CHAPTER 26

MANAGING INCIDENTS

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CONTENTS

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PRINCIPAL AUTHOR

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TITLE PAGE PHOTO

Helicopter based remote area fire initial attack crew departing on a mission, Yosemite National Park, California, USA

Source: Graeme L. Worboys

Introduction

Natural or human-caused incidents regrettably are common events in protected areas. Our aim in this chapter is to help prepare protected area practitioners to deal with such incidents. We do this by describing common incident types, how climate change is influencing the nature of incidents, pre-incident planning and preparation that may be undertaken, the actual management of incidents (using globally accepted systems for multi-organisation responses) and a description of post-incident follow-up requirements.

Our approach in this chapter has been to describe incident management in the context of moderate to high Human Development Index (HDI) country responses to protected area incidents. These countries often have the opportunity to have a depth of supporting logistical resources such as in the case of wildfire (also referred to as bushfire or unplanned fire) with fire tankers, bulldozers and water-bombing aircraft and can also access a range of incident management response information supplied from sources such as remote-sensing satellites, aircraft observers and incident computer-based modelling and forecasting capabilities. It is understood that many low HDI countries will not always have access to such resources and that incident responses may need to rely more on less machine-focused responses. Nevertheless, the principles of incident management still apply. They also apply across all protected area governance environments especially given that most large-scale incidents will involve many organisations and communities and the incident management system provides a very suitable framework for doing this. It would, for example, be a very suitable governance system for a protected area incident that includes multiple international relief agency support.

So, exactly what is an incident? We introduce two definitions here, with the first more general (less technical): 'as an event or cluster of events which may be accidental, intentional or natural in origin and which requires an emergency or law enforcement response' (Worboys and Winkler 2006:474). A more technical definition from an incident-control perspective is:

> [A]n event, occurrence or set of circumstances that has a definite spatial extent; has a definite duration; calls for human intervention; has a set of concluding conditions that can be defined; and is or will be under the control of an individual who has the authority to make decisions about the means by which it will be brought to a resolution. (AFAC 2013:1)

Whilst this chapter focuses on operational considerations, we are mindful that dealing with emergency management and incidents requires dealing with strategic policy development and procedural matters at the highest levels of organisations and government (Handmer and Dovers 2013). Such high-level considerations are the subject of Chapter 12.

Types of incidents

There are many different types of natural incidents that occur in or affect protected areas and people and many other human-caused incidents that involve or impact humans and these areas (Table 26.1). Protected areas are usually large and mostly natural land and sea areas that exist in a dynamic world. They face, in a 24-hour-a-day, seven-days-a-week management operation, a reality that incidents will happen, sooner or later. Anticipating this inevitability and managing for it are an integral part of day-to-day management. Understanding what types of incidents may occur and when and how they may happen is important, and this approach is typically linked to risk-management assessments by protected area organisations (see Chapter 8).

The types of natural and human-caused incidents identified may affect part or all of a protected area, they may be confined to a single site, they may have a local influence and, in the most severe events, they may be regional in scale. This means that managers of protected areas will typically be part of an incident response and part of a cooperative multi-organisation team dealing with an incident. Dealing with incidents in isolation is a thing of the past. It is rare indeed that a single emergency service can manage an emergency without some form of cooperation or assistance from other emergency services or supporting agencies (Yates 1999). This also means that the process of identifying the risk of particular incidents is quite critical since this underpins the development of organisational capacity (see Chapter 9), preparedness and preparation for working with other organisations.

Table 26.1 Incidents relevant to protected areas

Natural incidents that may affect protected areas	Incidents in protected areas caused by or involving people
Cyclones, hurricanes, typhoons	People lost in terrestrial and marine environments and underground
Tornadoes	Injured or sick people or people requiring rescue
Storms that could include strong wind, dust, dry lightning, hail, intense cold or intense heat	Infrastructure collapse
Storm surges	Vehicle accidents including trucks carrying toxic chemicals, pollutants or other injurious materials
Floods	Aircraft accidents
Mudslides and landslides	Marine vessel accidents
Glacial lake bursts	Pollution events
Blizzards and snow avalanches	Radioactive fallout
Droughts	Wildlife–human incidents
Wildfires	Wildlife poaching
Earthquakes	Wildlife trafficking
Tsunamis	Accidental fires
Volcanic eruptions and associated events such as ash-cloud fallout, nuée ardente and lahars	Arson and other felonies, murders, assaults, sexual assaults and acts of terrorism
Geological structure collapses	Resource theft
Meteorite impacts (a rare but historical event)	Social unrest and protests
Pest plagues	War and conflict
Diseases including human and wildlife disease outbreaks	Refugees and displaced people
Wildlife trauma/mass die-offs	Drugs
Cetacean strandings	

A changing world

Historical events can provide a broad guide to what incident risks a particular protected area may face, as can predicted conditions. The reality of climate change and the tracking of global carbon dioxide pollution at the highest forecast levels (see Chapter 17) in the early part of the 21st century bring with them a suite of atmospheric energy-enhanced and changed weather phenomena that protected area managers need to anticipate and prepare for. This is different from issues faced by previous generations of protected area managers. Despite extreme events such as droughts, major bushfires, cyclones, tornadoes and other weather incidents, past managers did not have to deal as much with the dynamic of rapid changes and greater extremes in weather. Such variation has been directly linked to carbon dioxide pollution of the atmosphere by humans and consequent climate change. Incident managers in protected areas (and elsewhere) are dealing with a changing world, and it is wise to examine some of the implications of climate change. Researchers, with their sophisticated climate models, are able to provide some insights for the future, and some of their climate change predictions and implications for incident management have been identified here (Table 26.2).

Humans and wildlife sharing space, Nazinga, Burkina Faso, West Africa

Source: Geoffroy Mauvais

Table 26.2 Climate change predictions and implications for incident management

Phenomenon	Prediction	Risk implications for protected area incident management
Carbon dioxide	Higher carbon dioxide levels provide a fertiliser effect on vegetation in some areas (the atmospheric concentrations of carbon dioxide, methane and nitrous oxide in 2013 had risen to levels unprecedented in at least the past 800 000 years)	Potentially more severe fire events through enhanced woody vegetation growth and higher levels of fire fuel
Temperature	Higher average temperatures, greater than 1.5°C by 2100 (each of the past three decades to 2013 was successively warmer than any previous decade to 1850) (In 2013, Australia experienced its hottest year on record)	More fire incidents due to longer periods of hotter conditions Higher average daytime temperatures affecting fire behaviour Higher average night-time temperatures during wildfires affecting incident control and safety New native fauna incidents through the movement of wildlife towards the poles New disease incidents through expanded home ranges of disease vectors such as mosquitoes More water-based incidents through greater visitor use of beaches and water bodies
Drought	An increase in drying in many parts of the world including an increase in the number of droughts	Human–wildlife incidents arising from drought conditions Drought-influenced social unrest and human drought refugee incidents
Extreme heat	An increase in frequency of extreme heat conditions (in Australia in January 2014, a 'dome' of hot air formed in Western Australia and moved anticlockwise around Australia causing extreme and prolonged 40°C plus temperatures across multiple States and Territories)	Extreme heat creates extreme fire behaviour conditions and very dangerous fire behaviour control conditions for any fire incident Heatwaves, their impact on protected area visitors and the potential for emergency first-aid incidents are increased
Wildfires	An increase in the number of extreme fires because of higher temperatures, reduced rainfall, the increased availability of fire fuel and changes in wind conditions (the average Forest Fire Danger Index [Box 26.1] in Australia increased in many locations from 10 to 40% during the period 2001–07 compared with the period 1980–2000)	The implementation of upgraded fire response safety procedures for incidents The potential for fire-generated meteorological phenomena such as fire tornadoes Enhanced training for incident controllers and planners
Extreme weather	Warmer conditions and higher energy in the atmosphere that lead to more severe storms	Severe storm incidents include the effects of thunderstorms, mini-tornadoes, tornadoes, lightning, strong winds and hail Dry lightning storms can cause multiple fire ignitions across a landscape Cyclone (hurricanes, typhoons) incidents are more powerful, with extreme wind, storm surges and heavy rain and flooding
Extreme cold	Extreme cold weather events will still occur within a context of overall climate change warming	Snowstorm and blizzard incidents such as search and rescue for lost personnel in remote protected areas
Snow	Reduced or enhanced winter snow deposition in higher latitude and mountain environments and greater variation in winter temperatures	Incidents involving avalanches may be triggered due to wetter snow layers during warmer conditions that lead to more unstable snow accumulation
Ice	The continued worldwide melting of permafrost, glaciers and ice sheets	Incidents associated with the collapse of unstable geological rock faces in steep mountain environments following the melting of permafrost Flood incidents down-valley caused by collapsed glacial melt lakes

Phenomenon	Prediction	Risk implications for protected area incident management
Precipitation: amount and pattern	Warmer temperatures may mean increased evaporation and enhanced rainfall events	Incidents caused by flooding of protected areas, which may involve stranded wildlife
Rapid run-off	More frequent extreme storms and torrential rainfall that cause rapid run-off and flooding	Incidents in protected areas where infrastructure is impacted and people are trapped by floodwaters
Floods	More frequent flooding due to greater atmospheric moisture	Incidents where protected areas are flooded, and people, infrastructure and wildlife are potentially affected
Sea-levels and storm surges	Global sea-levels are rising with the melting of the ice caps and glaciers (global sea-levels have risen an average 0.19 metres from 1901 to 2010). Higher sea-levels and more intense storms increase coastal impacts through storm surges	Incidents affecting coastal protected areas, especially during storms when the coastline is battered by higher water levels and large waves

Sources: ANU (2009); Williams et al. (2009); Climate Council (2013); Hannam (2013, 2014); IPCC (2013)

Smoke-filled Yosemite Valley, Yosemite National Park, USA, from wildfires burning in July 2008
Source: Graeme L. Worboys

One example of an incident influenced by the effects of enhanced climate change temperatures is the 2009 catastrophic bushfire episodes in Victoria, Australia, which burnt through a range of different land-use types including protected areas (Case Study 26.1).

Pre-incident planning and preparation

Anticipating incidents is a critical part of pre-incident planning and preparation. Once the potential has been identified, a risk-management assessment provides an important planning tool for protected area organisations to respond to such potential. Risk-management frameworks such as the standard AS/NZ ISO 31000 may be used to guide this process. The NSW National Parks and Wildlife Service (NPWS) in Australia, for example, with its system of 867 protected areas covering more than 7 million hectares (8.8 per cent of the State) (CAPAD 2010), operates within a very fire-prone part of eastern Australia. In undertaking its risk assessment for fire incidents, the NPWS has identified major areas of responsibility for its risk-based management approach (NPWS 2012) (Table 26.3).

Case Study 26.1 Victoria's 2009 catastrophic fire events

On 7 February 2009 in Victoria, Australia, the capital city, Melbourne, experienced a record-breaking temperature of 46.4ºC; and in the worst of bushfire danger days, storm-force wind speeds were recorded generally at 90 kilometres per hour with gusts to 115 kilometres per hour; the humidity was 6 per cent and the Forest Fire Danger Index (FFDI) (Box 26.1) exceeded its highest 100 'Extreme' calibration measure to read more than 150. In 2009, Victorian fire authorities had to deal with 316 fire events during these conditions (PoV 2010). Looming above the worst of these fires were rapidly upwelling and powerful convective columns that developed pyro-cumulus clouds to 8500 metres. These phenomena and an unstable atmosphere complicated the unfolding fire events with their own strong winds and lightning (Tolhurst 2009). Record-breaking firebrand spotting distances to 35 kilometres were recorded, as were mass short-distance spotting phenomena (PoV 2010). Regrettably, these multiple severe fire events caused the death of 173 people, and consequently 15 of these severe fires were the subject of a Royal Commission (PoV 2010). In post-fire media interviews, very experienced volunteers and professional firefighters advised, one after another, that they 'had never seen anything like this before' (ABC 2010). History shows that the 2009 Victorian fires were one of Australia's worst natural disasters, and it has led to the creation of a new FFDI category that is beyond 'Extreme'—called 'Catastrophic' or 'Code Red'. The extreme fire behaviour witnessed has been a potent warning for the future, since scientists are predicting that catastrophic fire events such as this will be more frequent, especially given higher temperatures and drier conditions. For the 2009 Victorian fires, Australia's research organisation, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), advised that the extremely high temperatures of the fire event were part of a human-influenced global warming trend (CSIRO 2009).

Box 26.1 The Forest Fire Danger Index

The McArthur Forest Fire Danger Index (FFDI) incorporates temperature, wind speed, humidity and a measure of fuel dryness. It was developed in Australia in the 1960s and calibrated on a scale from zero (no fire danger) to 100 for both forests and grasslands based on Australia's worst fire event in recorded history at that time, the 'Black Friday' fire event of 1939. An FFDI above 50 indicates that, due to fire crowning and spotting behaviour in Australia's eucalypt-dominated forests, weather becomes the dominant indicator of fire behaviour, the fire becomes very intense and it is difficult to fight a running forest fire front (Campbell 2009).

Table 26.3 NSW National Parks and Wildlife Service risk management for fire management

Risk	Control mechanism to reduce risk	Risk-reduction actions
Risks to the health and safety of staff and visitors including injury and death	Planning and procedural documents for: prevention preparedness response recovery	Use of approved and assessed equipment Use of the incident management system Individual burn plans for prescribed burning Incident action plans for bushfire suppression Appropriate training and competencies for all personnel Incident debriefing Counselling Actions to ensure the safety of visitors and neighbours
Risks to natural and cultural heritage values	Priority areas for specific fire management action specified	Natural and cultural values are recognised in protected area fire management strategies Fire management minimises pollution events
Risks to the community including disruption of economic activity and social structure and fabric and loss of confidence in the NPWS	Public and stakeholder input into fire management Meeting regulations and statutory requirements	NPWS fire management involves cooperation with neighbours and minimising impacts of bushfires on public and private assets including business
Risks to administration and finance and especially the excessive level of expenditure in suppression operations	Fire operations follow procedures established by the financial manual	The incident controller has financial accountability for expenditure during the fire event

Source: NPWS (2012)

Fire incident management (backburning during a wildfire), Snowy Mountains Highway at Yarrangobilly Caves, Kosciuszko National Park, NSW, Australia

Source: Andy P. Spate

Safety and welfare of people

Safety comes first in managing an incident. The safety and welfare of all people whether they are staff, visitors, neighbours or others are overriding priorities. This includes considerations such as:

- incident context including the nature of the incident, how dangerous it is for people, and continuous forecasts that help assess the future behaviour of the incident
- skills, competencies and fitness levels of staff and the appropriateness of their involvement with an incident
- quality, maintenance condition and suitability of the operational equipment to be used
- standby availability of temporary road signs such as road closure barriers
- effectiveness of incident administration systems to track deployment and rest and rotation opportunities and longevity of incident service (particularly for tracking pilot and aircrew hours at a long-term incident)
- provision of shelter, food, first-aid support and medical evacuation capacity for people involved in the incident.

Planning

Incidents are certainly not pre-planned and almost always occur at an inconvenient time, for protected area managers are never really short of work to do. Some protected areas have recurring incidents. Whether it is due to weather phenomena, fire susceptibility, wildlife issues, large numbers of visitors or other reasons, it becomes sensible to prepare plans for dealing with such recurring incident types. Such plans would be revised regularly and provide a constant check of whether or not training, equipment and other standby arrangements are organised.

A number of different types of incident management plans have been introduced (Table 26.4). These plans illustrate the diversity of pre-planning for incident events that could be completed by protected area organisations around the world. A vital common element for all of these plans is the importance of clearly recognising the specific governance arrangements for particular incident types. These governance arrangements will vary from incident to incident, as will the responsibility and accountability of protected area organisations for each incident type. Incident management plans will identify these requirements and roles.

Table 26.4 Potential protected area incident management plans

Potential incident management plan	Type of incident event	Some specific planning considerations
Wildlife		
Cetacean stranding plan	The plan deals with stranding on coastlines of marine mammals which may include whales and dolphins	The plan could include: Species identification guide Rescue response needs for individual species Safety considerations for rescuers, especially for cold water Management requirements for onlookers Specialist rescue support equipment The participation of marine mammal experts Incident governance protocols and stakeholder liaison checklists
Rogue animal incident plan	The plan provides guidance for responding to rogue animals such as crocodiles, elephants and tigers impacting humans and their livelihoods	The plan could consider: Policy and safety considerations for people Safety considerations for wildlife managers Specialist capture and transport equipment Veterinarian support Euthanising approval procedures Incident governance protocols
Marine oil pollution incident plan	The plan deals with oil spills in a marine setting that impacts protected area shorelines and native wildlife species	This document would typically form part of a larger incident response plan involving many organisations and could include: Procedures for de-oiling impacted wildlife Procedures for de-oiling coastline environments Incident governance protocols and stakeholder liaison checklists
Visitors		
Search and rescue plan	The plan deals with visitors to protected areas who become lost or require assistance in extreme events	The plan could include: Vocational capacity development guidance such as skill development for: remote area first aid, navigation, aerial observation, vehicle use, water-based access, snow-based access, caving and mountaineering Governance guidance, the identification of partnerships and liaison checklists with other organisations and especially the police, who may have overall responsibility for the incident
Visitor emergency evacuation plan	This plan will be most commonly used for medical evacuation emergencies, but it assists in dealing with safety evacuations caused by wildfires or severe storms that impact protected areas	The plan would provide guidance for: The competency levels for first-aid training required by protected area staff Logistical aspects such as methods to be used for medical evacuations, radio communication systems, helicopter operations and safety considerations Incident governance protocols
Wildfires		
Wildfire incident management plan	This plan would deal with all aspects of responding to unplanned fire events in a protected area	The plan would detail aspects such as: Detection, initial attack, mapping, forecasting fire behaviour and the triggering of incident control system procedures Staff competencies required, training needs, equipment preparation, staff roster and standby arrangements, and detection responsibilities The pre-assessment of fire fuels, terrain fire risk and fire potential Fire incident governance arrangements, reporting arrangements and key organisations with whom collaborative partnerships need to be established

Potential incident management plan	Type of incident event	Some specific planning considerations
Terrestrial pollution events		
Pollution incident response plan	The plan would provide guidance for responding to a range of pollution events such as air pollution (fires); stream or river pollution (such as petroleum product discharge); and vehicle accident pollution (such as toxic chemicals)	The plan could include: Staff competencies needed for awareness of and responses to toxic pollutant incidents Pre-planned responses for each different pollution event type Pollution event governance arrangements and incident response protocols Advisory contact lists for pollution incidents
Natural disaster incidents		
Natural disaster incident management plan	The plan would provide guidance for protected areas for reserves with a high probability of being affected by natural disasters such as floods, cyclones, earthquakes, tsunamis, volcanic eruptions and lahars	The plan could include: Natural incident governance arrangements The role of the protected area organisation as part of a larger incident response The deployment of equipment and personnel to assist with disaster responses The identification of vocational training required for dealing with such incidents

Preparedness

The planning and preparedness for incidents are undertaken at strategic, tactical and operational levels within protected area organisations.

Strategic preparedness

Organisational policies and procedures for dealing with each individual incident type will have been established and will be very clear. For staff, these could include matters such as occupational health and safety requirements, uniforms and protective clothing, minimum training standards, competency requirements, insurance and remuneration, and rostering arrangements. For plant and equipment, asset management systems would ensure the replacement of old equipment with new on a systematic basis (see Chapter 24), and minimum competency standards would be identified for personnel to operate such equipment. For organisational budgeting, there would be allocations provided for vocational training that ensured sufficient staff with the right skills and competencies were available for incident operations. For protected area organisations dealing with other organisations at a whole-of-government level, the message about the status, function and special conservation role of protected areas needs to be embedded within the psyche and incident modus operandi of organisations such as defence, forestry, emergency services, bushfire services, fire brigades, the police and departments of agriculture.

Tactical preparedness

Frontline staff of agencies and their national or sub-national protected area systems are typically located in or near individual protected areas and consequently they are dispersed across a national or sub-national area. When an incident impacts on an individual protected area, local cooperative incident response efforts are usually made by many organisations. For protected area managers, the numbers of their incident response staff may be bolstered by staff from other areas of the larger (perhaps national) protected area system. This is particularly important where an incident is large and needs multiple staff resources and support equipment, or is long in duration and needs relief incident crews to rest operational crews, or both. Tactical preparedness would ensure plans and procedures for mobilising and supporting the transfer of protected area staff during incidents are available. Tactical preparedness would ensure that cooperative incident management arrangements are in place across a larger region that may include multiple protected areas and that there are good working relationships between agencies and volunteer groups. Many incidents are much larger than individual protected areas, and may need pre-incident planning and preparation at a much larger scale. The impacts of a tropical cyclone (hurricane or typhoon) are one example of a larger-scale event.

Operational preparedness

For individual protected areas and their staff, a range of preparedness measures is typically implemented. Depending on the nature of the potential incident, staff rosters that anticipate incidents could be implemented and staff with the appropriate training could be placed on standby. Plant and equipment would be serviced and functional, and some may be held in readiness in certain weather (such as a fire unit in extreme fire conditions). Some special ranger patrol operations may be implemented when the probability of incidents is high and precautionary actions may be implemented

such as protected area fire bans, weather alerts, wildlife alerts or even temporary protected area closures. For fire operations, fire observation towers would be operational, fire-spotting fixed-wing aircraft flights after thunderstorms would be completed and water-bombing aircraft would be organised and on standby. All incident management plans would be up to date and a document that identifies all contact and other logistical information needed during an incident (the incident action plan) is current.

Prevention

Nature will guarantee that incidents will always occur. There are some incidents, however, for which a risk assessment identifies that either they can be prevented or the frequency of their occurrence can be lowered. Some of these prevention actions have been described (Table 26.5).

Surf lifesavers and swimmer safety (swim between the flags) at Wilson's Promontory National Park, a popular camping and beach destination in Victoria, Australia

Source: Graeme L. Worboys

Table 26.5 Prevention actions to minimise incidents

Potential incident	Protected area prevention action	Notes	Implications of the action
Avalanche	Reafforestation	Restoration of disturbed forests helps to stabilise snow layers and prevent avalanches	The number of avalanches is reduced
Extreme stormwater run-off	Catchment vegetation cover restoration	Restoration includes soil erosion control and vegetation replanting	Vegetation slows water run-off and lowers downstream impacts
Landslides	Catchment vegetation cover restoration	Vegetation restoration binds steep mountain slopes	The risk of slope instability and landslides is lessoned
Wildfire	Fuel reduction burning	Strategic fuel reduction such as near an urban–protected area interface	Reduced fuel increases the potential for successful fire suppression and control of any local ignition
Wildfire	Grass cutting and vegetation slashing	Mowing of grassland and slashing of vegetation at the protected area–urban interface	Reduced fuel increases the potential for successful fire suppression and control of any local ignition
Wildfire	Fire trail maintenance	Constant maintenance of fire trails provides rapid official access for fire suppression purposes	Rapid initial attack of fires helps to suppress wildfires
Wildfire	Protected area fire ban	The banning of all fires in the open	Fire bans reduce the chance of accidental fires
Wildlife	Wildlife barrier construction	Electric fences and other practical wildlife barriers	Barriers help to minimise human–wildlife incidents including crop destruction by large animals such as elephants
Floods	Protected area swimming ban	The closure of a popular protected area river swimming location	Swimming bans officially prevent swimming in dangerous flooded river conditions
Beaches: strong surf or strong currents	Swim between the flags or beach closure	Surf lifesavers may need to be contracted by the protected area organisation	Safety of visitors to the protected area is increased
Extreme weather	Protected area closure	The closure of a protected area due to extreme weather such as cyclonic winds, extreme heat or extreme cold	Protected area closures minimise or prevent search and rescues, the threat of tree fall and the threat of heat or cold exposure

Surf lifesavers and their standby rescue equipment at Tidal River, Wilson's Promontory National Park, Victoria, Australia
Source: Graeme L. Worboys

Responding to incidents

Incident response management systems have been developed to help achieve a coordinated response to emergencies by organisations. In the United States, the National Interagency Incident Management System (NIIMS), developed in the 1980s, provides a response framework for dealing with events that pose a potential or actual threat such as natural disasters, domestic terrorism, airplane crashes and law enforcement activities. It is used by all US federal agencies and State and county agencies involved in wildland fire events (Annelli 2006). The NIIMS is underpinned by the incident command system (ICS), which was established in 1970 following severe fires in California and manages an incident through established objectives and direction provided by executives and line officers (Annelli 2006). NIIMS was quite successful and provided the basis for the development of the National Incident Management System (NIMS) in 2003 for the United States (Annelli 2006). NIIMS was focused on wildfire, while NIMS addressed the challenges of all hazards or terrorist events and placed more emphasis on prevention and preparedness. NIMS is the official incident response framework used by the United States.

Australasian Inter-service Incident Management System

The Australasian Inter-service Incident Management System (AIIMS) was developed in the 1980s and was based on NIIMS, but was modified for Australian conditions. AIIMS responds to a key organisational need: the effective management of emergencies requires the coordinated efforts of multiple agencies (AFAC 2013:ii). It provides a common incident management system for all responding agencies and personnel and has been applied to the management of fire and flood events, windstorm and tsunami incidents, locust plague management, whale stranding management and to non-emergency events such as the coordinated response to a visit by a 'very important person'.

Given the universal applicability of the incident management concepts, fundamental aspects of the AIIMS approach are introduced here for protected area managers around the world. In the following text, we draw heavily on the AIIMS manual, published by the Australasian Fire and Emergency Service Authorities Council (AFAC 2013) to ensure the accuracy of our introduction to this incident management system. We highly recommend, however, that protected area professionals avail themselves of their own copy of the AIIMS manual (AFAC 2013) or its equivalent, and if possible, complete a formal course or courses on incident management. This chapter does not attempt to be a substitute for such essential vocational capacity development. We commence our introduction to the AIIMS by providing its definitions for three key terms (Box 26.2).

AIIMS principles

The Australasian incident management system is based on five underpinning principles that help to make the system easily understood and workable. AIIMS is adaptive, situational, relies on clarity of purpose, is designed to not be too unwieldy and is very clear about who is in charge and what the principal tasks are. It is a key reason the system is essentially successful at (potentially) the most chaotic of times. The five principles are as follows (AFAC 2013:11–20).

1. Flexibility: A flexible approach is taken with the implementation of AIIMS given it is employed across many different types of incidents.
2. Management by objectives: Management by objectives is a process of management (see Chapter 8) where the desired outcomes for the incident are established, and these incident objectives are communicated to everyone involved. The objectives are reviewed regularly against progress in resolving the incident.
3. Functional management: Functional management is about structuring an incident response organisation into sections and units based on the work to be performed. Eight functions are commonly recognised and may be delegated by an incident controller as a managerial responsibility as part of an incident response. These functions are described in this section.
4. Span of control: Span of control relates to the number of groups or individuals who can be successfully supervised by one person. The ideal ratio is 1:5, but this may vary.
5. Unity of command: Unity of command reinforces that there is one set of objectives for an incident that generates one plan for all incident responders.

Box 26.2 Definitions of key terms

AIIMS uses the following definitions in managing multi-agency incidents that may involve interstate and even international personnel.

Command

Command is the internal direction of the members and resources of an agency in the performance of the organisation's roles and tasks, by agreement, and in accordance with relevant legislation.

Control

Control refers to the overall direction of emergency management activities in an emergency situation. Authority for control is established in legislation or in an emergency plan. Control carries with it the responsibility for tasking other organisations in accordance with the needs of the situation. Control relates to situations and operates horizontally across organisations.

Coordination

Coordination is the bringing together of organisations and other resources to support an emergency management response. It involves the systematic acquisition and application of resources (organisational, human and equipment) in an emergency.

Source: AFAC (2013:18)

Levels of incidents

Communicating the nature of incidents is routine and important, and a common language has been developed to describe how large and complex an incident is. Identifying the 'levels' of an incident immediately helps potential participants to identify the degree of response that may be required and who might be involved. For this reason, the AIIMS recognises three classes of incidents.

Level one incidents are generally local and typically can be dealt with by an initial response team. Level two incidents are more complex and are characterised by the deployment of resources beyond the initial response or an incident that has been broken up into response sectors or has witnessed the establishment of functional sections, or a combination of these responses. Level three incidents are complex and may require the establishment of divisions for effective management and the delegation of all functions to a larger incident management team (AFAC 2013:22). Some incidents that are very large, complex and protracted may be split (geographically or functionally) into two or more incident teams for more effective management (AFAC 2013:25).

Managing an incident

Pre-incident

The AIIMS is applied in the Australian context of legislative responsibilities and arrangements in place with State and Territory organisations (AFAC 2013:28). For protected area organisations, there is an imperative for top-level and middle-level managers to ensure that incident management organisations, their senior staff and potential incident controllers are well briefed and aware of the special needs of protected areas. Anticipating incident events, pre-planning responses and thoroughly briefing key stakeholders on the protection of special sites such as karst areas would be part of this work.

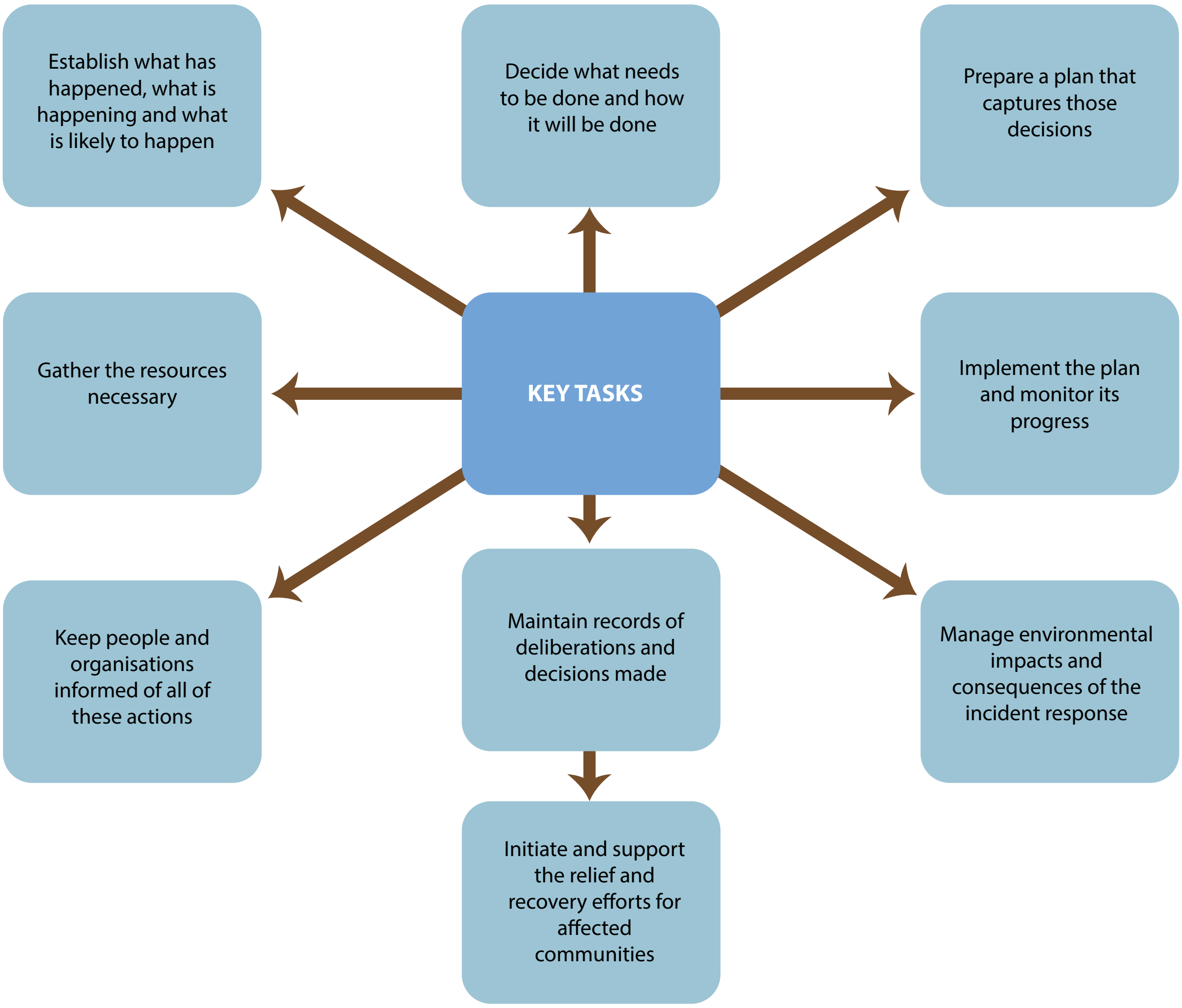

Figure 26.1 Key tasks for the incident controller
Source: AFAC (2013:32)

Responding to an incident

For level two and level three incidents, the incident controller typically establishes an incident management team, and for larger and more complex incidents, delegates most of the key managerial functions. This incident management team works within a network of supporting agencies, with each organisation's chain of command operating beyond the team's structure (AFAC 2013:31). The key tasks of the incident controller and the incident management team are reasonably common sense, but they are not necessarily sequential and may evolve in a somewhat 'disorganised but becoming organised' environment of the initial response (Figure 26.1).

The incident controller and the incident management team will meet regularly and will assess the status of the incident including the planning, resourcing, implementation, safety and welfare of people controlling the incident, impacts to infrastructure and the environment, and the effectiveness (and efficiency) of the incident operation.

Shift change (changeover)

The changeover from one shift to the next is a critical stage of an incident operation. Shift changes will be frequent during a 24-hour period, the actual frequency depending on the nature of the incident. For wildfires in protected areas, the changeover is commonly every 12 hours. For marine incidents such as whale strandings, where respondents are often immersed in water for periods, the changeover frequency will be much greater.

The changeover includes the transfer of information from the operational incident team to the new team. For a fire incident, for example, the system benefits by each new incident team possessing very similar skills and competencies to the incident team which preceded them. This is of course part of the responsibilities of the

Case Study 26.2 Incident controller changeover briefing

The incident

The AIIMS incident control system has been operational in Australia since the 1980s and lessons learned and experiences gained over many years have contributed to improved practice. One such lesson about efficient changeovers was learned during the summer of 1994. A prolonged drought had affected many parts of eastern Australia at this time; it was hot and tinder dry and lightning storms had set alight large tracts of bushland in national parks to the west of Sydney. These included the Blue Mountains and Wollemi national parks. The fires were large, they had been fought for many weeks and it was time for the scheduled relief of one incident controller to provide for some much needed rest. It was clear that, without rain, the fires were highly likely to continue for many more weeks and this brief rest period was needed. The relief controller was flown northwards from the Blue Mountains to the Hunter Valley, and towards a seemingly continuous north–south line of fire and extensively billowing smoke more than 30 kilometres in length. On approach, it was clear that this large fire front was actually a series of fire fronts vigorously moving eastwards under strong winds.

The context

The Hunter Valley of New South Wales lies to the north of Sydney and immediately east of the Wollemi National Park, with the park's grand cliffs and escarpments providing a majestic setting for the valley. This valley is well known in Australia for its fine horse studs, its picturesque vineyards and fine wines, and is perhaps infamous for its expansive open-cut coalmines that produce high-quality black coal for industry and export. The 1994 Bulga fire was a large fire burning on the eastern escarpment of the park and it was the destination of the relief incident controller. Immediately east of the Bulga fire was one of the Hunter Valley's great coalmines and a north–south mined (ready for transport) inverted-v wedge-shaped stockpile of black coal many kilometres long. The coal stockpile was at right angles to the fire front, it was downwind and just a few kilometres from the fire, with a severe weather change forecast.

The changeover

The pre-twilight changeover briefing was memorable. It was to the point. Severe wind strengths capable of extending the fire to the stockpiled coal and even beyond were forecast. There was more. Between the coal dump and the fire, there were storage sheds for explosives used in the mines, and to the south, there was a bushland military training area with unexploded ordnance—a no-go area for any firefighting personnel or equipment. The briefings included details of the weather front, the 24-hour weather forecast, the safety of personnel and an offer of major plant (bulldozers) by the coalmining companies. The incident control plan provided to the new incident team was clear. A massive fuel break control line was to be bulldozed north–south along the Hunter Valley floor to help cut off the rapidly easterly moving fire. Massed fire tankers from New South Wales and interstate were on site to help stop the fire on this all-important fuel break.

Given the circumstances, the actual changeover had to happen quickly and the incident action plan also had to be put into operation straight away. During the night, with the assistance of some of the world's largest bulldozers sourced from the deepest parts of the nearby Hunter Valley coalmine, a control line many kilometres long and at least 50 metres wide was constructed and then patrolled by multiple tankers. The fire was stopped on its eastern flank and suppressed and the coal stockpiles did not catch fire. The changeover briefing had been clear, to the point and successful, and the fire plan objectives were successfully implemented for that 12-hour shift.

Preparing for the next changeover

Following the drama and volatility of the night's events, the next edition of the incident action plan still had to be developed and the briefing for the new incident control team's shift prepared, for the fire had been controlled on just one flank, and was still burning.

two incident controllers who manage their combined 24-hour operation to ensure there is a harmonisation of individual personnel competencies across both 12-hour shifts. If such a fire incident extends for many weeks, incident controllers would also need to consider an effective replacement/resting strategy for their highly skilled teams as key individuals take some well-earned rest days. At a changeover, a typical incident controller briefing session could include the following key details:

- current situation
- incident objectives and strategies for the incident
- special hazards
- key risk exposures (political, economic, social, public health and environmental)
- current incident action plan
- incident action plan to be inherited by the new shift
- key contacts (such as inter-organisational and community contacts) (AFAC 2013:33).

Case Study 26.2 illustrates a changeover briefing: the circumstances and interaction between two incident controllers at a major wildfire event in the Hunter Valley, Australia. Changeovers at a large incident can be logistically complex and difficult to implement. Typically, they take far longer than planned for, and an aim of incident controllers is always to refine changeovers so they are efficient. Changeovers can also be dangerous—for example, if there are delays in replacing crews at key fire-control sites. Given this complexity, some changeover management tips are provided by the AIIMS (Box 26.3).

Box 26.3 Changeover tips

Lessons learned to improve the efficiency of changeovers include:

- changeover is best done during daylight hours
- they need to be planned and prepared for
- planning needs to be at all operational levels
- changeover briefings specific to each operational level should be developed
- crews should changeover at a suitably safe area close to their operational area
- personnel should be transported in groups relative to their destination
- the incoming shift should be fed before the changeover and the outgoing shift fed after the changeover
- avoid changeover times that are critical to the incident management operation (AFAC 2013:34).

For fire incidents, changeover times are usually in the cool of the evening and early morning to avoid the dangerous fire behaviour that occurs during the heat of the day. Major weather changes of course will influence such timing.

Box 26.4 Incident action plan contents checklist

Incident action plans are constantly developed and refined and underpin an incident controller's actions. For fire operations, with their 12-hour shifts, two plans are developed every 24 hours. Some organisations have pro-forma plans to be filled out for efficiency, given there is very little time to get this work completed. The contents of an incident action plan may include:

- the current situation
- predictions of the likely development of the incident and risk
- incident response objectives
- contingency plans and alternative strategies
- risks and mitigating actions
- incident management structure and personnel
- management arrangements (such as the establishment of sectors and divisions and their roles)
- resources to be allocated
- maps of the incident and the governance geography of the response (divisions, sectors)
- medical plan and occupational health and safety issues such as dealing with dangerous chemicals, hostile animals or response equipment that may be dangerous
- communications plan including information on all agencies
- timings of meetings and changeovers
- accommodation and welfare arrangements
- logistical arrangements
- traffic management plan for the incident
- an information plan for managing inquiries (AFAC 2013:49).

Incident action plans

These plans are developed and continually refined in a dynamic environment. They may be informal or, as the scale and complexity of an incident increase, they may be formal documents. The planning includes the gathering and analysis of information, a risk assessment for incident responders and, to those directly affected by the incident, the setting of incident objectives and strategies and the implementation of the plan. The plan is developed with input from the entire incident management team's functional leaders and others. Generally, a plan does not detail the tactics as to how a strategy will be achieved; rather this level of detail is prescribed by the operations team (Figure 26.2). The possible content of an incident action plan has been described by AIIMS (Box 26.4).

The common operating picture

The common operating picture is important AIIMS language for the agreed and shared description of an incident (AFAC 2013:65). It describes what has happened, what is happening now and what is forecast to happen, and provides a common situational awareness of the incident. It is part of the language of an incident that helps make incident management work. Given the incident controller is responsible for all aspects of an incident, he or she is also responsible for ensuring clarity with the common operating picture if this is needed.

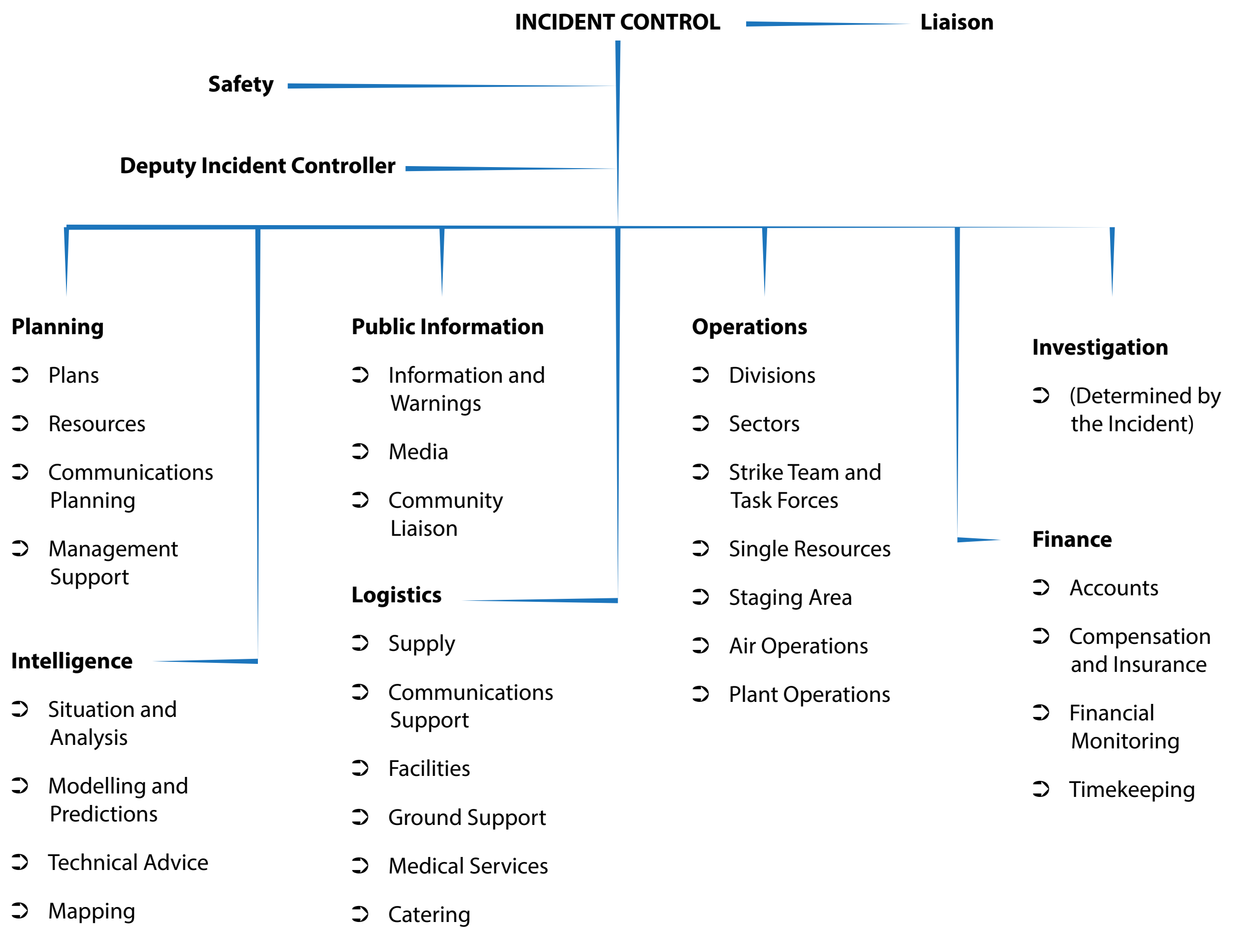

Figure 26.2 Incident management team structure

Source: AFAC (2013:40)

Briefings

It is critical for any incident that people are thoroughly briefed about all aspects of the incident prior to dispatch, before being deployed, at regular intervals during the incident and especially during changeovers. Debriefing after each shift and prior to dispatch from the incident is critical (AFAC 2013:68).

The incident management team

An incident management team structure may include incident control and seven key supporting functions as well as liaison, safety and a deputy incident controller position (Figure 26.2).

Incident controller

The incident controller takes responsibility for managing all activities related to an incident. This is potentially an enormous task and the appointed office will typically have had extensive experience and advanced training. Experienced protected area managers may be appointed as incident controllers, particularly where an incident is confined to a protected area. The incident controller's responsibilities may include the need to:

- take charge and exercise leadership of the response and the response team
- establish a management structure
- set response objectives (including the safety of affected communities)
- develop and approve the incident action plan
- implement the incident action plan
- provide information and warnings to others
- establish effective liaison and cooperation with all relevant stakeholders
- obtain and maintain the necessary human support and other resources and services
- apply a risk-management, safety-focused approach
- ensure relief and recovery considerations are addressed and services provided to those impacted
- ensure collaboration between response and recovery agencies (AFAC 2013:80).

Planning

Planning is a role protected area management staff commonly find themselves having to undertake within a multi-agency incident response. This often reflects their knowledge of the local incident area and their extensive training in natural resource management. The planning officer's responsibilities may include:

- analysing information on the current and projected incident situation
- identifying new and emerging risks (political, economic, social, public safety or environmental risks)
- developing alternative incident objectives and strategies for decision makers
- disseminating information relevant to controlling the incident and potential safety issues (Figure 26.2)
- documenting the incident action plan for the subsequent operations period
- developing a communications plan for the incident (based on the latest incident action plan), including guidance for the incident controller and the public information team
- planning for any contingency in the implementation of the incident action plan
- maintaining an effective register of all resources requested, en route, allocated to and released from the incident
- considering recovery and rehabilitation in the incident action plan
- developing changeover and demobilisation plans
- collecting, collating and storing incident records (AFAC 2013:92).

Intelligence

Responsibility for this commonly lies with the planning team, though for large, complex incidents it may be established as a section in its own right. It may be assisted by a situation and analysis unit, a modelling and predictions unit, a technical advice unit and a mapping unit. It would normally be supported by incoming information from a range of sources including ground and air observers, local knowledge, weather forecasts and other sources. Intelligence analysis will include addressing a number of key questions in relation to the incident (AFAC 2013:103).

- What is happening?
- Why is it happening?
- How can different accounts of what is happening be reconciled?
- What is likely to happen next?
- What are the emerging risks/opportunities at the incident?
- What is the worst-case scenario?

Public information

This critical function ensures that accurate and timely information is made available to incident stakeholders and the greater community outside the incident management team. This work includes the provision of warnings and information, dealing with the media and managing any media issues, and consultation and liaison with affected communities (AFAC 2013:111). This media work may involve briefings, press conferences, media releases, media inquiries and media inspections of the incident area. Working with local communities may mean arranging community meetings and preparing community information updates. There is also a role in collecting information such as from social media from the general public and news media for feedback to the intelligence unit.

Operations

The operations officer has the responsibility of implementing actions to help resolve the incident and for looking after all of the people and equipment assigned to the operations section. The operations officer typically has a constantly changing situation and needs to be adept at dealing with such change. Rapidly changing fire conditions with weather changes is an example of such a dynamic environment. For a large incident, operations may have division commanders, sector commanders, staging area managers, air operations managers and plant operations managers reporting to them (AFAC 2013:123). The responsibilities may include

- ensuring the safety and welfare of operations personnel
- helping to develop the incident action plan
- establishing processes for adequately briefing personnel prior to deployment
- ensuring personnel are properly equipped
- keeping personnel informed of the situation at the incident (especially safety matters)
- establishing processes for debriefing personnel post shift or post stint
- providing regular progress reports to the incident controller
- identifying new and emerging risks at the incident and ensuring they are managed effectively (AFAC 2013:121).

Investigations

Complex incidents may require an investigations unit to be established. Investigations may be required, for example, to establish the point of origin of a fire incident; for floods, the evaluation of flood levee bank performance or breaches; for a biosecurity matter, to determine how a disease entered a region or how it spread (AFAC 2013:133). The responsibilities of an investigations officer may include:

- documentation in the incident action plan of the purpose and expected outcome of the investigation
- development of an investigation plan
- communicating with other functional areas of the incident management team
- keeping the incident controller informed of the need for liaison with external bodies such as the police (AFAC 2013:134).

Logistics

The logistics officer provides support for the control of an incident that includes human resources, facilities, services and materials (AFAC 2013:139). This can be a very difficult role, particularly when logistical support may be required over a very large area such as a fire front. Just think of ensuring, for a rough, rugged and remote fire perimeter, how firefighters are to be fed, how their vehicles are to be fuelled and their equipment serviced, and how their safety and health considerations are looked after. Then double this challenge because you are dealing with two shifts a day as well as adding the complexity of the fact that one of the shifts is at night.

To undertake such tasks, logistics may be supported by a supply unit that acquires and distributes equipment and materials, a communications support unit (radio, communications and information technology), a facilities unit (feeding, sanitation, accommodation), a ground support unit (transport for personnel, food and resources), a finance unit, a medical services unit and a catering unit. The responsibilities of a logistics officer may include:

- providing a safe working environment for logistics personnel
- developing the logistics section of the incident action plan
- planning how the logistics section will work
- procuring human resources as required
- procuring other physical resources, facilities, services and materials
- establishing effective liaison
- providing progress reports on logistical support
- estimating future service and support requirements
- facilitating the establishment of staging areas in support of the operations section (AFAC 2013:139).

Finance

Unless an incident is very large and prolonged, logistics will typically look after the finances for an incident. The finance officer may be supported by an accounts unit, a compensation and insurance unit, a financial monitoring unit and a timekeeping unit. Complexity comes into this work, for example, where industrial awards for workers of organisations are linked to the number of hours worked and where additional penalty payments may need to be made if they exceed certain hours worked. Where a finance section is established, the responsibilities of a finance officer may include overseeing all financial management and financial recordkeeping, and overseeing the management of insurance and compensation claims arising from the incident (AFAC 2013:148).

Managing incidents

This chapter has described natural and human-caused incidents that may affect protected areas. Pre-planning in anticipation of such incidents has been discussed and the AIIMS approach for coordinating multi-agency incidents, particularly as they relate to protected areas, has been introduced. In this section, we will describe how protected area organisations may deal with some more common incidents that occur in or affect protected areas.

Wildfire incidents

Wildfire events may be anticipated for many protected areas of the world and there are many pre-season and fire-season actions that can be undertaken. Many of these actions have been described in Worboys and Winkler (2006). Here we focus more on the climate change world of the early 21st century in discussing additional protected area fire incident response considerations.

Information needs

It is anticipated that enhanced data and access to timely analysed information will need to be secured to service the increasingly sophisticated modelling used for planning and forecasting fire behaviour. This could include:

- increasing sophistication in the collection and use of real-time ambient protected area condition data such as for site-based temperatures, humidity, soil dryness, fuel loads and fuel availability

- increasing sophistication in the collection, storage, retrieval and use of protected area natural resource and terrain information (a database) utilising a geographic information system or equivalent system that provides the basis for further computer software applications and analysis of data
- more sophisticated fire behaviour modelling for the range of native vegetation communities of protected areas that integrates with an established protected area database, real-time protected area ambient condition data and additional weather information sourced from meteorological organisations that include surface and upper atmospheric conditions
- a range of active fire incident data sources such as infrared information and observations secured from a variety of sources such as satellites, drones and manned aircraft.

Skills and competencies

Extreme fire behaviour means it will be far more precarious than normal to deploy personnel near major incidents during 'blow-up' days. Protected area managers involved with fire incidents will need to thoroughly appreciate fire behaviour and its potential, while vocational training and personal research of the literature will be important parts of their development (Box 26.5). Vocational training will also need to ensure that there are:

- staff who have competencies in utilising fire modelling computer software and who can generate fire spread and fire behaviour information during real-time fire incidents to effectively service the needs of the intelligence unit and planners in an incident control team
- staff with advanced training in all aspects of incident management to ensure that the protected area agency is actively contributing to the governance of fire incidents at the highest levels
- staff who appreciate the effects of fire incidents on biodiversity values and their protection and who can communicate these matters to form part of the decision-making considerations during the incident management (Box 26.6).

Wildlife incidents

The human population of Earth is forecast to be about nine billion by 2050. This increase of two billion from the early part of the 21st century will mean more pressures on natural habitats and an increase in human–wildlife encounters. Protected area managers will need to deal with these wildlife incidents and some considerations include:

- encouraging and facilitating tolerance of native wildlife by local communities
- managing wildlife incidents so they are dealt with by trained wildlife management professionals rather than vigilantes
- training staff to deal with incidents that involve animals dangerous to humans such as elephants, large cats, gorillas, crocodiles and snakes
- ensuring the right partnerships are established with native wildlife veterinarians as a basis for dealing with unforeseen problem-animal incidents as well as outbreaks of wildlife disease
- ensuring the right equipment is on standby, and if necessary, is used to translocate problem animals away from communities
- sharing experiences and exchanging wildlife management methods with professional colleagues in other protected areas
- working with local communities to construct physical barriers (such as anti-elephant trenches) or to undertake noise-making, scare shooting or planting of thorn hedges

Very low-intensity fire managed as an incident, urban protected area, Canberra, Australia
Source: Graeme L. Worboys

Box 26.5 A grand array of fire phenomena

'Fire phenomena' may be seen as the spectacular, such as fire tornadoes (McRae et al. 2013), pseudo-flame fronts (Byram 1959) and pyro-cumulonimbus clouds (Fromm et al. 2010), but some phenomena can appear to be mundane—ignition, spread and fire shape—yet important to gaining an understanding of fires, being safe during fires and predicting fire behaviour. The 'mundane' can become more interesting as inquiry becomes deeper: thus, 'ignition' becomes more interesting when spontaneous combustion (Armstrong 1973), arson (Willis 2004) and the various forms of lightning (Fuquay et al. 1979) are considered. Below, only a few phenomena—some spectacular, some mundane—are considered.

The usual sequence for a fire event is: ignition when fuel dryness allows it; fire spread when the fuel is continuous—or when discontinuities can be overcome because of spread uphill or in winds that cause flames to lean over and connect patches; acceleration until a quasi-equilibrium rate of spread is reached (Cheney and Sullivan 2008:32); a period of quasi-equilibrium rate of spread, which varies according to weather, fuels and topography; a cessation of spread; and a time when all flames and smouldering have ended. The maximum quasi-equilibrium rate of spread in Australian grasslands is about 6 metres per second (Noble 1991), while that in forests is about half of this (Gould et al. 2007:100).

If flames are tall enough, fire may reach into the canopies of shrubs and trees ('torching') or even spread there ('crown fires') (van Wagner 1977). If there is a peaty substrate beneath the soil surface, fire may spread into it by smouldering, but at a very slow rate of 3–12 centimetres per hour (Wein 1983). If a fire above the organic soil surface sets multiple fires in the peaty surface, the area covered in any given period will increase. Peat fires can be a major cause of smoke pollution, causing health problems and great expense over a number of months, as in Indonesia and a number of neighbouring countries in 1997–98 (Cochrane 2009a).

Fire heats the air around it, causing the heated air and smoke to expand and rise. With rising heat and smoke, air is drawn into the base of the fire and at higher levels in the convection column. Flames will be drawn away from the unburnt fuel unless the ambient wind or slope can overcome the effect. In large and extremely intense fires, the ambient wind can be captured by the convection column and effectively act as a windbreak (Raupach 1990). Fire whirlwinds (vortices) can develop at the perimeter of fires and these can be great or small, horizontal or vertical (Forthofer and Goodrick 2011). The most extreme vortex is the fire tornado (McRae et al. 2013).

In light winds, the smoke rises vertically or at a high angle and may develop a pyro-cumulus cloud at its peak due to condensation of moisture in the convection column. In a large, intense fire, the billowing clouds of smoke may be topped by a pyro-cumulonimbus cloud reaching up to 15 kilometres or so above the ground and from which black hail may emerge and tornadoes may be spawned (Fromm et al. 2006); smoke may be transported internationally via the stratosphere (Fromm et al. 2010).

The classical elliptical shape of the wind-blown fire (burning with, at right angles to and against the wind) narrows as wind speed increases (Alexander 1985). South-eastern Australia's tragic 2009 bushfires showed an almost rectangular shape just before a strong wind change led to fingering of the fire from one flank (Cruz et al. 2012:Figure 7). The fire's perimeter is not always smooth (see, for example, Coen 2011).

Sharples et al. (2012) detected ribbons of fire spreading rapidly, perpendicular to the wind direction, along a ridge in rugged terrain ('channelling'). Albini (1993) observed a ribbon of fire emerging from the fire's flank and spreading parallel to, and faster than, the main front, while Radke et al. (2000) observed 'fingers of death' and Coen et al. (2004) saw 'flaming fingers' emerging from fire perimeters. A fingering pattern can develop downwind after a sharp wind change, with the overall shape of the perimeter changing dramatically as the fire dies (see, for example, Cruz et al. 2012:Figure 7).

According to the patterns of ambient wind and convection throughout the profile of the fire, pieces of burning material—firebrands—may be lofted and dropped at various places ahead of the main fire front, setting 'spot fires' up to 33 kilometres ahead of the fire (Cruz et al. 2012). Near the front itself, firebrands may be common and cause spot fires; in extreme cases, these may be so numerous that the front of the fire consists of burning spots rather than an identifiable line—the pseudo-flame fronts of Byram (1959).

Fires burn a vast array of fuels in a wide range of topographic situations with great fluctuations of weather. They may cause darkness to descend prematurely on the ground or light up a night sky; they may trickle along or race up steep slopes; they may crackle and pop or create a roar so loud that shouting to someone nearby cannot be heard. Landscape fires exhibit a complex and intriguing spectrum of phenomena that challenge our understanding yet are important to public safety and the prediction of damage and recovery of our social, economic and environmental assets (Gill et al. 2013).

— A. Malcolm Gill

Box 26.6 Fire regimes and biodiversity

Extreme fires make headlines. As such, a particular fire, or episode of fires, demands attention mostly because of its dire consequences for human life and property. When flora and fauna are of concern, however, consideration of more than one fire occurrence at any one place may be necessary if the effects of fires are to be understood (see, for example, Bradstock et al. 2002, 2012). This has special significance to the conservation of biodiversity—the range of indigenous ('native') plants, animals and other organisms.

In a large fire—a fire event—the fire burns through a range of vegetation types in fuels of varying composition and quantities arrayed in various ways, and with various moisture contents; the fire may cross hills and dales throughout the day and night and burn under various changing weather. Along the way it may affect various environmental, economic and social assets.

As it progresses, the fire affects populations of animals and plants to various degrees, according to the variations in its properties as it spreads. Some plants are readily killed when all their leaves and buds are killed, but this does not necessarily occur everywhere within the fire for all populations of the same species because of the variation in local fire intensity—the rate of heat release per metre of fire perimeter (Byram 1959). Populations of a different plant species might be fully defoliated by fire but readily re-sprout. Some animals might die but many survive. Dead birds and large animals may be obvious after a large, intense fire but they may constitute only a fraction of the population; the extent of population survival for different species needs to be determined before judgment is made about the effects of the fire event.

The immediate effects of fires constitute their 'severity' (see, for example, Keeley 2009; Medler 2010). The 'severity' of the fire, in its simplest terms, is whether individual plants or vegetation in general have tops that are green, brown (scorched) or black (charred) (Gill 2009). Whether the fire burns and removes a deep organic substrate or only burns above ground—'fire type' (Gill 1975, 1981)—can be significant to plant survival. Thus, removal of the substrate can lead to the death of even tall trees as many of the roots are destroyed and they topple over into what may be still-burning substrate. 'Severity' may then be measured as the extent of root damage.

Recovery from the severity of the fire may depend on such things as: seed supplies; local breeding populations; the amounts and types of precipitation at various times after the fire; food–shelter mixes for grazers; distance to nearest reproducing source; time to flower and fruit or breed; and the level of predation (for animals) or grazing (for plants). Left too long, some plants may reach old age and die without replacement; other plants may spread during the inter-fire period. Some animals may proliferate as their habitats improve, then decline as another habitat develops in the same place just as populations of other animal species increase.

Factors associated with fire occurrence (intensity, season, type and interval) and factors associated with the local environment (heights of trees, distances to reproductive sources, species present, and so on) can be important for the persistence of a species locally. The factors of fire occurrence together constitute the variables of the fire regime—'a key concept in many scientific domains' (Krebs et al. 2010:53)—while the factors relating to the environment provide the context within which species operate and which help determine their success or otherwise. 'Fire regimes' represent the relevant history of fires and their properties at a point in the landscape as far as the fire-effects application is concerned.

With each fire event centred in a different place, and in time, a pattern of ages of fuels develops. The footprint of the original fire event being considered is gradually covered by the footprints of other fires. The extent of overlay varies widely not just because of the position of each fire but also because of the large variation in areas of fires (Williams and Bradstock 2008). At any one point through time a series of varying intervals, intensities and types of fires may occur in a fire-prone landscape. In short, the variables of the fire regime vary temporally, about an average, as well as spatially.

In trying to understand and predict the effects of fire regimes on plant and animal species, most attention has been paid to fire interval, as in the classic paper of Noble and Slatyer (1980) in which fire responses of plants, timing of seedling regeneration and life history markers were used. Increasingly, intensity and season are coming into consideration. 'Type of fire' is rarely considered so far perhaps because peat fires may not occur in the area of concern or are only small.

The many millions of species of organisms that fires encounter around the world—whether in rainforests (Cochrane 2009b) or deserts (Brooks and Minnich 2006) or the many environments and ecosystems in between—behave in many different ways as a response to present and past fire regimes. Attention to the nature of future fire regimes and environments is now essential. Fire regimes are changing as a direct consequence of rising human populations and their impacts (such as fire suppression, prescribed burning, unwanted ignitions, changing fuels) or indirectly (such as through changing atmosphere and climate, more intensive management, more land being cropped).

Changing atmospheric composition changes the rates at which plants grow and fuels accumulate; changing climates are likely to involve more extremes in temperatures (warmer), precipitation (up or down), relative humidity, wind speed and possibly lightning ignitions—all affecting the nature of fire regimes (Cary et al. 2012). The challenge is to consider the effects of all fire regime components on all fire-prone organisms (Gill and Stephens 2009) in a changing environment as a guide to predicting the success or otherwise of our efforts to conserve biodiversity.

— A. Malcolm Gill

Rangers guided people away from this dangerous bull elk (*Cervus elaphus*) during the mating season, Mammoth, Yellowstone National Park, USA
Source: Graeme L. Worboys

Saltwater crocodile (*Crocodylus porosus*), Kakadu National Park, Northern Territory, Australia: rangers provide warnings and signs, and conduct an extensive awareness-raising campaign about this very dangerous animal to help prevent any incidents
Source: Graeme L. Worboys

- planting non-palatable crops such as tea or pasture near the boundary of the protected area
- working with communities to deal with problem animals such as bush pigs, baboons and gorillas, with crop-raiding gorillas, for example, being thwarted by volunteer community guards
- working in partnership with international non-governmental organisations (NGOs) who may be able to support enhanced wildlife management measures
- for marine incidents, such as cetacean strandings, ensuring the right wildlife expertise is available to direct the incident response relative to the animal needs, and that the rescuers have the right equipment to support the needs of such incidents
- for large-scale marine oil pollution incidents, working in close cooperation with multiple response organisations to deal with oil-impacted wildlife and to clean up polluted protected areas
- planning a response utilising the incident management system where large-scale criminal poaching of wildlife is ongoing (Worboys and Winkler 2006).

Natural phenomena

Climate change-influenced extreme weather events are forecast to be more frequent during the 21st century, including severe storms with strong winds, extreme dust storms, flooding rain, heavy snow and severe hail storms. Protected area managers can be expected to be involved more and more as part of multi-organisation responses to such incidents. The special expertise of protected area staff, especially their knowledge of the local geography, may be called on to assist, for example, with:

- search and rescue in mountain protected areas associated with severe snow storm and potential avalanche events
- dealing with karst areas and caves, where cavers or tourists have been trapped by the flooding of caves following severe rain storms
- responding to people as well as wildlife trapped by rising floodwaters
- dealing with animals dangerous to humans that have been mobilised by floodwaters such as venomous snakes and crocodiles
- assisting with the evacuation response for tourists and locals during unforeseen volcanic eruptions at volcano protected areas.

Humanitarian disasters

Natural and human-caused humanitarian disasters regrettably will continue to happen during the 21st century. Protected areas may be directly affected by these events, including the translocation of people from their homes to temporary emergency accommodation centres. Protected area managers will need to be sympathetic and helpful, but also vigilant. If possible and appropriate, they may need to assist with the emergency management of people in need, as the potential for a protected area to be immediately and severely impacted to supply basic needs such as fuel wood, materials for constructing shelter and food and water will be high. These needs will have to be met and the challenge will be to achieve this without the destruction of the protected area. Protected area managers, if possible, should help to provide solutions and some considerations may include:

- participating with the organisation responsible for managing an evacuation centre (the equivalent of an incident management team) and for dealing with humanitarian needs
- working with leaders of evacuees at the evacuation centre as a basis for responding to basic needs that may otherwise have been sourced from the protected area and securing assistance to help conserve the protected area
- establishing security arrangements that help protect the protected area.

At times of human conflict in or near protected areas, the first priority is to save lives and staff may be withdrawn from impacted protected areas. For any protected area managers who decide to stay, the advice is to maintain neutrality and impartiality and to build trust (Worboys and Winkler 2006), though clearly the situation could be difficult and dangerous. The safety of protected area staff is always the first priority in such situations.

Recovery

In the immediate aftermath of an incident, protected area managers would be expected to participate in or organise:

- confidential counselling services for any staff who may need such a service through an employee assistance program
- an internal protected area organisation debriefing
- a multi-organisation debriefing
- meetings with community organisations concerning the incident
- restoration of any cultural heritage sites that have been disturbed
- restoration of any disturbance to the protected area
- responses to any native fauna which may be impacted.

The aim is simply to ensure that any incident management improvements necessary can be made, that the community has had an opportunity to contribute to those improvements and that any interagency improvements needed have been identified. For larger, more complex incidents, or where there has been a loss of property or life, protected area managers would be expected to contribute to more formal inquiries established to review the incident.

Incidents (regrettably) will always be a routine part of protected area management. Anticipating these inevitable events includes identifying potential incidents (based on history and experience), pre-incident planning and preparedness that includes staff training, standby arrangements and prevention works. Being trained in incident management systems such as the AIIMS system is also critical, for it places protected area managers in the position of being a valued member of a typically larger, multi-organisation incident management team during incidents.

Conclusion

Incidents (regrettably) will always be a routine part of protected area management. Anticipating these inevitable events includes pre-incident planning, preparedness that includes staff training and prevention works. Being conversant with incident management systems such as the AIIMS system is also critical, for it places protected area managers in the position of actively contributing as part of a larger incident team during incidents.

Montague Island Nature Reserve is an important bird breeding and seal haulage site located several kilometres offshore from Narooma on the south coast of NSW, Australia. Service boat access to the island is from Narooma and via an infamously dangerous narrow 'Narooma Bar' entrance where fast- flowing estuarine waters meet open ocean swells in an often chaotic sea. The NSW National Parks and Wildlife Service maintains a permanent staff presence on the island, and incident planning has recognised the potential for medical emergencies (including an inability to evacuate personnel in rough seas), lightning strike fires, structure fires, pollution events and maritime incidents such as boating accidents.

Source: Graeme L. Worboys

Spencers Creek, Kosciuszko National Park, is an alpine headwater stream of the Snowy River, one of Australia's iconic rivers. Charlotte Pass Village and its snowbound winter skiing facilities are found at the very headwaters of Spencers Creek. Based on historical precedents of accidental fuel oil pollution of Spencers Creek, fires and lost people, incident planning by the park managers has been critical to minimise potential impacts.

Source: Roger B. Good

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