STUDY OF DIGITAL GEOHERBS BASED ON GIS AND GEO-INFORMATIC TUPU

Wang Jing'ai[a,b] Zhang Wensheng[c,d*] Gu Bin[c,d] Liu Zhen[a,b] Su Yun[a,b] Wang Yongyan[c,d]

（a.College of Geography &Remote Sensing Sciences, Beijing Normal University, Beijing 100875, China;

b.Key Laboratory of Regional Geography, Beijing Normal University, Beijing 100875,China;

c.Protection and Utilization of Traditional Chinese Medicine of Beijing Area Major Laboratory, Beijing 100875, China

d.Institute of Natural Medicine and Chinese Medicine Resources, Beijing Normal University, Beijing 100875, China)

Keywords: digital geoherbs, GIS, Geo-informatic Tupu, suitability evaluation, YI medicine

1. Introduction

"Dual-health of earth and human beings" is a new mode of sustainable development, which highlights the idea of dual-health (Shi et al., 2004). Nowadays, in order to pursue this sustainable development mode and return to natural and traditional medicine, Traditional Chinese Medicine (TCM) as the treasure of traditional culture and medicine of China, attracts more and more attention from all over the world. TCM has already contained the idea of "Integration of human and nature" and "Harmonious development of human and nature" since 2000 years ago (Jiang, 2001). Chinese herbs are the basics of TCM, approximately 12 800 species, 90 percent of them are plants (Chen et al., 2003). On one hand, Chinese herbs as drugs help people keep far away from diseases. On the other hand, as products of natural environment, Chinese herbs are important parts of natural resources. Their sustainable development is significant for coupling both human health and earth health. As we all know, China is a large country with diverse natural conditions and environment, on which Chinese herbs depend. Therefore Chinese herbs have obvious regional characteristics. But producing areas of geoherbs (genuine Chinese herbs with long clinical usage, definite clinical effect and specific producing areas) have been shrinking year by year, due to the interruption of human being's activities. So protection of geoherbs is a vital task of sustainable development of TCM. Suitability evaluation and layout of geoherbs habitat are key steps of protection of geoherbs. But how could we protect geoherbs and evaluate suitable geogerbs habitat? "Digital Earth" provides us the answer.

Researches on suitability evaluation and layout of geoherbs resources were generally completed by traditional methods before, such as spot survey, sample survey and interview survey. For example, *Lonicea edulis Turcz* resource in Heilongjiang Province of China was investigated by spot survey (Yang et al., 2002); spatial distribution pattern of *fritillaria unibracteata* community in China was researched by sample survey (Chen et al., 1997). But the traditional methods hardly applied in large areas and the results of them are always reserved by oral or paper media with less information, low precision and bad flexibility, which can't cater to the sustainable utilization of geoherbs. As products of specific spatial environment, geoherbs fully reflect the influence of

*Corresponding author. Tel:+86-10-62205268; fax:+86-10-62200669-0. E-mail address: cmzws@263.net (Zhang Wensheng).

environment on them (Guo et al., 2005). Following the times of “Digital Earth” coming, we get a new way to accomplish suitability evaluation and plan of geoherbs habitat by combining modern “Digital Earth” techniques such as GIS with traditional Geo-technology. The habitat of pnax ginseng was investigated and the model of its resources investigation was established by remote sensing (Chen et al., 2005); appropriate producing areas of *fritillaria thunbergii* in Yin county of Zhejiang Province, China were analyzed based on GIS, and the map of suitable producing areas of *fritillaria thunbergii* was completed (Wang et al., 2006); the habitat characteristics for the growth of *atractylodes lancea* was studied by GIS, and the suitable precipitation and temperature that affect *atractylodes lancea* growth were concluded (Guo et al., 2005). Here we apply GIS and Geo-informatic Tupu method in suitability evaluation and layout of YI medicine in Chuxiong of Yunnan Province, China, to reestablish the multi-dimensional model of geoherbs habitat, finally complete the suitability research of geoherbs in Chuxiong by massive spatial information and corresponding model. Based on which, we can extend researches on suitable geoherbs habitat throughout China and complete the “Digital Geoherbs Box” of China.

YI medicine is a vital part of TCM. After thousands of year’s clinical practices this ethical medicine is handed down from one generation to another by oral or book in Yi (Qin, 2005). Chuxiong is the cradle of YI medicine with a long history of YI medicine development and abundant biology resources. Chuxiong is located in the north of Dianzhong Plateau with various climate types, enough sunshine and the soil there is fertile for plant to grow. There are 243 families, 1381 species herbs in Chuxiong, accounting for 9.2 percent herbs of China (Dai, 2004). Therefore applying “Digital Earth” techniques on suitability evaluation and plan of geoherbs in Chuxiong is very necessary.

2. Method

2.1 Digital study of geoherbs

The growth of geoherbs depends on their living environment, but earth environment is multi-dimensional, which consists of seven basic layers (climate, physiognomy, soil, vegetation, water, animal and human beings). We extract digital information from every basic layer and overlay them by “digital earth” techniques to form groups of basic digital units, which contain all the environment information of geoherbs. Based on basic digital units, digital study of geoherbs comes true.

2.2 Suitability evaluation and plan of geoherbs habitat

According to records of geoherbs habitat, factors affecting the distribution and growth of geoherbs are landform, climate, soil, vegetation, etc. We choose altitude (H), gradient (G), slope aspect (A), humidity (M), temperature (T), soil (S) and vegetation (P) as evaluation indices. Corresponding data origins are Digital Elevation Model (DEM) data, climate map, soil map, vegetation map, etc.

Firstly, we obtain standardized digital Map of Natural Factors (MNF) such as H map, G map, A map, M map, T map, S map and P map of target area from data origins by GIS. Secondly, extract suitable areas from each MNF and complete serials habitat factor Tupu (Hn，Gn，An，Mn，Tn，Sn and Pn) of each herb. Thirdly, overlay them and obtain suitable habitat Tupu (Rn) of each herb. At the last, we can guide the programming of geoherbs planting by integrating the Land-use Map (Ln). The whole flowchart is shown in Figure 1.

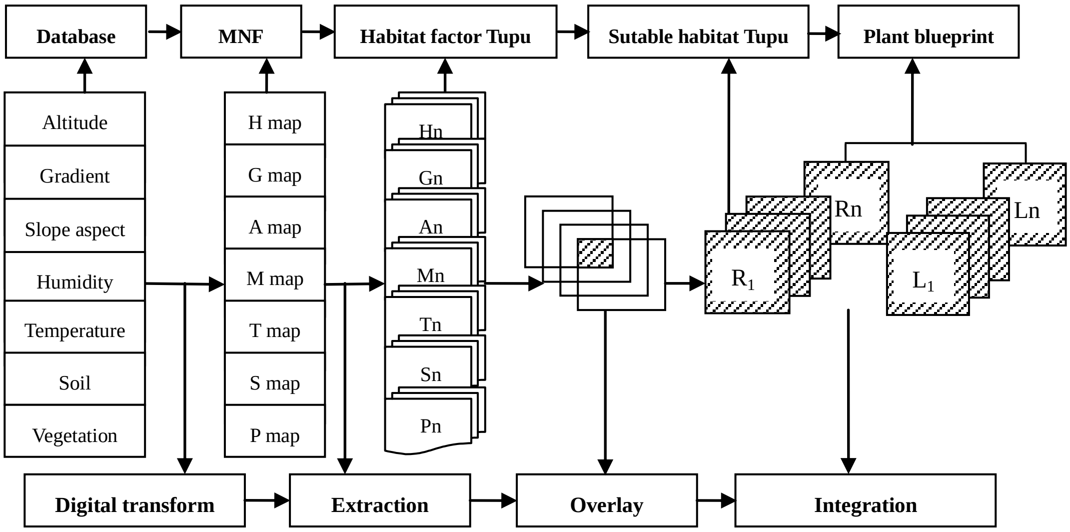

Figure 1. Suitability evaluation and plan of geoherbs habitat flowchart

Here are some vital steps: 1) Data extraction: Accurate three-dimensional information is recorded in DEM, so we can extract altitude, gradient and slope aspect information efficiently from DEM (Zhang et al., 2000); 2) Information spreading: The amount and precision of information can be enhanced by transforming non-digital information to digital one and further revising it by remote sensing; 3) Serials habitat factor Tupu overlay: Carry out Hn∩Gn∩An∩Mn∩Tn∩Sn∩Pn＝Rn step by step, with the suitable habitat region of each YI medicine continuously being restricted, by which we can avoid the interaction of different environmental factors; 4）Land-use Map integration: Further consideration assisted with Land-use Map is necessary, Land-use map reflects the influence of human's activities on nature. The geoherbs planting must be guided not only by theory but reality.

3. Case

3.1 Geoherbs resources in Chuxiong

Chuxiong (29 258km^2) is located in the north of Yunnan Province, from which nearly 40 percent Chinese herbs of China are produced. Chuxiong consists of ten counties (Chuxiong, Suangbai, Moding, Nanhua, Yaoan, Dayao, Yongren, Yuanmo, Wuding and Lufeng). Chuxiong is the main producing area of some important geoherbs, accounting for 23 percent geoherbs of Yunnan and 9.2 percent of China. Chuxiong is mountainous, nearly 90 percent of which are hills. Because of diversity of landform and altitude, the distribution of climate factors is complicated. There are six climate zones (from North tropical zone to frigid-variable zone) in Chuxiong, so the Chinese herbs there are diverse and abundant. Some of them have been widely used, such as *Eucommia ulmoides Oliv*, *Galium elegans Wall ex Roxb*, *Paris delavayi Franch*, etc (Qiu et al., 2005).

3.2 Data and Indices

Considering the availability of data, we chose DEM (Yunnan, 1:250 000) and vegetation map (Chuxiong, 1:400 000) as data origins. Because indices interact with each other, for example altitude influences temperature and slope aspect influences water distribution. We selected four main typical factors: altitude, gradient, slope aspect and vegetation as evaluation indices and ignored others. Then we standardized and classified the four indices（Table 1）, otherwise spatial information of geoherbs habitat can not be extracted by GIS.

Table 1. Evaluation indices and grade system

Indices	Grade system		
Altitude（H）	1) 0—500m;	2) 500—1000m;	3) 1000—1500m;
	4) 1500—1700m;	5) 1700—1900m;	6) 1900—2100m;
	7) 2100—2500m;	8) 2500—3000m;	9) >3000m.
Gradient（G）	1) 0°—5°;	2) 5°—10°;	3) 10°—15°;
	4) 15°—25°;	5) 25°—50°;	6) >50°.
Slope Aspect（A）	1) Angle=0°, flat;		
	2) 0°<Angle≤45°, 315°<Angle<360°, North slope;		
	3) 45°<Angle≤135°, East slope;		
	4) 135°<Angle≤225°, South slope;		
	5) 225°<Angle≤315°, West slope.		
Vegetation（P）	1) *pinus Yunnanensis Franch*, *Pinus kesiya var.langbianensis* forest and Shrub;		
	2) *Castanopsis fargesii Franch* and *Lithocarpus glabez (Thunb.) Nakai* community;		
	3) High mountain *Quercus serrata Thunb* forest;		
	4) *Rhododendron* and *V.bracteatum Thunb* Shrub;		
	5) *Heteropogon Contortus (Linn.) P.Beauv. ex Roem. Et Schult* and *Cymbopongon. Citrates (dC.) Stapf* Grassland;		
	6) Farmland.		

3.3 Habitat Tupu extraction and overlay

We extracted habitat Tupu of each YI medicine by GIS and then overlaid them, the framework is shown in Figure 2.

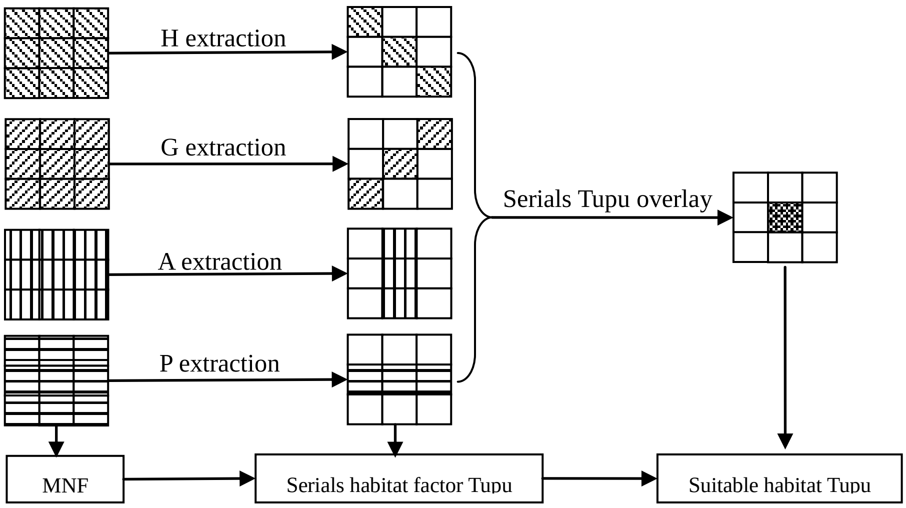

Figure 2. Habitat Tupu extraction and overlay framework

1) Completed standardized digital MNF of Chuxiong based on database. Extracting altitude, gratitude and slope aspect accurately form DEM is the key step; 2) According to suitable

environment of each YI medicine, extracted serials habitat factor Tupu (suitable altitude Tupu, suitable gratitude Tupu and suitable slope aspect Tupu) from digital MNF; 3) Overlaid the four habitat factor Tupu, then suitable geoherbs habitat Tupu was obtained, some examples are shown in Figure 3.

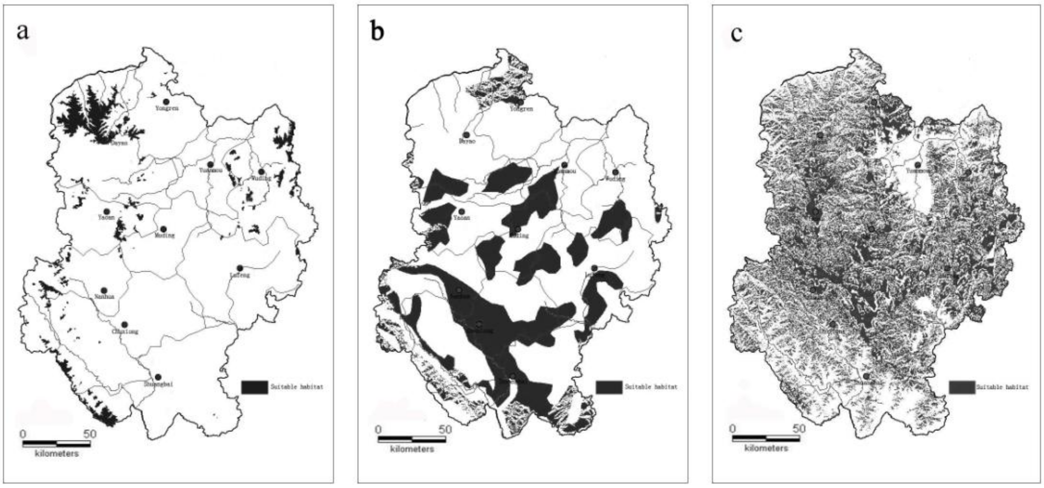

Figure 3. Examples of suitable geoherbs habitat Tupu

Shade shows the suitable habitat. (a) *Aucklandia lappa Decne*; (b) *Smilax glabra Roxb*; (c) *Eucommia ulmoides Oliv*.

3.4 Integration of suitable habitat Tupu with Land-use map

The suitable herbs habitat Tupu illustrates the theoretic largest suitable habitat, which can’t be applied directly to guide the geoherbs planting, due to the interference of human activities. Therefore we need further integrate suitable habitat Tupu with the Land-use map to guide planting. There are forest, basic farmland, common plantation, garden plot, ley and building land; six land types in Chuxiong. Basic farmland and building land can’t be used for geoherbs planting; garden plot and ley are not very suitable for geoherbs planting, but the forest and common plowland in the suitable habitat Tupu are suitable for geoherbs growth. We can also calculate the acreage of suitable habitat and suitable producing areas. Figure 4 shows the suitable habitat Tupu of *Erigeron braviscapus (Vant.) H.-M.* and land types in one part of it.

Left map is the suitable habitat Tupu of *Erigeron braviscapus (Vant.) H.-M.*, one part was taken for example (as circled) to show the integration of suitable habitat Tupu with Land-use map in the right map; a: basic farmland, b: common plantation, c: garden plot, d: ley, e: building land, f: forest.

3.5 Natural unit and administration unit overlay

The county government generally manages Geoherbs planting. On the base of suitable producing areas, we can manage the geoherbs planting by integrating natural unit with administration unit. We took 12 important geoherbs in Chuxiong as cases and calculated suitable producing area of

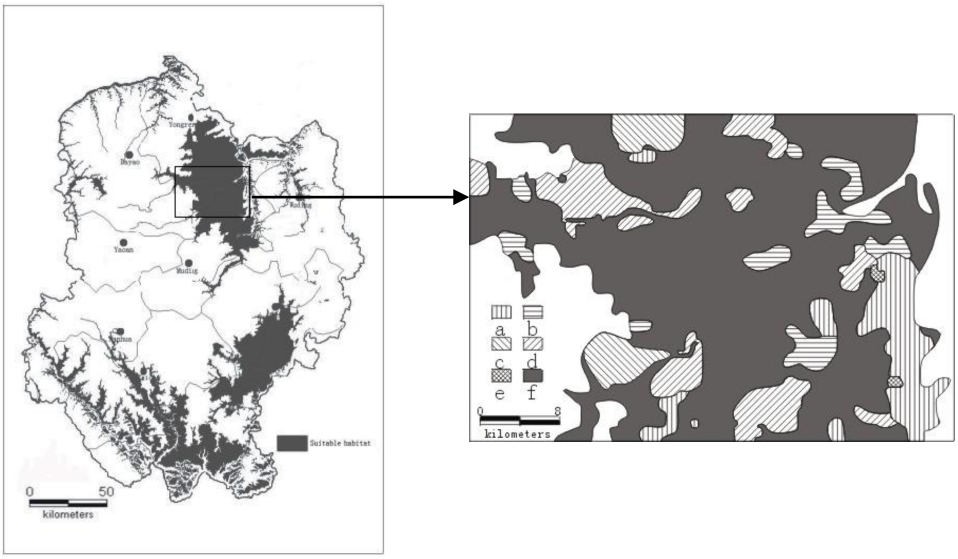

Figure 4. Suitable habitat Tupu of *Erigeron braviscapus (Vant.) H.-M*. and land types in one part of it

each geoherb in ten regions of Chuxiong, then classified them as three grades: The most suitable county (with the largest suitable producing area); suitable county (with large suitable producing area) and not suitable county (with small suitable producing area), so the planting blueprint was completed as Figure 5 shows, based on which we can decide where to plant them reasonably and preserve them efficiently.

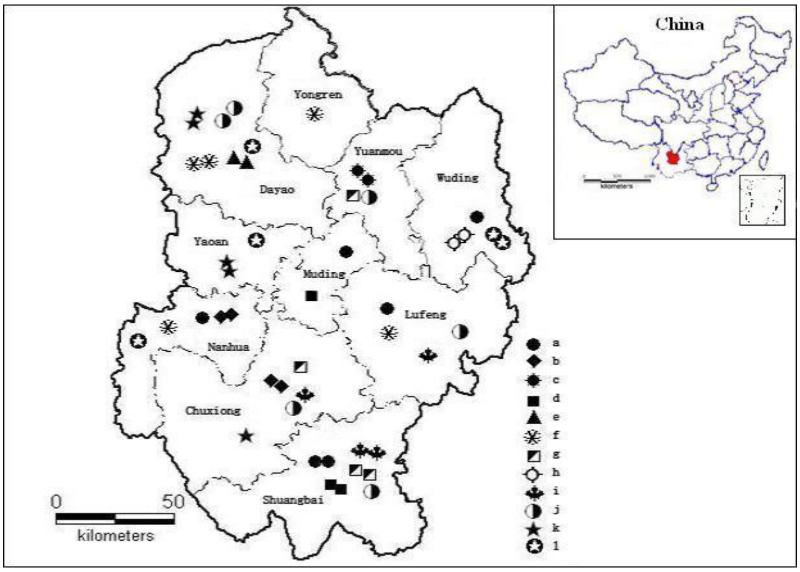

Figure 5. Suitable producing areas of 12 main geoherbs in Chuxiong

Shade in the map of China shows the location of Chuxiong in China. Single symbols present suitable county, double symbols present the most suitable county. a: *Lablab purpureus (L.) Sweet-Dolichos lablab L*; b: *Smilax glabra Roxb*; c: *Erigeron braviscapus (Vant.) H.-M*; d: *Platycodon gradiflorum (Jacq.) A.DC*; e: *Aucklandia lappa Decne*; f: *Cynanchum otophyllum Schneid*; g: *Laggera pterodonta (DC). Banth*; h: *Paris delavayi Franch*; i: *Agrimonia zeylanica Moon*; j: *Bupleurum marginatum Wall. Ex DC*; k: *Poligonatum kingianum Coll. et Hemsl*; l: *Eucommia ulmoides Oliv*

4. Conclusions and discussion

As the “Digital Earth” times coming, digital study and management of geoherbs resources become quite necessary. We evaluate and plan suitable geoherbs habitat by GIS and Geo-informatic Tupu method, finally establish the appraising system and model of suitable geoherbs habitat. Geoherbs resources analysis in Chuxiong is taken as a case to show the importance of GIS and Geo-informatic Tupu method in the study of TCM resources sustainable utilization and development.

Results show that: 1) GIS and Geo-informatic Tupu method is effective and efficient in the study of digital geoherbs, by which we can avoid the interaction among different environmental factors and illustrate suitable geoherbs producing areas apparently and directly; 2) Based on the results of suitability evaluation and plan of geoherbs habitat, programming of geoherbs planting is achieved. Suitability evaluation of geoherbs habitat in Chuxiong as a typical case direct us further researches on sustainable utilization of geoherbs; 3) Further assisted with Global Positioning System (GPS) and remote sensing, we can enhance the precision of original data and complete the suitability evaluation of geoherbs habitat more accurately.

As a traditional knowledge, study of TCM resources needs not only traditional methods but also modern theories and techniques. Otherwise TCM resources can’t cater to the need of society development. “Digital Earth” techniques such as GIS are promising in research of TCM resource survey, dynamic supervision, production evaluation, plant diseases and insect pests inspection. So combination of traditional techniques with modern ones is our inevitable choice. Traditional Geo-informatic Tupu method can directly illustrate complicated data clearly in the map by its analysis and processing functions (Liao et al., 2001), while traditional mathematic method is ineffective when dealing with massive complicated messages (Zhang et al., 2003). And modern methods also have drawbacks. For example, we can’t identify minor things from intricate backgrounds by GIS, so it couldn’t provide accurate information of geoherbs resources storage and single plant growth condition. But most wild geoherbs are not the dominant species in community, so sample survey is inevitable (Zhou et al., 2005). In addition, with the assistance of GPS and remote sensing techniques we can get more accurate data of geoherbs and their living environment. So the precision of suitability evaluation and plan of geoherbs habitat can be enhanced. In a word, combining traditional methods and modern “Digital Earth” methods together we can elaborate superiority of each other.

5. Summary

In order to pursue sustainable development mode of “Dual-health of earth and human beings”, we focused our research on sustainable development of TCM and sustainable utility of Chinese herbs, especially the evaluation and layout of geoherbs producing areas by GIS and Geo-informatic Tupu method.

We took the research of traditional YI medicine resources in Chuxiong of Yunnan Province, China as a case to explore the application of GIS on suitability evaluation of geoherbs habitat. Combining GIS and Geo-informatic Tupu method, we can accomplish habitat spatial information restoring accurately for every geoherb and draw suitable geoherbs habitat Tupu and digital distribution map. Integrating digital distribution map with Land-use Map, we can program geoherbs planting and further spread the “Digital Earth” techniques to the researches of comprehensive evaluation of suitable geoherbs habitat throughout China and complete the “Digital Geoherbs Box” of China finally.

The “Digital Earth” idea and technology will impact the sustainable development of TCM and the world natural medicine. Finally, provide us an effective way to achieve “Dual-health development of both earth and human beings”.

6. Acknowledgement

Preparation of this manuscript is supported by grants from National Basic Research Program of China (2006CB400505) and Beijing Municipal Commission of Education Co-construction Program (SYS100270430).

7. References

Shi Peijun, et al. (2004). “The earth health-human being health model” of biological resources development and ecological construction. *Resources Science* 26, 2-8.

Jiang Xiaoning. (2001). “Integration of nature and human” is the key of sustainable development of Traditional Chinese Medicine. *Zhejiang Journal of Chinese Traditional Medicine* 36, 277-279.

Chen Dan, et al. (2003). Importance and strategy of Traditional Chinese Medicine resources protection. *Lishizhen Medicine and Materia Medica Research* 14, 705-706.

Yang Chengyun, et al. (2002). Resource survey of *Lonicea edulis Turcz* in Heilongjiang Province. *China Wild Plants Resources* 21, 18-19.

Chen Shilin, et al. (1997). Unmerical studies on spatial distribution pattern of *fritillaria unibracteata* community. *Journal of Southwest China Normal University (Natural Science)* 22, 416-420.

Guo Lanping, et al. (2005). Application of “3S” techniques in the continuous usage of Traditional Chinese Medicine resources. *China Journal of Chinese meteria medica* 30, 1397-1400.

Chen Shilin, et al. (2005). Preserving survey of panax ginseng resources based on remote sensing technology. *World science technology/Modernization of traditional Chinese medicine and materia medica* 7, 37-43.

Wang Yu, et al. (2006). Suitability evaluation of *Fritillaria thunbergii*’s producing area based on GIS. *China Modern Medicine* 8, 4-6.

Guo Lanping, et al. (2005). Habitat characteristics for the growth of *Atractylodes lancea* based on GIS. *China Journal of Chinese materia medica* 30, 565-569.

Qin Guozheng. (2005). Some ideas on preserving YI medicine culture and researching YI medicine in Yunnan Province. *Journal of Yunnan College of traditional Chinese medicine* 28, 1-4.

Dai Jia-lin. (2004). Destruction and prospect of YI medicine industry in Chuxiong, *Yunnan technology administration* 1, 41-44.

Zhang Rong-qun, et al. (2000).Study on digital elevation model setting up and its application. *Computer and Agriculture* 15, 62-64.

Qiu Bin, et al. (2005). Survey on important Traditional Chinese Medicine in Yunnan Province. *Journal of Yunnna traditional Chinese medicine and materia medica* 26, 51-52.

Liao Ke, et al. (2001). On geo-informatic Tupu and digital earth. *Geographical Research* 20, 55-61.

Zhang Hong-yan, et al. (2003). On geographic framework of Geo-informatic Tupu method. *Geo-information Science* 1, 101-103.

Zhou Yin-qun, et al. (2005). Study on methods of traditional Chinese medicine resources survey. *World science and technology-Mordenization of tradition almedicine and mat eria medica* 7, 130-136.