Monitoring and Management of Visitor Flows in Recreational and Protected Areas
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Developing New Visitor Counters and their Applications for Management

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Abstract: Developing visitor flow models for managing visitors to conservation areas is not possible without accurate visitor count data from the field. However, obtaining such counts in a reliable and cost-effective manner has proven to be more difficult than may be expected. Reasons for this are reviewed, and the features that park managers want in their visitor counting tools are discussed. Based on these demands, development of new visitor counters is underway, along with integrated systems for systematic collection and management of the data they provide. However, more effective direction is required from visitor flow models to guide the deployment of these new counter systems. This is an ongoing programme, and the presentation provided here summarises background information and progress to date.

INTRODUCTION

Information on visitor numbers is essential for a variety of strategic and operational planning tasks in park management, such as that carried out by the Department of Conservation (DOC). These may include:

- justification for visitor facility, service and staff provision;
- design standards for some visitor facilities and services;
- performance reporting on visitor service provision;
- relating use-levels to social and physical impacts;
- identifying demand trends and making forecasts;
- scheduling of maintenance tasks, staff allocations and resource provision; and
- linking particular sites into wider systems of visitor flow and impact modelling.

These are only some of the many management outcomes supported by visitor count data (Hornback and Eagles, 1998; AALC, 1994; Watson et al., 2000; DOC, 1992; AALC, 2000). The important point is that visitor monitoring is concerned with more than counting methods and technology - it is about providing fundamental visitor management data. The more reliable the data from visitor counting techniques and systems, the better the outcomes from its applications in processes such as visitor flow modelling. Without reliable data, no matter how good a model is developed, the old saying always applies - 'garbage in-garbage out'.

OBTAINING VISITOR COUNT DATA

Collection of visitor count data in conservation areas is not an easy task, given that many of them are remote, have few roads or towns, have many entry and exit points, do not have electricity supply, and usually have few staff present on-site. Moreover, visitor counting practice across park management agencies has generally been accompanied by uncertain specification of monitoring objectives, a wide variety of counting and sampling methodologies, and few examples of structured visitor monitoring frameworks to integrate count data and apply the information to management. In this context, visitor monitoring can often be characterised as an opportunistic exercise, involving a mix of different counting methods and techiques, and a strategic sampling of visitor sites that optimises data needs and site conditions with resourcing capacities.

Management agencies have a wide variety of counting techniques available to them (Table 1), of three broad types:

- Direct observations – using staff observers or camera recordings at sites
- On-site counters – devices to record visitor presence and store the counts at sites
- Inferred counts – other data counts used to provide on-site estimates

Management agencies will use some combinations of these counting approaches, depending on their particular information needs, visitor use patterns, site characteristics, operational resource capacities and staff capabilities. In an extensive interview study, Cope et al. (2000) summarised a wide variety of monitoring approaches taken by land management agencies in the UK countryside. In a previous study of the same agencies, Cope and Hill (1997) found that a high proportion of managers were undertaking some sort of visitor monitoring, but that the methods used were widely varied from place to place. Overall, these approaches were not co-ordinated or systematic, and many relied on on-site questionnaire surveys or car counts. With reference to more remote settings, a survey of over 400 US wilderness managers in multiple agencies (McClaran &Cole, 1993) found that 63% relied on 'best guess' estimates of visitor use and 21% used 'frequent field observation'. Only 16% had any systematic procedure for deriving their estimates (permits or counts). In a survey of 308 managers from across the four main park management agencies in the US, Washburne (1981:165) found that the techniques for measuring use-levels fell into four classes: 'best guesses' based on informal observations, trail registers, trail registers calibrated by visitor counters, and agency administered permits. Almost 40% were using the 'best guess' informal observations, although this approached 80% for the Fish and Wildlife Service, reflecting their more highly dispersed sites and low visitor use profile. Permits were used by about 40% overall, although this approached 70% in the National Park Service, reflecting their more defined visitor sites and extensive use of permit systems. Australian experience perhaps sums up this situation best. When reviewing the status of visitor monitoring in the several parks comprising the Australian Alps National Parks, the AALC (1994:29) stated that, "with the exception of Namadgi National Park, existing visitor monitoring systems are more 'opportunistic' than 'systematic'".

In more recent times, other technology options have developed. For example, most use-level estimates in the US National Parks Service now come from vehicle counters located on key access roads (Street, 2000). The higher population levels present in and around UK natural areas have allowed greater use of manual counting and visitor survey techniques (Cope and Hill, 1997; Cope et al., 2000). Many different counting techniques are used across different park systems in Australia (AALC, 1994), with the most common being – automatic counters, ranger observation and fee collection (McIntyre, 1999). Most agencies develop a blend of these different techniques, and some interesting new possibilities can be developed. For example, while vehicle counts are the most common technique across the State Parks of Victoria, in some places use estimates based on car counts were highly related to particular weather conditions. An inferential weather-based model and associated use-estimation formulae were applied, releasing the expensive car counters for use elsewhere (Zanon, 2001). In other cases, stratified sampling for visitor counts using observational surveys, combined with probability calculations and associated projections, may be used rather than monitoring by onsite counting devices (e.g. Gregorie & Buhyoff, 1999).

CHOICE OF COUNTER OPTIONS

All of these methods have advantages and disadvantages (Table 1), and the final selection of a visitor counting approach and technique will always be based on a necessary compromise between need for accuracy and practical capacity to measure. Assuming that appropriate management objectives have been determined for a visitor monitoring system, there are three main factors that will determine what combinations of counting techniques and sampling approaches are used: visitor use patterns, physical settings, and availability of resources.

Visitor Use Patterns

Visitor use patterns vary at different places and times, including the number of visitors, the activities they are engaged in, group sizes, and the areas and facilities that they use. These variations have different implications for counting strategies, depending on the scale of the monitoring system required. Many examples exist of different monitoring systems developed for application to individual parks as stand-alone units (e.g. Cope et al., 2000). This may be a relatively simple exercise of identifying strategic points where visitors can be counted such as key access roads or trails. Sometimes particular facilities such as visitor centres or accommodation sites can give strategic counts.

However, once visitors are within a park and are entering more remote locations, their activity tends to be widespread and diverse. Counting options become more limited, with techniques such as periodic observation combined with visitor counter devices being more applicable. These counters will not generally pick up distinctions between different visitor types and activity groups, (e.g. bikers and walkers). So in particular cases of need, specific observation programmes may be required to complement the raw visitor counts. However, collections of parks and other protected areas may be considered together, and strategic locations must be determined to represent the whole system. The strategy recommended by AALC (1995) is that a modest number of priority sites should be selected across the park system, which may be:

- places of specific management concern
- places where specific management actions are under consideration
- places which are considered representative of broader management issues.

Overall this suggests some hierarchy of visitor counts is required through a series of key index count locations, allowing some flexibility to undertake different site- and issue-specific counting as required. To maintain the internal integrity of a visitor counting system over time and allow

Observation	Descriptions – including advantages (+) and disadvantages (-)
Field observers	*Onsite recording of visit numbers by staff using hand counters or recording forms.* (+) - Accurate, flexible and mobile, can include descriptive data, can be permanent in some staffed sites, preferred means for calibration of other counts. (-) Costly in staff time, competing staff tasks and priorities, often used in unsystematic and opportunistic ways, less feasible away from permanent sites or key access ways.
Camera recordings	*Film/video onsite and visitors count carried out when returned to base. Sometimes time-lapse photography is used to give sample shots. Special cases have used aerial photograph survey samples.* (+) - Accurate, flexible and mobile, can include descriptive data, main alternative to observations for calibration of other counts. (-) - Costly and vulnerable equipment to use and maintain, staff time needed to interpret films, power requirements mean not a long-term option, less feasible away from permanent sites or key access ways, privacy issues.
Counters	
Mechanical	*Physical displacement/movement triggering an attached mechanical count device (e.g. hinged boardwalks, turnstiles, gates, doors, stiles). In some cases, the displacement of paired magnets has been used to generate counts.* (+) - Simple to build and maintain, low cost, built in to existing structures, long history of staff use and experience, can be linked to electronic loggers. (-) - Moving parts susceptible to wear, water, deformation and/or blockage, associated high maintenance, often detectable and subject to vandalism or false counts, no date/time references, specific on-site structures required.
Pressure	*Direct pressure triggering a sensor, transmitting a count to a data recording devices (e.g. pneumatic tubes, sensor cables, pressure pads, strain gauges).* (+) - Wide variety of technology for people and vehicles, can connect to variety of devices (electronic loggers, camera, video), easy to conceal, small size and weight, easier to protect from weathering, low power use, adjustable sensitivity and interval to exclude some false counts, can get time and date data. (-) - Needs careful sensitivity calibration when constructed, maybe temperature variable, limited battery life, subject to integrity of electronics, usually requires being built in to a structure.
Seismic and vibration	*Vibrations from direct pressure triggering a buried sensor, transmitting a count to a data recording devices (e.g. buried mats or tubes linked to sensor, geophones). Sonic vibrations have been investigated.* (+) - Easy to conceal, small size and weight, easier to protect from weathering, low power use, can get time and date data. No structures are needed, can be buried in paths, may identify bicycles. (-) - Soil type, compaction, moisture content, freezing and bury-depth can all affect sensitivity, as can footfall weight. Needs very careful sensitivity calibration at each site used. May undercount groups.
Active optical	*Light beams interrupted by visitor passing, transmitting a count to a data recording device (e.g. active infra-red, visible light beam).* (+) - Small size and weight, inexpensive, accurate, not temperature sensitive, long range, adjustable sensitivity and interval to exclude some false counts, can get time and date data. (-) - Needs careful alignment of transmitter and receiver (or reflector if not a through-beam system), alignment sensitive to disturbance, hard to conceal so susceptible to vandalism, lenses/reflectors may be obscured or soiled, higher power consumption, light-beam counters maybe highly visible.
Passive optical	*Change in infra-red signature triggering a count, transmitted to a sensor (e.g. passive infra-red).* (+) - Small size and weight, inexpensive, accurate, adjustable sensitivity and interval to exclude some false counts, can get time and date data, low power consumption. (-) - Variable detection range depending on object infra-red characteristics relative to background, may undercount groups if distance large, large sudden lighting changes may trigger false counts, lenses may be obscured or soiled.
Magnetic sensing	*Changes in magnetic fields from passing metallic objects, trigger a count to a data recording devices (e.g. induction loops, magnetic pads, countcards).* (+) - Small size and weight, inexpensive, loop/pad sensors buried so not easily detected, other sensor boxes/cards sometimes buried (or on surface), can get time and date data, can indicate vehicle type, adjustable sensitivity and interval to exclude some false counts. (-) - Primarily for vehicle detection (including bicycles), need sensitivity adjustment and calibration for different vehicle types and loadings, possibly needs specialised interpretative software, relatively expensive for sensor and download interface units.
Microwave sensing	*Detects changes in reflected radio waves from moving objects.* (+) - Small, can be set to detect vehicles or people, can be set to detect direction, can get time and date data, adjustable sensitivity and interval to exclude some false counts. (-) - Usually for vehicles, needs clear line of sight, set high making it hard to conceal, will undercount groups, cannot distinguish vehicle type, high power consumption, relatively expensive, not much park application to date.
Inferred	
Visit registers	*Voluntary self-registration of visits (e.g. track registers, hut books, visitor books).* (+) - Flexible and low cost, simple, can gather basic extra data, can link with safety check in/out processes, good indicator if well calibrated. (-) - Limited by voluntary basis, requires ongoing calibration, sites vulnerable to vandalism, response rates vary with site location, presentation, maintenance and advocacy, regular maintenance and checking required.
Permits Bookings Fees/charges	*Records from site or trip permits, facility or trip bookings, and of fee payments for facilities/trips.* (+) - Flexible and low cost, simple, accurate, can gather considerable extra data, can link with safety management processes, can cover concession activity clients. (-) - Permits not required in most NZ sites, non-permit visitors missed (day users, other activity groups, non-compliant visitors), applicable for areas/activities only where permits required. Bookings not required in most NZ sites, other visitors missed (day users, other activity groups), applicable only for areas, activities or facilities where bookings required. Fees only required for some facilities (huts/camps), other visitors missed (day users, other activity groups), applicable only for areas, activities or facilities where fees required, often major fee-compliance problems.
Indicative counts	*Counts of elements linked to visitor use (e.g. carpark use, accommodation, public transport, weather indexes and many other options).* (+) - May offer local calibration advantages if suitable option available. (-) - Highly opportunistic and variable potential at different sites.

Table 1: The main visitor counting options

calibration and indexing functions, some count sites should be permanent, some periodically rotating according to identified need, and others allowed on a case-by-case basis to meet particular short-term needs. This diversity of function indicates that a variety of count techniques should be available to managers.

Physical settings

The physical settings used by the visitors, and their behaviours within them will also affect what counting options are available to managers. Roads and tracks are obvious channels where visitor counts can be carried out, particularly if they are key access points. For some counting devices, locations where visitors are confined to single file are also required. Sometimes the physical layout of a visitor use system needs to be modelled to identify where different types of counts can be used.

When counter devices are being applied as the preferred counting option, as is often the case in New Zealand, climatic elements are also an important consideration. Water penetration has proven to be a particular problem for most kinds of counter devices, corroding metallic components and destroying electronics. If combined with sub-zero temperatures, the freeze-thaw cycles can seriously damage the structural integrity of counters. While low temperatures can reduce battery life, high temperatures may cause warping and deformation of structures holding counters. Sometimes mechanical parts may be jammed through soil or ice intrusion, or count sensitivity reduced by snow or run-off soil cover, leading to serious under-counting. And where such counters can not easily be concealed (e.g. unforested settings) problems with vandalism and tampering have been commonly identified.

Overall, the physical demands placed on counters in outdoor environments require that they be water-resistant, discreet, robust and include few if any moving parts.

Availability of resources

The main limitation to developing a visitor counting system will be the availability of staff and funding resources to operate a system. In the past many agencies have not identified the systematic collection of visitor data as being as high a priority as the collection of other biophysical data (AALC, 1994; Cope et al., 2000; Loomis, 2000;). This situation is changing as the importance of visitor data is being more widely recognised, and it's collection is more often systematically planned. For example, a very specific implementation program has been developed and applied incrementally in the Australian Alps National Parks over the last 10 years (AALC, 1994; 1995).

No matter how much funding is made available, the high number and diversity of places used by visitors across park management systems means that some compromise, in the form of a sampling solution, will always be required. Improved efficiency in counting accuracy, operational costs, strategic sampling strategies and data management processes will maximise the utility of a visitor monitoring system. The important point is that the visitor counting task must be seen as being only one component of a complete visitor data management system driven by a series of specific management objectives (AALC, 1994; 1995; Hornback & Eagles, 1998; McIntyre, 1999; Watson et al., 2000;). Such a system, based on traffic counts, has been established over the last five years in South Australia. This features a central reporting system, a standardised set of traffic counters, customised software interfaces, staff training procedures, and the capacity to integrate data from other monitoring modules when developed (NPW, 1999).

PREFERRED COUNTER FEATURES

Once the three main factors above have been addressed, the questions for managers then become which counting options to use. Given the nature of visitor use of New Zealand conservation areas, where permit and fee systems are rare, staff and resources are widely spread, electricity supply is absent, vehicle access is limited and environmental conditions are often harsh and variable, there is particular emphasis on having good visitor counters in the field. While the requirements of the overall visitor management system are the key determinants of data needs, sampling strategies, and the associated resource allocations for locating monitoring effort, park managers in New Zealand have also developed considerable experience in the actual operation of such counters. When asked what features they consider important in visitor counter hardware, their responses have been largely consistent (Raine & Maxey, 1996), and in accordance with similar managers overseas (Gaveda, 1999; Watson et al., 2000). The desired features commonly include:

- high portability
- lightweight construction
- accurate counts
- low maintenance
- low cost
- robust
- easily concealed
- low power consumption
- water resistance
- tolerant of temperature variations
- minimal moving parts or electronics.

Simplicity was a consistent theme. In some cases reservations were expressed about the value of having more sophisticated systems collecting more detailed data, due to the greater vulnerability of the hardware and software involved. "The responses also suggested that complex systems with cameras and date-stamps are not in demand"

(Gaveda, 1999:3). Furthermore, "The most surprising result of the survey was that enthusiasm for more sophisticated data collection came quite low on the series of priorities for counter performance. DOC staff cared much less for direction-of-travel and time-based data logging than they did for accurate, reliable performance" (Raine & Maxey, 1996:9).

Such preference for simplicity and reliability reflects the previous experience of managers with counter development. Manager accounts of their experiences with different types of counters (Raine & Maxey, 1996) show a highly variable success rate, with many examples of hardware and software failure. Manager preference for simple systems is therefore understandable, and there is often warranted scepticism about the promise of better results from new technology.

In addition, the purpose of the counts has not always been clearly specified, nor has any integrated data management system usually been available to collate count data and provide reporting options back to park managers, or to other potential users of the data. This failure to ensure data delivery back to managers in a practically useful way has added to scepticism about the value of visitor counting, counting devices and count modelling systems, and sometimes reduced commitment to their applications.

Recent developments indicate that this situation is changing, as shown by the development of new counter options and more integrated data management systems in Australia (NPW, 1999), and New Zealand. The remainder of this paper describes recent progress made in New Zealand in developing visitor counters and an integrated counting system.

NEW DEVELOPMENTS IN NEW ZEALAND

Two separate streams of work in the DOC have converged to provide the basis for an integrated visitor counting and reporting system. The first has been development of the Visitor Asset Management System (VAMS). The second has been initiation of a visitor counter development project within the Science and Research Unit of the DOC. Both are required to provide an adequate basis for the application of any visitor flow modelling tools.

Data integration through the VAMS

The VAMS is an interactive database based on key management information about the approximately 4000 designated visitor sites throughout the 30% of New Zealand's land area managed by the DOC. Each specific site may be referenced individually from the database, and there is extensive site-specific information attached to each site. This includes the physical condition of the site and any facilities provided at it, the recreational setting and social values associated with it, and any management prescriptions and task scheduling required. The system is designed to allow new information fields to be added as required, including visitor count information. This provides a practical template for storing, accessing and reporting on visitor count data. Data may also be accessed in different ways from the central database to allow wider analysis processes.

Current development of these data management processes in VAMS accompanied by development of new visitor counter hardware, and associated data download and transfer software. This download and transfer function is provided through a handheld data logger (PSION Walkabout) to which count data may be downloaded from counters in the field, and transferred to the central VAMS database.

New Visitor Counter Development

Based on literature review, personal experience, and feedback from park managers, many of whom had experience of developing their own counting options in the past, the preference was for developing on-site counters as the basis for a counting system. Four distinct types of counter units were identified as being necessary for covering the general range of DOC visitor counting needs (Table 2). Where necessary for counter calibration checks and count projections using visitor flow models, these could be supplemented by other counting options, as described in Table 1.

A need for case-specific counter options was also identified for meeting more specialised management information needs, such as finding use levels for particular facility types (e.g. toilets) or visitor groups (e.g. mountain bikes). However, these were considered secondary priorities in the counter development process, and will be addressed on a case-by-case basis as required.

Developing the step counter

The step-counter was the first unit to be developed, and this has incorporated development of most of the data logging and VAMS integration software that will be required for operation of the other units. It is simply a modified wooden board incorporating a pressure sensor, and is placed on tracks as a frontboard in the lowest step in earth-filled or fully wooden step sequences (Figure 1). Its' development was based on video recordings, field observations and research generalisations (e.g. Irvine et al., 1990; Templar, 1992; Crosbie, 1996), that in a series of steps in a stairway:

Counter Units	Proposed Setting and options
Step-Counter	Pressure-sensor built in to the vertical front-board of a back-filled earth step or multi-step structure. On a wide range of tracks from frontcountry to remote backcountry. *Development action –design new unit*
Boardwalk-Counter	Pressure/strain-sensor built in to a boardwalk path or bridge structure. On a range of tracks - mainly in the high-use frontcountry and the more developed backcountry areas. *Development action – design new unit*
Path-Counter	Pressure/vibration sensor buried under a hard path surface, or infra-red detection across it. On high use tracks with priority on full access (e.g. wheelchairs, prams, disabled, elderly - steps or boardwalks not present). *Development action – new application of existing units*
Vehicle-Counter	Pressure, vibration or inductive loop-sensor buried under road surface, or built into road structures such as bridges or culverts on strategic roads. *Development action – assess new design or new application of existing units*

Table 2: Counter types, settings and development options.

- Almost all walkers stand on the leading edge of the last step down, and almost none extend their stride to stretch over the leading edge from further back on the stair tread.
- Most walkers use the first step up and stand on the leading edge, and both these behaviours increase with increased stair height.
- Walkers scan ahead and hesitate to adjust their stride to the first step in an up-stair sequence.
- Preferred stair heights are 20-22cm, with greater step height increasing 'hits' by people on the leading edge.

The simple design and installation requirements of the step-counter has resulted in a robust unit that is simple, water proof, has no moving parts, and is relatively cheap (under € 300). Yet it also includes electronic capacity to store many thousands of records, including the date and time of each count made. When installed and operated according to instructions, the counter has proved to consistently and reliably produce a high 'hit rate' of counts. From visual and video-based field observations, around 95% of people descending, and 80% ascending consistently stepped on the counter. This gives an effective overall 'hit-rate' between 85-90%. Based on these observations, and feedback from field managers, the contact area on the leading edge of the step was increased in width to increase the hit-rate further.

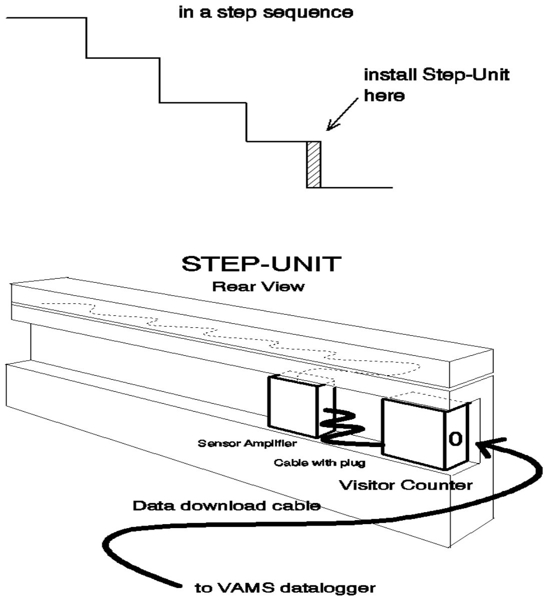

Figure 1: Step Unit construction and placement

While it must be acknowledged that such a counter can never be 100% accurate, the key point is that any discrepancy will be largely constant, and can be estimated using field calibrations. As long as any error is found to be consistent, its size is less important.

Other counters and applications

Work is underway on a counter design to be installed in the wooden boardwalks that are commonly used to protect sensitive soils and vegetation, or are provided as bridges over small streams. With the availability of step counters, and new boardwalk counters, a practical visitor counter option will be available for most of the tracks provided in natural areas by the DOC. In addition, passive infra-red detection units are currently being evaluated as the basis for development of a path-counter option. These will provide coverage of those more developed tracks where steps and boardwalks are not required. Work on vehicle counters has not yet commenced, as commercial units are available, and some count data can also be obtained from road management agencies. However, more site-specific information needs at access points to natural areas will require further development of more cost-effective vehicle counters.

The component software required for count logging, data downloading, integration into the VAMS database, and output reporting is being completed. This provides a complete link between counts taken in the field and data being available online to park managers. As the other counter options become available (e.g. path and vehicle), the effective coverage of visitor counting needs will increase to a wider range of sites. These developments will be reported on as they are completed.

CONCLUSIONS

The development of new counter units and associated data management systems is providing a more reliable and practical mechanism for park managers to collect visitor count data. However, even with correct counter installation, some error in counts is inevitable. These are acceptable as long as they are checked using field calibrations of observed and logged counts, the error levels found are relatively constant, and that the appropriate corrections are applied to the counts.

All of this work represents development and refinement of the counting mechanisms. However, only a small sample of the sites managed by the DOC can practically be monitored with these mechanisms. These must be selected according to a deployment strategy that provides representative coverage, and allows indexing and extrapolation of counts into wider visitor flow systems. This is the other main stream of work required to provide a comprehensive visitor counting system to park managers, and is currently being investigated.

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