An Integrated System for Forest Management and Enterprise GIS Using ArcGIS

Kazuto Nishimura, Susumu Takagishi, Xiaodong ZHAO, Shinichi Nakamura

Abstract

This paper reports on our experiences in developing a forest management system for Saga Prefecture, one of the local governments in the Kyushu region of Japan.
The database system was established by combining ArcGIS (ArcSDE, ArcEditor and Spatial Analyst) with an Oracle database to provide the infrastructure for geographic information.
Application of integrated GIS by local government entities is spreading in Japan. Such systems integrate all attributes and spatial data to support forest management and local government planning.

1. Introduction

Much progress has been made in the past in introducing a variety of forest administration information systems in Saga Prefecture. This includes a forest registration management system, a forest management works planning system, and forestation management system. Efforts are now being made to upgrade these forest administration information systems and improve their efficiency, in order to implement an e-municipality (electronic government) capability. Under these circumstances, positioning a forest geographical information system as one important element to accelerate the realization of e-municipalities is being contemplated. Accordingly, a forest geographical information system (GIS) to enable uniform management and control of existing forest registration data, forest planning diagrams (scale = 1/5,000) and other map information was created, and work was undertaken to build a system to improve administrative services, such as dissemination of information in response to the various needs of the prefecture's inhabitants, and to ensure efficient execution of forestry activity administration, including coordination of forestry planning materials, in conjunction with accelerating and streamlining activities and supporting plan proposals.

In addition, based on the need to uniformly manage existing forest registration management systems, forest planning diagrams (scale = 1/5,000) and other map information, and support extension of the program to an integrated GIS system in the future, system development was undertaken while giving consideration to the following contents.

Effective application of existing systems (improvement of forest registration management systems)

To link the forest registration management systems and GIS now in operation, the basic database engine was upgraded from Access97 to Access2002. Enhanced operability and improved functionality of the systems were achieved as a result.

Adoption of a global standard engine

The ArcGIS Series was adopted for the GIS engine, to enhance its standard functions as a GIS and enable creation of the minimum functions necessary for customizing.

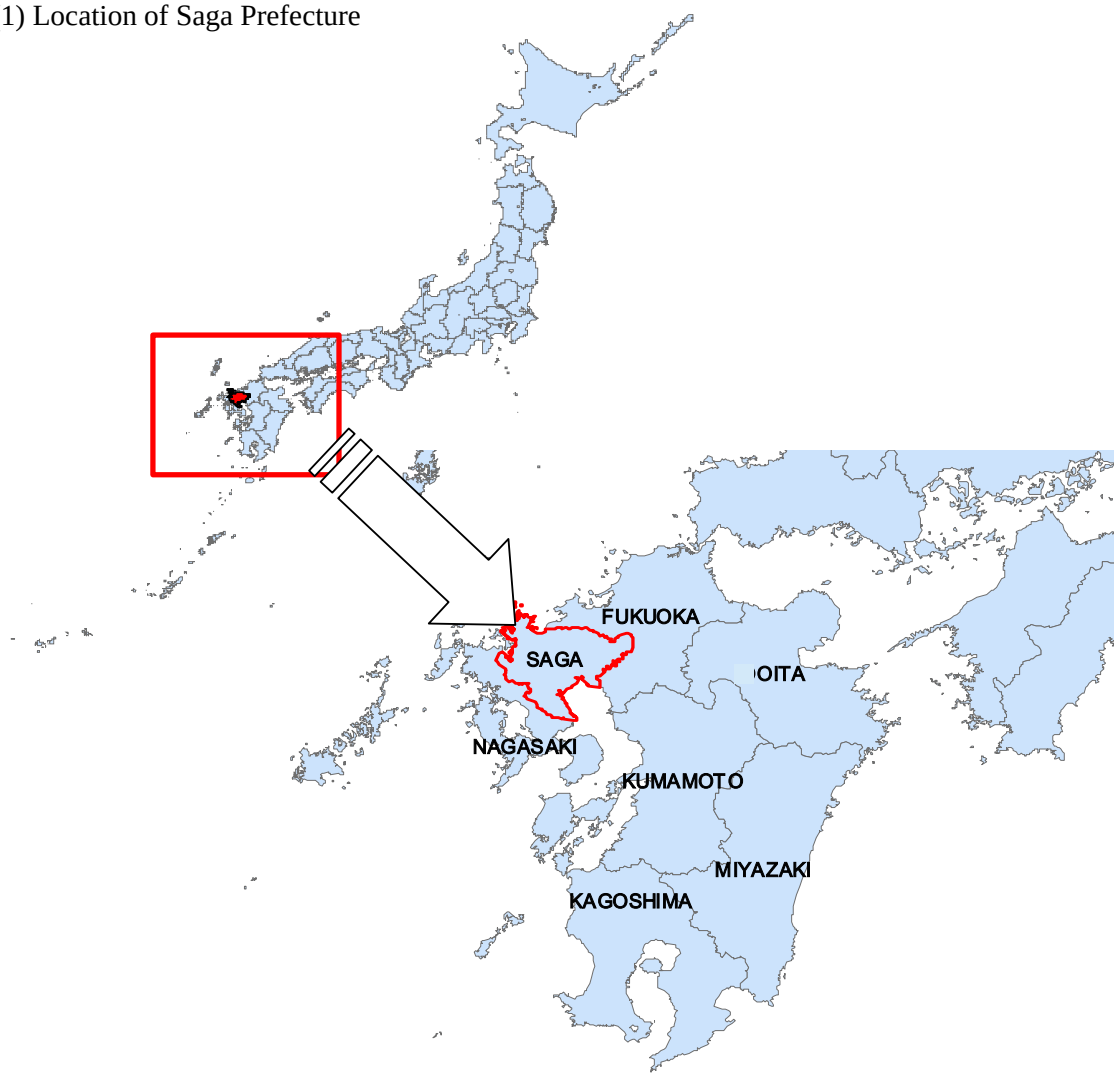
Development towards an integrated GIS

The geography database server ArcSDE, which can effectively share and utilize the GIS information managed by each local bureau on the prefecture’s LAN-WAN, was selected to create a system that can be developed into a future integrated GIS.

2. The Study Area

The scope of the area subject to data consolidation was the entire area of Saga Prefecture.

(1) Location of Saga Prefecture



(2) Overview of Saga Prefecture

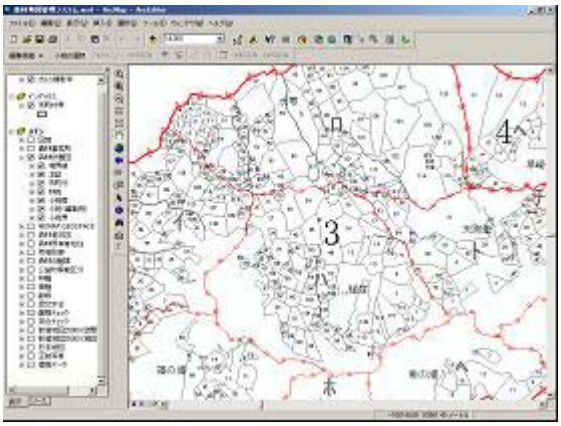
With a population of 870,000 people and an area covering 2,439 square kilometers, Saga Prefecture is the smallest of Kyushu's seven prefectures. Located in northwestern Kyushu, Saga Prefecture is bordered by Fukuoka Prefecture to the east and Nagasaki Prefecture to the west, while facing the Genkai Sea on the north and the Ariake Sea to the south. The climate is hot and humid, making it an ideal place to live. The structure of the economy is characterized by a large mix of primary industries centered on agriculture and fishing, plus a heavy weighting in the construction industry and manufacturing, with tertiary industries representing a small portion of the economy overall.

3. Data Used

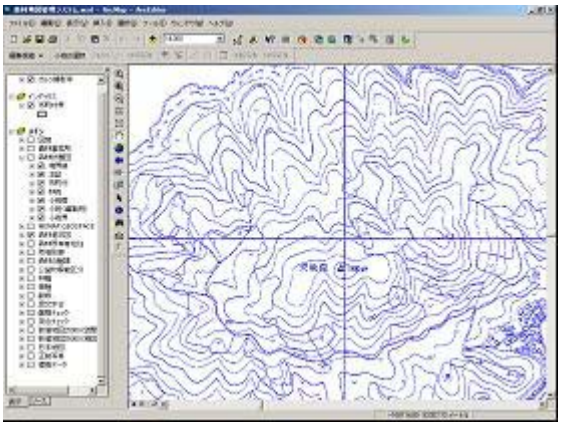
The data used for the forest Geographical Information System is described below.
All of the vector data, grid data and raster data were registered in ArcSDE. A pyramid layer was constructed to draw the raster data at high-speed.

(1) Examples of data views

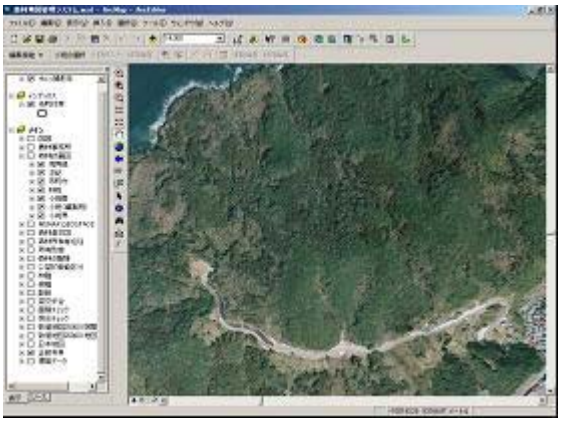
Forest plan diagrams



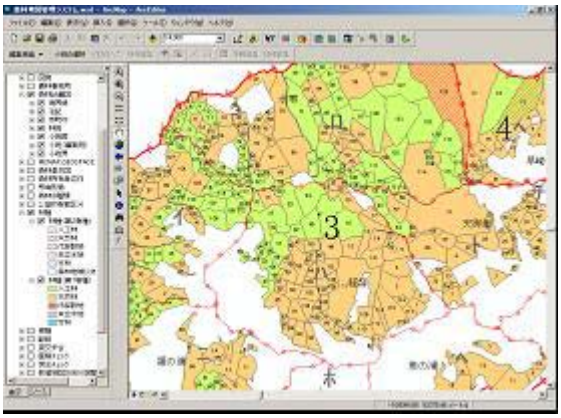
Basic forest diagrams



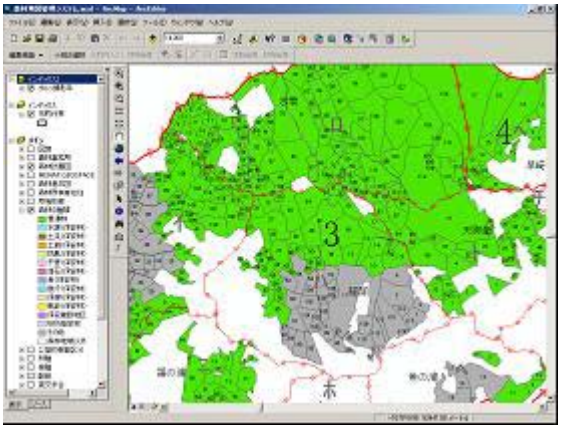
Orthography



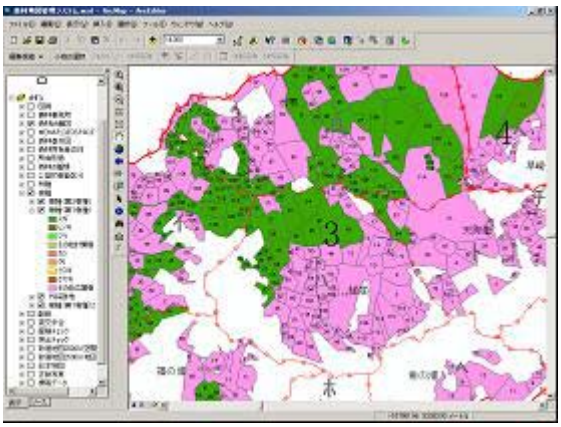
Classifications by tree type (forest planning diagrams)



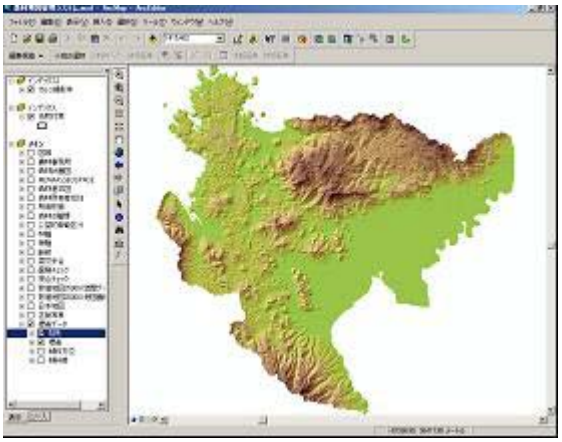
Forest classifications



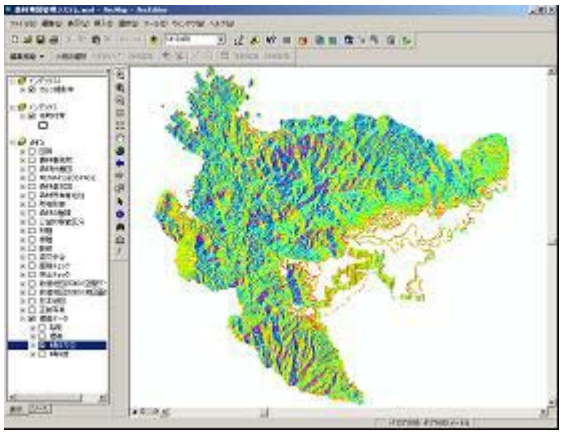
Tree types



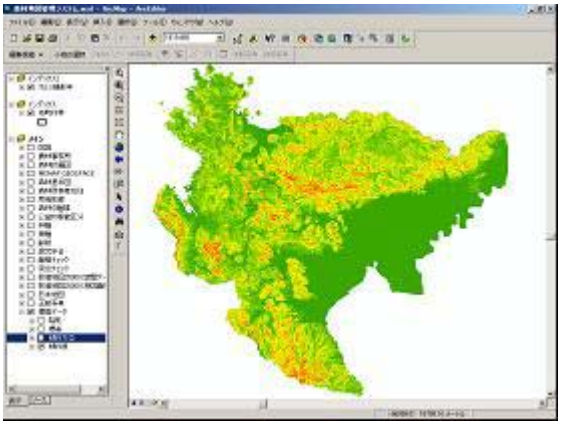
Viewshed



Aspect



Slope



(2) Data composition tables

	Layer name	Composition layer	Geometry type	Consolidation scale	Source
01	Quadrangle tiles	Forest basic diagram quadrangle tiles	Polygon	1/5000	Forest basic diagram
		Agriculture and forestry office quadrangle tiles	Polygon	1/25000	
		1/25000 quadrangle tiles	Polygon	1/25000	
02	Agriculture and Forestry Office	Agriculture and Forestry Office	Polygon	1/25000	
03	Forest plan diagrams	Line	Line	1/5000	Forest planning diagram
		Notes	Point	1/5000	Forest planning diagram
		Municipalities	Polygon	1/5000	Forest planning diagram
		Forest stands	Polygon	1/5000	Forest planning diagram
		Small stand groups	Polygon	1/5000	Forest planning diagram
		Small stands (for editing)	Polygon	1/5000	Forest planning diagram
		Small stand boundaries	Polygon	1/5000	Forest planning diagram
04	MEMAP GEOSPACE	GIS_memap_line	Line	1/2500	MEMAP GEOSPACE
05	Forest basic diagram	Forest basic diagram	Raster	1/5000	Forest basic diagram
06	Forest owner residence	Forest owner residence	Polygon	1/5000	Forest planning diagram
07	Ownership form	Ownership form	Polygon	1/5000	Forest planning diagram
08	Forest classification	Forest classification	Polygon	1/5000	Forest planning diagram
09	Public interest function	Public interest function	Polygon	1/5000	Forest planning diagram
10	Forest types	Forest type (First tree type)	Polygon	1/5000	Forest planning diagram
		Forest type (Second tree type)	Polygon	1/5000	Forest planning diagram
11	Tree types	Tree type (First tree type)	Polygon	1/5000	Forest planning diagram
		Deforestation site	Polygon	1/5000	Forest planning diagram
		Tree type (First tree type)	Polygon	1/5000	Forest planning diagram
		Tree type (Second tree type)	Polygon	1/5000	Forest planning diagram
12	Age class	Age class (First tree type)	Polygon	1/5000	Forest planning diagram
		Age class (Second tree type)	Polygon	1/5000	Forest planning diagram
13	Mixture percentage	Mixture percentage	Polygon	1/5000	Forest planning diagram
		Tree type (First tree kind)	Polygon	1/5000	Forest planning diagram
14	Area check	Area check	Polygon	1/5000	Forest planning diagram
15	Abutment check	Abutment check	Polygon	1/5000	Forest planning diagram
16	Numeric map 25000 (spatial database)	Administrative representative point	Point Line	1/25000	Numerical map 25000 (spatial database)
17	Numeric map 25000 (map image)	Numeric map 25000 (map image)	Raster	1/25000	Numeric map 25000 (map image)
18	Orthogonal projection photo	Hilly and mountainous areas Ortho_h12	Raster	-	Saga Prefecture
		Hilly and mountainous areas Ortho_h11	Raster	-	Saga Prefecture
		Hilly and mountainous areas Ortho_h10	Raster	-	Saga Prefecture
		JFTA Orthogonal	Raster	1/5000	Japan Forest Technology Association
		GSI Orthogonal	Raster	-	Geographical Survey Institute
19	Map of Japan	Map of Japan	Polygon		
20	Altitude data	Shadow	Raster	1/25000	Numeric map 50m mesh (altitude)
		Altitude	Raster	1/25000	Numeric map 50m mesh (altitude)
		Inclination azimuth	Raster	1/25000	Numeric map 50m mesh (altitude)
		Inclination level	Raster	1/25000	Numeric map 50m mesh (altitude)
21	Municipalities	Municipalities	Polygon	1/25000	Numeric map 25000 (spatial database)

4. Points to note when editing data

The shohan boundary that is the minimum boundary used by the forest geographical information system is comprised of the shicho boundary, the rinpan boundary, the shogun boundary and the shohan boundary, from the outside boundary side. Each boundary does not begin from the higher-ranking boundary, but shares that boundary. To satisfy this requirement when editing data the topology rules were set as follows.

(1) Participating feature classes and ranks

Feature class	Class	Rank	Subtype	Topology rule	Remarks
Shicho	polygon	4	-	Related	Municipalities
Rinpan	polygon	3	-	Related	Forest stands
shogun	polygon	2	-	Related	Small stand groups
shohan	polygon	1	-	Related	Small stands
Line	line	5	-	Related	Municipality, forest stand, and small stand group boundary lines
Chuki	point	5	-	Related	To display forest stand and small stand group labels

(2)Topology rules

Main feature class	Topology rule	Referenced feature class	Remarks
Shicho	Must Not Overlap	-	
Shicho	Must Not Have Gaps	-	As a shape, those with a space are exceptions
Shicho	Area Boundary Must Be Covered By Boundary Of	rinpan, shogun, shohan	
Shicho	Boundary Must Be Covered By	line	
Rinpan	Must Not Overlap	-	
Rinpan	Must Not Have Gaps	-	As a shape, those with a space are exceptions
Rinpan	Must Be Covered By Feature Class Of	shicho	
Rinpan	Area Boundary Must Be Covered By Boundary Of	shogun, shohan	
Rinpan	Boundary Must Be Covered By	line	
shogun	Must Not Overlap	-	
shogun	Must Not Have Gaps	-	As a shape, those with a space are exceptions
shogun	Must Be Covered By Feature Class Of	rinpan	
shogun	Area Boundary Must Be Covered By Boundary Of	shohan	
shogun	Boundary Must Be Covered By	line	
shohan	Must Not Overlap	-	
shohan	Must Not Have Gaps	-	As a shape, those with a space are exceptions
shohan	Must Be Covered By Feature Class Of	shogun	

5. System design

The system is conceived as a system that operates on a stand-alone basis on computers installed in Forest Administration Sections. For management of forest registration data, the system will continue using without any changes the forest registration management system now being used. The punch card input data used for data updates is processed on the host side, and after being processed the forest registration data is downloaded to the forest geographical information system. On the forest geographical information system side, the cadastre survey results data are used and the revised forest plan diagram data and revised forest registration data are correlated; when there is a discrepancy, the data are revised. A summary of the activity processing is shown in Figure 1.

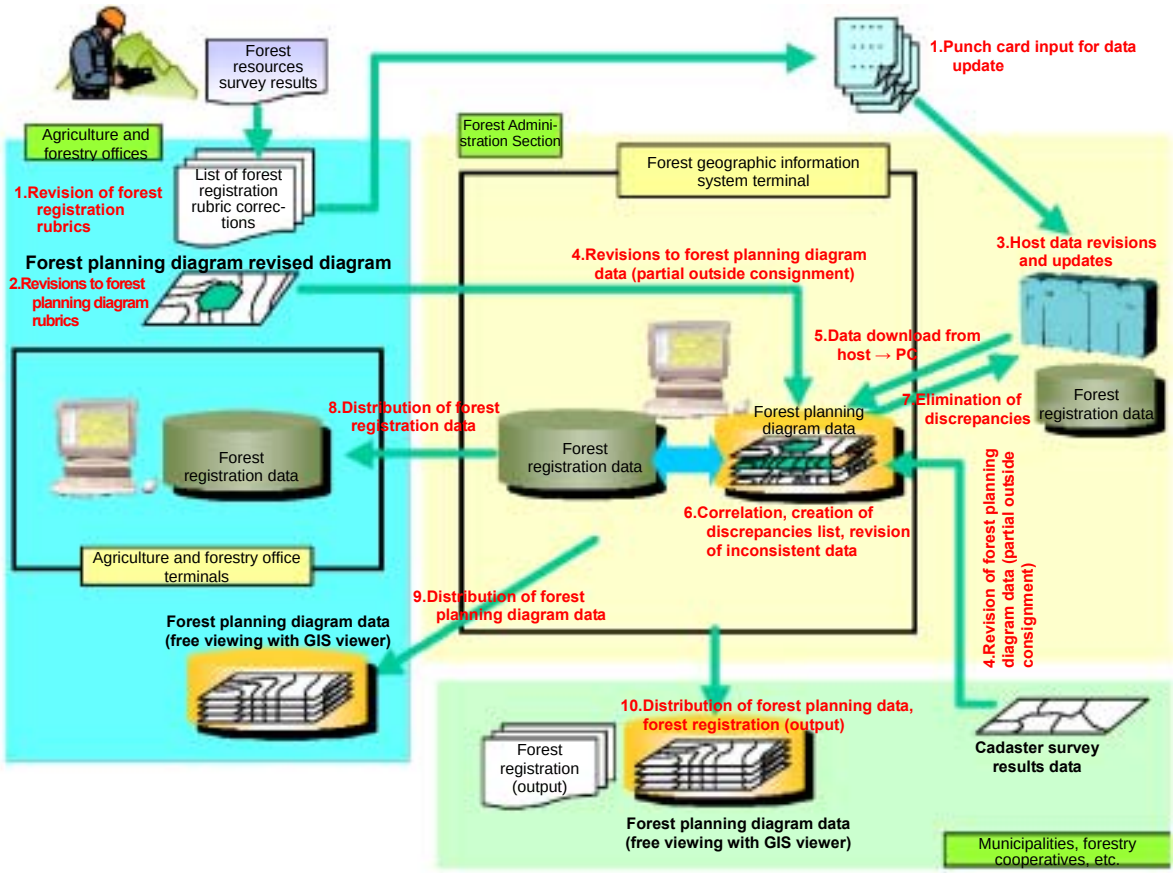


Figure 1 Activity processing flow under the forest geographical information system and scope of the forest geographical information system

6. System Configuration

The software configuration is shown in Fig. 2. The decision was made to move the existing forest registration management system database and applications from Access97 to the current version of Access2002. For the GIS engine that will serve as the foundation of this system, the decision was made to adopt ArcSDE8.3 as the GIS data server, and ArcEditor8.3 and the enhanced features of Spatial Analyst as the software for GIS viewing and editing, both selected from the "ArcGIS family", the software family in widest use around the world. In addition, the free GIS viewer ArcReader was introduced into existing PCs in Forest Administration Sections and at agriculture and forestry offices, making it possible to view the forest planning diagrams.

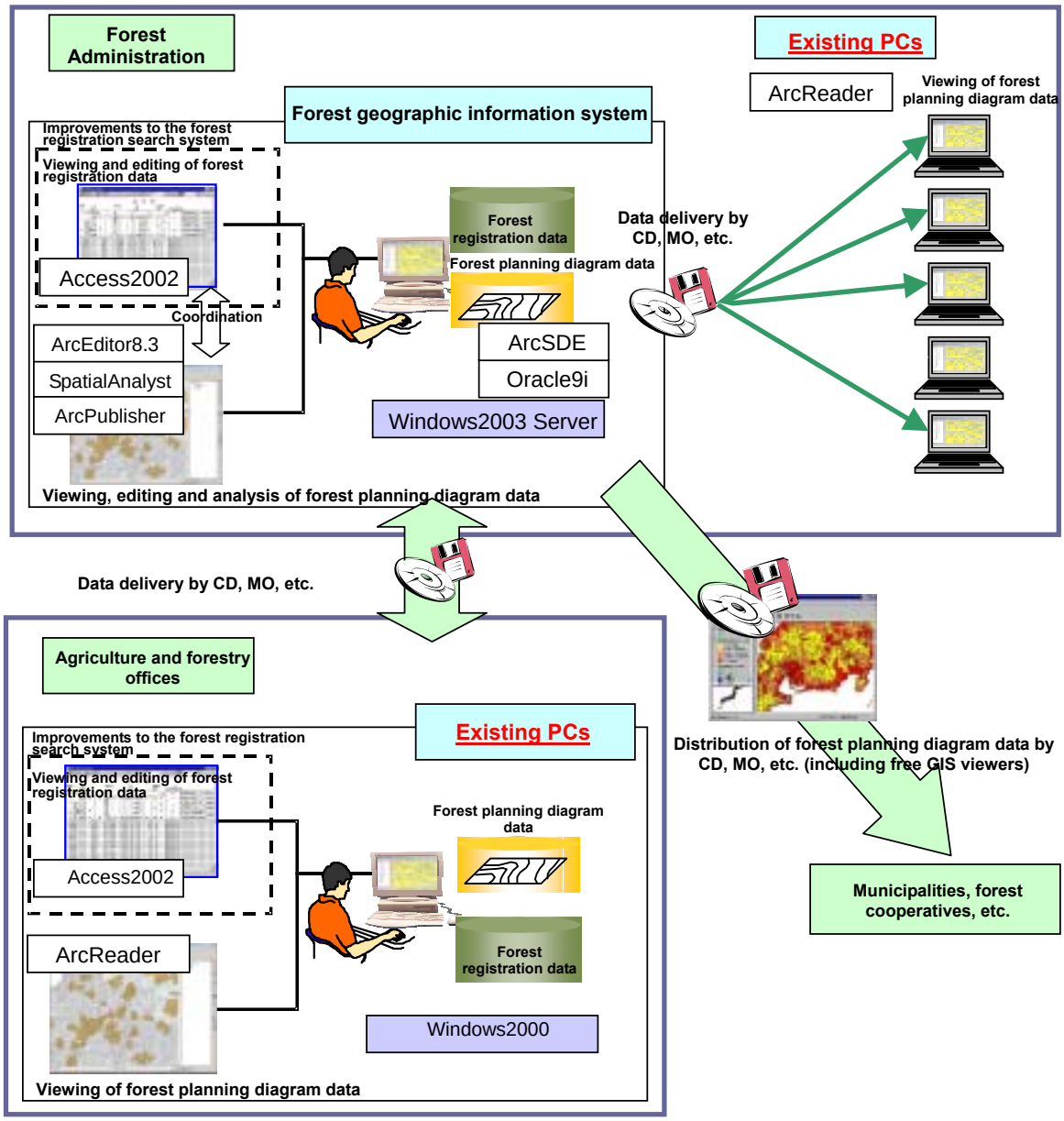


Figure 2 System configuration

7. Results

In addition to the basic GIS functions, the forest planning activity-related functions described below were developed in the forest geographical information system. The following results were obtained by using these functions.

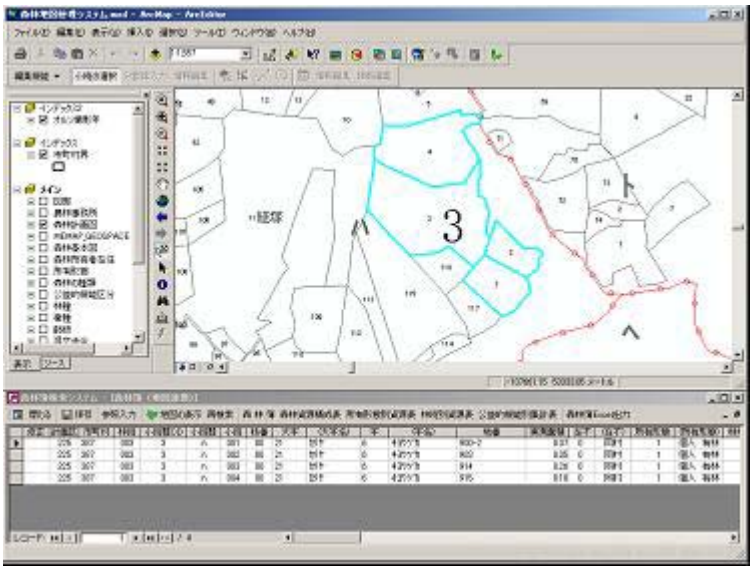
(1) Coordination of forest registration data and forest planning diagram data

Function

Although forest registration data will be managed by the improved forest registration management system and the forest planning diagram data will be managed using GIS, coordinating these two data sets will enable users to call the data from both directions.

Result

The location of a small stand group selected on the forest registration management system side can be displayed using GIS, and the attribute information on a small stand group selected on GIS can be displayed using the forest registration management system.



(2) Arbitrary totaling by forest registration item

Function

This function can deal with forest registration category total items, such as number of cases, total value, and min-maximum values of.

Result

Enables users to sum data, such as the total value of cumulative amounts by forest stand type and tree type, or small stand area by municipality and by forest age, and create color diagrams (ranking diagrams).

(3) Editing of forest registration data and forest planning diagram data

Function

This function will select locations for editing from the forest registration system (attributes) or the forest geographical information system (maps), and perform editing operations such as correction, deletion, addition and subdivision of forest registration data. The correction, deletion, addition and subdivision of forest planning diagram data (maps) envisions editing by the multiple users who will be able to use the system in the future, and the ArcSDE versioning function was used. Specifically, a user interface was created to enable users to register revisions easily in the original data by using a check-in function, after defining and editing the

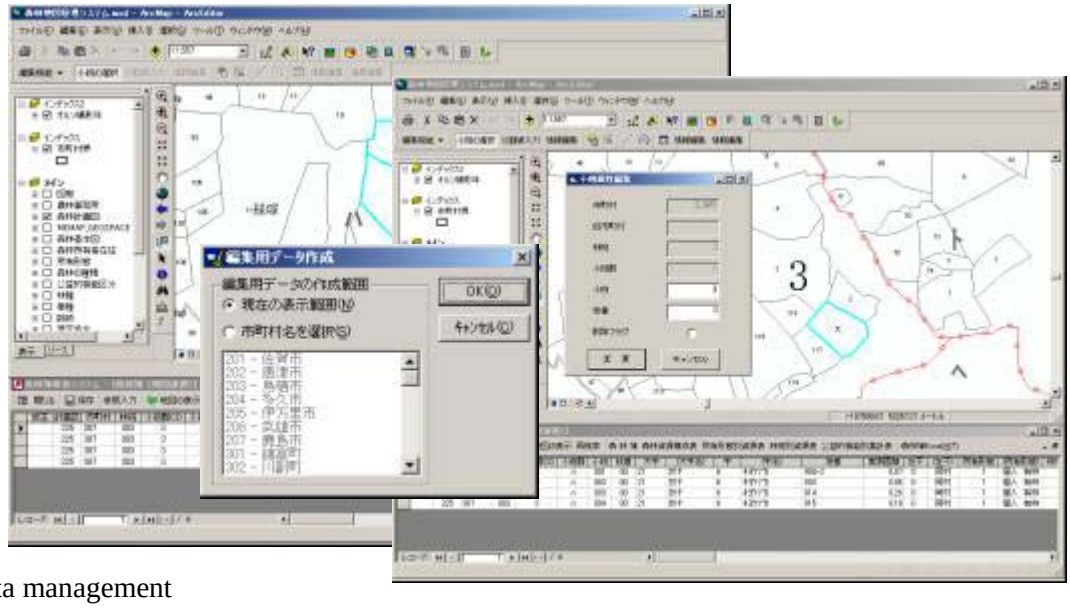
areas targeted for editing using a checkout function, utilizing a continuous series of steps.

In addition, forest planning diagram correction can be made after scanning, repositioning, and overlapping orthogonal projection images or the results of a forest resources survey.

Result

Until now the editing of forest planning diagrams had to consign to outside vendors, but agencies can now perform data updates in-house. Moreover, by using the versioning function, it is possible to respond immediately to updates by two or more users.

This has made it possible to improve the accuracy of forest registration and map data by editing, by comparing backgrounds based on the forest registration system (ledger data) and the forest geographical information system.



(4) Data management

Function

This function regularly makes a backup, to provide against unforeseen accidents affecting the forest registration data or map data.

Result

Enables users to restore data to the backup point in time when data has been damaged or mistakenly deleted.

(5) Discrepancy list extraction

Function

This function performs a correlation (linkage) of the forest registration data corrected on the host computer and the forest planning diagram data corrected by using either the results of a forest resources survey or the results a cadaster survey, to extract the discrepancies (1 to 0, 0 to 1, 1 to N, N to 1, etc.) between the forest registration data and the forest planning diagram data.

Result

Enables users to verify the extraction result according to the list, and classify and display the forest planning diagram data according to the type of discrepancy.

(6) Data conversion for host use

Function

This function converts the forest registration data managed on the host computer and incorporates the data into the forest geographical information system. The function will also convert forest geographical information system data into data for use on the host computer.

Result

Enables users to correlate the forest registration data and the forest planning diagram data on the forest geographical information system. Also enables users to return the data that eliminated a discrepancy to the host computer.

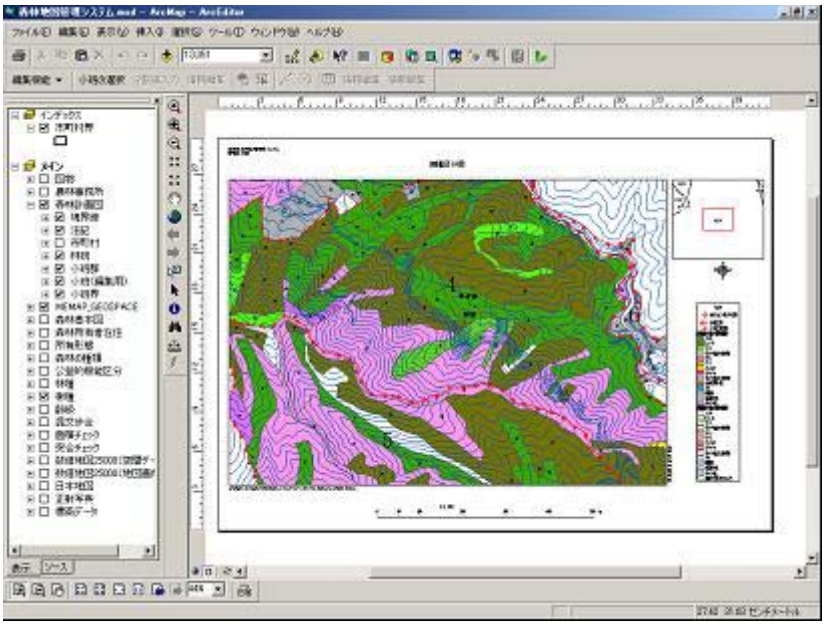
(7) Printing of forms and standard diagrams

Function

This function enables users to print forms and diagrams by using forest registration data extracted according to arbitrary conditions.

Result

Enables users to utilize forms they’ve created for reports and other documents, because the forms can be output in a commercially available spreadsheet software format such as EXCEL. The function also enables users to print the forest basic diagrams and forest planning diagrams at the quadrangle tile units specified by the prefecture, up to a maximum A0 size.



8. Conclusions

The forest geographical information system utilizes forest registration data and forest planning diagram data and is the key data management system in the forest management field. The forest management field encompasses a wide range of activities, and it is believed the data can be utilized for various activities by applying and enhancing this basic system.

In activities such as those concerning afforestation or erosion control and forest roads, for example, the system enables users to build various ledger management systems by synchronizing the respective ledgers. Development of this system proceeded while keeping in mind future development of a comprehensive system for all forest administration.

Figure 3 shows an image of a comprehensive forest information system encompassing all forest administration. Such a system is designed to increase the efficiency of forest administration activities as a whole, by mutually providing data using a system that supports various activities such as afforestation (forest management works history management), erosion control and forest roads, and prevention forests, centered on a core system that utilizes forest planning activities. In addition, such a system will make it possible to use the Internet to disseminate various forest-related information to inhabitants of the prefecture.

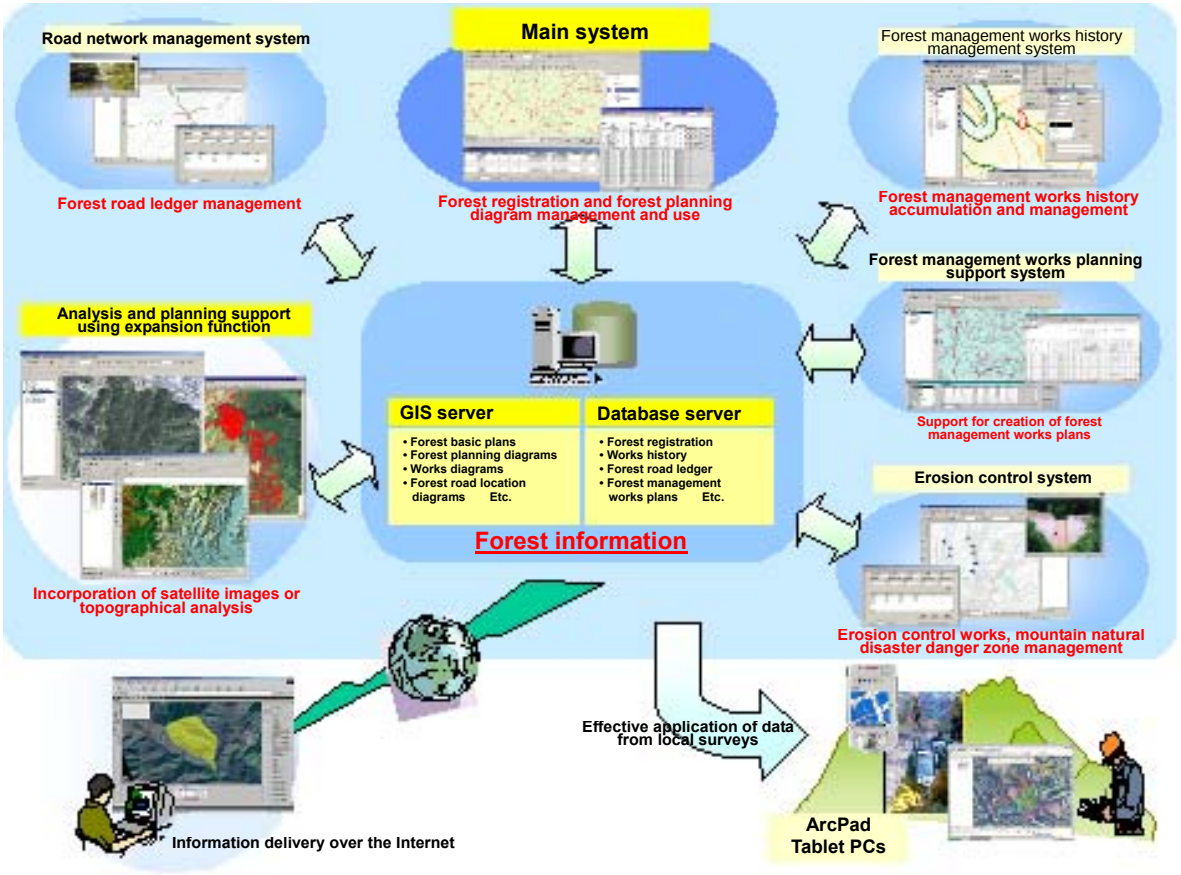


Figure 3 Image of the overall forest information system

9. Acknowledgements

We wish to express our gratitude to staff of Saga Prefecture and Saga Densan Center Corporation for their co-operations to the developed GIS-based system.

AUTHOR INFORMATION

Kazuto Nishimura
Project Manager
Environment Group, Technology Department, Government Ministries Division
Pasco Corporation
1-1-2 Higashiyama
Meguro-ku, Tokyo 153-0043
Japan
Telephone: +81-3-6412-2501
Fax: +81-3-6412-2561
E-mail: kazuto_nishimura@pasco.co.jp

Susumu Takagishi
Project Manager
Technology Department, Kyusyu Division
Pasco Corporation
3-5-2 Higashihie
Hakata-ku, Fukuoka 812-0007
Japan
Telephone: +81-92-451-3526
Fax: +81-92-414-0350
E-mail: susumu_takagishi@pasco.co.jp

Xiaodong ZHAO(PhD)
Technology Department, Kyusyu Division
Pasco Corporation
3-5-2 Higashihie
Hakata-ku, Fukuoka 812-0007
Japan
Telephone: +81-92-451-3525
Fax: +81-92-414-9858
E-mail: xdzhao@pasco.co.jp

Shinichi Nakamura
Technology Department, Kyusyu Division
Pasco Corporation
3-5-2 Higashihie
Hakata-ku, Fukuoka 812-0007
Japan
Telephone: +81-92-451-3525
Fax: +81-92-414-9858
E-mail: shinichi_nakamura@pasco.co.jp