up as signatories to the Urban Design Protocol which promotes strategies addressing these areas of urban form.

One interesting exception was Manukau City Council's Keeping track document which indicated as priority "actions or measures" the following urban form/design concepts: "design", "attractive", "function/form of city", "Legibility/connectivity", "transport efficiency", "intensification", "density", and "robustness". Apart from density, I haven't included these in Table 1 as it is unclear what tangible urban form characteristics/indicators they wish to measure, nonetheless, it is a small step that they have included them as priority areas.

Another weakness in several of the strategies was the poor link between the monitoring topic and the indicators identified. An example is one strategy which has a monitoring issue: "Scattered Development - Subdivision" indicating a concern with distribution/dispersion. However, the indicators they identified were:

- Total area of land with different zoning
- Number, location and size of additional lots created from subdivision.

These indicators do not give good information about population distribution and even relying on existing information and basic census data, more appropriate indicators could be identified.

A final issue is the lack of progress in utilising more advanced technology to assist in urban form monitoring and plan evaluation within local authorities. This includes using GIS systems, aerial photos, and satellite images for monitoring. I have also not seen any evidence of uptake of some of the more advanced software packages that have been developed overseas for urban modelling for example UrbanSim™ and Community Viz™.

These weaknesses most likely reflect one or more of the following:

- The choice of indicators being data availability driven combined with the lack of data available for many local authorities and the lack of priority (due to cost) given by local authorities to obtaining new and more detailed data (for example through aerial surveys, analysis of satellite images, or on-the-ground observation)
- the development of monitoring strategies based on (often poorly defined) plans and policies, rather than as part of a comprehensive urban sustainability monitoring programme based on an empirically-based conceptual framework for monitoring which reflects the link between SEEC well-being and urban form and operationalises this through a monitoring framework which tracks these relationships over time.
- The lack of adequate national direction and data collection for urban form and urban design monitoring (including the Government's potential role in collecting more advanced spatial data);
- The considerable requirements for monitoring that local authorities have coupled with their significant resource constraints
- potentially a lack of understanding of the importance of urban form and urban design to the environmental, social, environmental, economic and cultural (SEEC) well-being of communities within some councils.

Concern over the lack of national direction in urban indicators was raised earlier by Miller (2003). She criticises the late effort made by MfE to develop indicators of urban amenity and their focus on using a pressure-state-response model which she sees as inappropriate for urban areas. She concluded that "evaluation of planning processes and outcomes is probably the most poorly performed of planning tasks (p.337) and that "overall MfE has failed to provide clear guidance and assistance for local authorities to

undertake any meaningful assessment of the quality of their planning performance” (p.341).

The lack of direction nationally is of particular concern, given the importance of consistency in data collection to allow meaningful comparison between cities/districts and the need for specialist expertise in designing monitoring/ data systems, which is beyond the skill set in many local authorities¹⁴. The issues of costs are also significant for local authorities who already feel overburden by central government shifting increasing responsibilities on them. There is a strong argument in terms of both data quality/consistency and cost efficiency for central government to take a stronger role in monitoring urban form in New Zealand and actively assisting local authorities to evaluate the effectiveness of their plans and policies in contributing to urban form and design outcomes.

Conclusions and recommendations

The purpose of this paper was to discuss the importance of monitoring urban form as part of settlement sustainability monitoring, review approaches to monitoring urban form at the national and local levels in New Zealand, and highlight areas for further work.

It is clear from the growing body of research evidence that urban form is an important contributor to the social, environmental, economic and cultural (SEEC) outcomes of settlements, described often in terms of “sustainability”, “liveability”, and/or “quality of life”. As such, it is important that planners and policy-makers monitor urban form in order to:

- evaluate progress towards any objectives for urban form and design (for example urban design protocol principles)
- monitor the success of policies and actions that may contribute to urban form and design outcomes
- identify areas of concern and decide priorities
- better understand the connection between urban form and design and SEEC outcomes.

In order for a monitoring system to achieve these objectives, it needs to be based on a clear conceptual framework. This conceptual framework should be based on research evidence on (1) the key areas or characteristics of urban form that are believed to contribute to SEEC outcomes (2) the most valid and reliable ways of measuring urban form.

Overall, the initial review of national and local level monitoring in New Zealand reported in this paper indicates that, at present, monitoring of urban form is poorly performed at both the national and local level. Nationally urban form has been virtually completely absent from all indicators/reporting on “quality of life”, “liveability” and “sustainability” in the last 5 years.

At the local level, councils’ monitoring is heavily driven by data availability and the need to monitor plans and policies, which often do not have clearly defined urban form and design objectives. Furthermore, councils often lack the resources (expertise, technical, financial) to develop robust urban form monitoring systems. As a result a large proportion of urban form monitoring is based on information about zoning and consents information. While this provides some information about changes to and pressures on urban form, the differences in requirements for consents, as well as the largely subjective nature of many consent decisions, and the different categories for zoning in each district make inter-city comparison almost impossible.

¹⁴ Some regions have tried to regional monitoring strategies to overcome some of these issues (for example Waikato)

Overall, greater attention needs to be given by local authorities to this topic. This should be seen as part of local authorities' responsibilities under the Urban Design Protocol. However, any effective national and coordinated local level monitoring strategy requires national level guidance and expertise. Monitoring is a specialist field and requires specific expertise. It is not reasonable to expect many local authorities to have this expertise 'in house'. Furthermore, data consistency and cost-effectiveness requires a national approach.

New Zealand would benefit from a standard set of indicators and measures of urban form to allow comparisons to be made nationally. These should encompass the full range of urban form characteristics and be based on an empirically derived conceptual framework of the relationship between urban form and SEEC outcomes. For many areas of urban form, there is a strong argument for national government to be responsible for data collection and analysis.

The international research on this topic provides an excellent starting point for the development of a national set of indicators that is applicable to the sub-national level. This set could be based on the key characteristics of urban form and indicators identified in Table 1.

Finally, monitoring is only effective if it is integrated into the policy and plan development cycle. Across the board, local authorities need to ensure that their monitoring systems are user-focused and that they feed into policy and plan development cycles in a timely way and in way which has meaning and importance to both decision-makers and communities.

There have been many advances in spatial data and analysis systems which not only provide more useful data but also more user-friendly data presentation. It would be worthwhile for the suitability of these types of systems for the New Zealand context to be further explored. Again, there is a strong argument for this to be led nationally to maximise the opportunities for consistency across local authorities and cost-effectiveness for New Zealanders.

Appendix 1.

Table 1 below summarises the key characteristics of urban form that were identified in the literature review. A brief description of the characteristic and its relevance is provided along with the indicators that were identified. The numbers after each indicator show the source(s) of the indicator. A key for these numbers is provided below. For ease of comparison the published research sources are indicated in plain text, the indicator sets in bold and the NZ local authority monitoring in italics.

A summary of the measures used for each of the indicators from the studies reviewed is available from the author in the full research report. It is important to note that many of these indicators are used for tracking changes over time (density, population, distribution etc), as well as for 'state' measures of good urban form.

Key:

Published research:

- (1) Galster et al (2001)
- (2) Fulton *et al.* (2001)
- (3) Ewing, Pendall & Chen (2002)
- (4) Song and Knaap (2004)
- (5) Bertaud (2001)
- (6) Knaap *et al.* (2006) – summary paper
- (7) Burton (2000)
- (8) Krizek (2003)
- (9) Hess *et al.* (1999)

Indicator sets:

- INTERNATIONAL**
- (10) UNHSP Urban Indicators
 - (11) UN Indicators of Sustainable Development
 - (12) OECD Indicators of Environmental Sustainability
 - (13) EEA Indicators
 - (14) UK Sustainable Development Indicators
 - (15) Local Agenda 21 in United Kingdom
 - (16) WHO healthy cities programme
 - (17) Sustainable Seattle Report Card
 - (18) Greater Vancouver Liveable Region
- NEW ZEALAND**
- (20) Quality of Life in New Zealand's Largest Cities
 - (21) Statistics New Zealand Monitoring Sustainable NZ
 - (22) Statistics New Zealand Linked Indicators Programme

New Zealand Local Authority Monitoring:

- (30) Whangarei DC
- (31) Kapiti Coast DC
- (32) Manukau CC
- (33) Hamilton CC
- (34) Rodney DC
- (35) Waikato DC
- (36) Queenstown Lakes DC
- (37) Auckland CC
- (38) Rotorua DC

Key urban form characteristics	Description	Indicators
Density	<p>Density is the simplest and most common measure of urban form and is used in many popular sprawl assessments (Sierra Club, 1999; US News and World report, 1999 cited in Knaap <i>et al.</i> 2006). Density represents how much land is consumed for a given population. Population density refers to the population/ houses per land area. Development density refers to population/houses per "developable"¹⁵ land area.</p> <p>Density is important as reduced density or declining density is considered an indication of urban sprawl. Low density development increases automobile dependence, consumes farmland, and raises the costs of public infrastructure (American Planning Association, 1998 cited in Song and Knaap, 2004). However at the metropolitan level the way density is distributed (see below) is much more important for its shape than the average density (Bertaud, 2001). However, density is also measured for sub-metropolitan areas, particularly those targeted for intensification. Density is usually measured using census data.</p>	<ul style="list-style-type: none"> • Gross population density (3,4,5,6,7,11,12,31,34) • Development density or net density (1,2,6,7,33,36) • Average number of people per house (30,33,34) • Housing density (8,31,35,36,38) • Average land consumption/ Built up area per person (5) • Floor area (4,5,6,11,31,35) • Residential lot size (3, 4,31,34,36,38) • Employment density (6) • Composite indicator: residential density(3) • Density unknown (32)
Distribution/	Distribution or dispersion represents how a	<ul style="list-style-type: none"> • Density gradient (6)

¹⁵ developable land excludes land that cannot be developed because it is in public use, subject to regulatory barriers, or other constraints. This is argued by Glaster *et al.* (2001) to be a better measure than total land area.

Dispersion	<p>population is distributed within a metropolitan area. It is generally measured in terms of density gradients or density profile, however, Bertaud (2001) uses a dispersion index as an alternative measure that corrects for differences due to the size of the built up area. Sprawl is characterised as both a lower density in the centre as well as a flatter density gradient. It is also sometimes characterised by discontinuous development (leapfrog development). In polycentric cities, the density around multiple centres/nodes is also important.</p>	<ul style="list-style-type: none"> • Density Profile (5) • Dispersion Index (5) • Population by distance to center of gravity or CBD (5) • Population and employment centrality (6) • Composite indicator - Strength of metropolitan centers (3) • Centrality(3) • Density at median distance (6) • Average distance per capita to the CBD (5) • Centre of gravity (5,7) • Eccentricity(5) • Continuity (1) • Concentration (1) • Clustering (1) • Centrality (1) • Contiguity (6) • Nuclearity (extent mononuclear) • Extremes and variations in density (7) • Population growth by area (coastal, mountain - 11) (within & outside of growth containment area - 18) • Properties by size category (34) • Fragmentation of rural land, use patterns, subdivision (32)
Size	<p>The size of a metropolitan area is an important measure of urban growth, particularly in relation to the relative increase in population. For example, Fulton <i>et al.</i> (2001) looked at over the period 1982-1997, trends in how rapidly American metropolitan areas were consuming land for urbanisation.</p>	<ul style="list-style-type: none"> • Total area of land in urban use (2,6,12) • Increases in population and changes in population areas (2,11)
Shape	<p>The shape of a city is important for people understanding travel behaviour as "intuition suggests that the more compact and circular cities should have shorter travel distances" (Knaap et al 2006, p.11).</p>	<ul style="list-style-type: none"> • Oblong ratio (6) • Compactness (6)
Composition	<p>Composition refers to the amount of space dedicated to different land uses, which is usually measured at the sub-metropolitan or neighbourhood level. Tracking changes in land use over time is an important base measure of urban form.</p>	<ul style="list-style-type: none"> • Area of land with various zoning (6,31,35) • Area of land in use X/ by area (6, 11,14, 22,30,32, 34) • Spatial land use and development pattern-mapped (30) • Unused/vacant land of various zoning (31,35,36) • Land cover (22, 38) • Total area of Green/ open space (6, 12,18,20,30, 31,32,34,36) • Area of land Protected and/or as a percentage of total area (11,16,18, 36, 38) • Area of agricultural land reserve (18) • Forest area (change) (11)
Transportation Network	<p>The nature of the transportation networks is an important indicator at both the overall metropolitan level, as well as at the sub-metropolitan or neighbourhood level. Research suggests that better connectivity within and between neighbourhoods will lead to more walking and biking, fewer vehicle miles travelled, better air quality, and a greater sense of community among residents (Benfield <i>et al.</i>, 1999 cited in Song and Knaap, 2004). However, others have argued that the square street pattern which maximises connectivity also increased the land coverage of paved surfaces thereby reducing the overall environmental performance of the form (CMHC SCHL, 2002). Measurements of the transport network usually rely on GIS data and other local/transport authority data or the use of orthophotos and other remote sensing technology (6)</p>	<ul style="list-style-type: none"> • Total road network (6,18) • Length of roads by type (31,35) • Street miles per capita (6) • Road network directness (6) • Road network density (6) • Internal connectivity/street patterns (4,6,8,9) • External Connectivity (4,6) • Composite Indicator: Accessibility of the street network (3) • Total transit supply (6) • Transit service density (6) • Public transport network cover (16) • Length of non-motorized infrastructure (pedestrian and bicycle) (6,17,18,30, 31,38) • Length of roads with/without separate

		<ul style="list-style-type: none"> cycle lanes (31,35) Length of sidewalks (9,34) Length of pedestrianised streets (16) Pedestrian route directness (6) Bicycle network coverage (6,16) Community satisfaction (34) Distance of bus priority lanes (37) Distribution of walkways (30)
Diversity/Mixed use	<p>Diversity or mixed use refers to how different activities are mixed with a metropolitan area or sub-metropolitan area. At the metropolitan level, the concern generally rests with the mix between employment and population and employment diversity. However, housing-type diversity has also been identified as an important indicator. At the neighbourhood level, a mix of residential and non-residential uses can facilitate walking and biking, lower vehicle miles travelled, and consequently improve air quality, and enhance urban aesthetics (APA, 1998 cited in Song and Knaap, 2004). Diversity can be computed in proportions and ratios or in summary measures such as Gini coefficients and entropy measures (6)</p>	<ul style="list-style-type: none"> Jobs-housing ratio (6) Jobs housing balance (6) Housing diversity (6,7,31) Employment diversity (6,8) Mix of non-residential uses in neighbourhoods (4,7,30) Mix of activities spatially (30) Quantity/spread/mix of key facilities (7,31) Distribution of parks/reserves (30,31) Quantity of mixed use buildings (7) Land use mix (6,1) Proximity (1) Composite Indicator: Neighbourhood Mix of homes, shops and offices (3)
Accessibility/Proximity	<p>Accessibility is concerned with the access people have to services such as transportation or other services. Some authors have also used the term accessibility to how easy it is a city is to travel around based on the form of a neighbourhood/ city; however this is covered here under other characteristics. Accessibility is often measured in terms of proximity between places to and from which people want to travel. Proximity is important as too much separation between land uses creates travel distances that are too long (APA, 1998 cited in Song and Knaap, 2004). Proximity can be measured by 1. gravity measure to all potential attractors (weighted by distance); 2. distance to nearest attractor; or 3. number of attractors in a given distance (6). Often proximity is related to distances that can be covered by walking (accepted as within ¼ mile (Duany and Plater-Zyberk, 1992 cited in Song and Knaap, 2004) or cycling or by distances that can be travelled by car over a specific period of time (i.e. 30 minutes). It can be measured for individual households, jobs, attractions as well as for aggregates of households and jobs (census tracts, TAZs). Proximity measures usual rely on GIS data.</p>	<ul style="list-style-type: none"> Accessibility to jobs (6) Accessibility to commercial uses (6) Accessibility to mass transit (4,6) Accessibility to amenities (4,6) Accessibility of services/facilities (32) Accessibility to physical activity opportunities (6) Accessibility to green/open space (16,17,30,38) Pedestrian accessibility (4,6,32) Transit-oriented employment density (6) Travel destinations (32)
Urban design	<p>Urban design refers to the design or look and feel of the built environment at the sub-metropolitan or neighbourhood level. Urban design is seen to have an important influence on how people use space, in particular how people travel, with good urban design seen to increase walking and cycling.</p>	<ul style="list-style-type: none"> Transportation infrastructure design(6) Building design (6) Environment Context (6) Building accessibility (6) Perceptions of safety, cleanliness, attractiveness etc.(6,20,22) Walkability – pedestrian sheds (32) Community Satisfaction (20)
Development trends	<p>This category refers to indicators and direct measures of new development or changes to land use that will inherently change urban form. In a pressure-response-state type of monitoring system these would be pressure indicators. They only provide us with information about the state of urban form if there is also a benchmark measure to which the change can be added/deducted to, to arrive at an estimation of the given state (however, this is less reliable than measuring urban form characteristics directly as it maximises room for error).</p>	<ul style="list-style-type: none"> Location of population increase (18) Development by activity/location (general) (7,18,30,31,33,34,35,36, 37) Composition (overall land use/zoning) changes (13,31,32) New Mixed Use (31) Subdivision (31,34,35,36)/ Rural residential development (38) New residential intensification (15,20) New residential development density (14,19,31,33,35,36) New transportation network (35,36) Design of new development (31,35) Area of new public open spaces (37)

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UNHS Programme "Urban Indicators"

http://ww2.unhabitat.org/programmes/quo/urban_indicators.asp

UNCSD list of indicators of sustainable development (accessed November 2006)

<http://www.un.org/esa/sustdev/natlinfo/indicators/indisd/english/worklist.htm>

OECD Indicators of Environmental Sustainability

<http://www.oecd.org/dataoecd/7/47/24993546.pdf>

European Environment Agency (EEA) Set of Indicators

<http://themes.eea.europa.eu/indicators/>

UK Sustainable Development Indicators

<http://www.sustainable-development.gov.uk/progress/national/index.htm>

WHO Healthy Cities indicators

<http://www.euro.who.int/document/hcp/ehcpquest.pdf>

Sustainable Seattle Report Card indicators

<http://www.sustainableseattle.org/Programs/RegionalIndicators/>

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Ministry for the Environment (2006) *Gentle footprints: Boots'n'all*

Ministry for the Environment (Oct. 2006) *Reporting on the Environment*

MfE (2007) *Environmental Indicators*

<http://www.mfe.govt.nz> Accessed 18/12/2006

Ministry for Social Development (2006) *Social Report*

<http://www.socialreport.msd.govt.nz>

Statistics New Zealand (August 2002) *Monitoring Progress Towards a Sustainable New Zealand*

<http://www.stats.govt.nz>

Quality of Life in New Zealand's largest cities

<http://www.bigcities.govt.nz>

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Auckland City Council *Our Changing Environment: State of the Environment Report 2004/2005*

Hamilton City Council (2002) *Sustainability Indicators*

Kapiti Coast District Council (2002) *Monitoring Strategy – Capturing Our Environment*

Manukau City Council (n.d.) *Keeping Track Environmental Monitoring Strategy (2003-2013)*

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Waikato District Council (2004) *Integrated Monitoring Strategy*
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Queenstown Lakes District Council (2005) *Monitoring Strategy*