Chapter 6

CONCLUSIONS

Airborne sketch-mapping method has been used for about 80 years, and it has been an important tool for collecting data of individual forest insects and diseases. Color and NIR aerial photography have been in use for more than 30 years. Video camera and digital camera systems have been developed for 10 years. Satellite remote sensing data with middle spatial resolution such as Landsat TM has being used in forest health protection for more than 20 years. Therefore remote sensing has been an operational system in collecting data of forest insects and diseases in different scales for over 80 years. And it is a necessary means and useful tool in support of decision making to improve forest health for the forest protectors. There have been many successful applications of remote sensing in forest health protection in China, great potentials of this technology have been demonstrated, and it is substituting traditional ground surveying method all over the world.

There are four distinct characteristics in the evolving process of forest diseases and insects. The first is intuitiveness of forest change, usually appears as a change of color of all or a portion of the leaf. Therefore NIR, multi-spectral remote sensing image or data can be used to identify forest damage condition because near infrared band is very sensitive to changes of vegetation chlorophyll concentrations and vegetation water content. The second is the periodicity of forest insects and disease, it happens in specific time interval of a year, and we must choose best data acquisition time when it is concurrent with the life cycles of insects and diseases. The third is multi-scale in monitoring different type of insects and diseases. We should use remote sensing data of different resolution according to the monitoring goals, such as damage areas caused by pine caterpillars can be monitored with TM data, whereas damage areas caused by pine wood nematode disease (*Bursaphelenchus xylophilus* Nickle) should be monitored with airborne remote sensing data or high resolution satellite data. The fourth is the accumulation of forest damages. Insects and diseases of different generations and types often damage the trees continuously. It is the major influential factor that limited the monitoring accuracy. In other words, the remote sensing technique is more suitable for assessing the forest damage.

Now we have remote sensing data acquisition systems in two kind of platforms, the satellite platform and the airborne platform. Satellite data can be classified into three classes, coarse resolution, middle resolution and fine resolution. Airborne data can also be obtained with different sensors such as airborne video, airborne visual sketch-mapping, airborne digital camera and airborne photography. Each of them has its own strengths and weaknesses, and we must choose among them with great care in forest health protection (Table 6.1)

Aerial visual sketch-mapping is a low-cost, highly flexible method for data collection, but its results are subjective and its accuracy is difficult to validate. Airborne videography is a tool that provides similar flexibility and low cost as aerial sketch-mapping, and can permanently record forest conditions at any time. Videography has lower resolution than aerial sensors, and it is more difficult to distinguish subtle damage symptoms. Digital camera systems can provide higher resolution product than airborne video cameras at relatively low cost. It is a pity there is no professional infrared digital camera available in China and some developing countries. Instead, we have to use the commercial digital cameras.

Satellite remote sensing can cover earth surface at regular intervals and has the advantage of currency and large dimension. It can be classified into different types according to spectral resolution and spatial resolution. Landsat

TM, SPOT and IKONOS are well-known satellite remote sensing data, and they have found wide applications. Landsat TM data has proved to be good mean of monitoring severe forest insects and diseases, and it is also a good method to assess the damage caused by forest insects and diseases. With fine resolution comparable to airborne remote sensing, IKONOS data (high-resolution satellite data) can be used effectively to detect individual tree damages caused by dangerous forest insects and diseases, and it has good potentials in the protection of forest (Table 6.2).

Geographic information system (GIS) technology is now widespread in forest managements and is increasingly indispensable. Recent use of global positioning systems (GPS) offers the possibility of collecting the exact coordinates of geographic positions. GPS now permits the establishment of a link between a map and a real, physical location on Earth surface, whether it refers to an area, a moving object in the air, ocean and land. The GPS+GIS combination thus permits flexible, real-time management of forest resources at the landscape level. In the field, two types of positioning are commonly used during surveys: static and dynamic. These are most often carried out with georeferrenced information such as the specification of sampling plots, the actual damage region for treatment, or the track and instantaneous position of a flight. Therefore GPS is an indispensable technique to forest health specialists. GPS and remote sensing data is the main resource for GIS data updating. The integration of remote sensing, GIS and GPS will create a new era of forest health protection.

Table 6.1 Comparison of alternative remote sensing systems in forest health protection

Criteria	Sensor Type				
	Airborne sensor			Satellite sensor	
	Sketch-mapping	Digital videography	Digital camera	Landsat	IKONOS
Acquisition cost	Medium	Medium	Medium	low	High
Spatial resolution	High	Medium	High	low	High
Spectral range	Visible	Visible	Visible, Near-IR(some systems)	Visible,Near-, mid-, Thermal-IR	Visible,Near-
Temporal resolution	Use-and Weather-defined	Use-and Weather-defined	Use-and Weather-defined	16 days	3 days
Reliability of data	Difficult to measure	High	High	Medium to low	Medium
Probability of acquisition During specified biowindow	High	High	High	Medium to low	Low
Data in digital format	Difficulty in the developing countries in resent years	yes	yes	Yes	Yes
Currently operational	Yes-widely used	Yes-widely used	Yes-on project basis	Yes-in some forest damages	Under development

Table 6.2 use of alternative remote sensing systems in forest health protection

Criteria		Sensor Type				
		Airborne sensor			Satellite sensor	
		Sketch-mapping	Digital videography	Digital camera	Landsat	IKONOS
Damage detection	Large scale				operational	operational
	Middle scale	operational	operational	operational		operational
	Small scale	operational	operational	operational		operational
Damage mapping	Large scale			possible	operational	operational
	Middle scale		possible	possible		operational
	Small scale		possible	possible		operational
Damage orientation	Large scale				operational	operational
	Middle scale	operational	operational	operational		operational
	Small scale	operational	operational	operational		operational
Damage quantity	Large scale	operational	operational	operational	operational	operational
	Middle scale					operational
	Small scale					operational
Damage assessment	Large scale				operational	operational
	Middle scale	operational	operational	operational		operational
	Small scale	operational	operational	operational		operational

Large scale means that we cannot accurately detect the damage areas less than 1 hectare.
Middle scale means that we cannot correctly detect the single tree damages.
Small scale means that we can exactly detect the single tree damages.