

Table II-2-4 Result of principal component analysis of the stream sediment samples

No.	Eig value	Eig pct	Eig sum	Factor loading										
				Fact Id	Z-1	Z-2	Z-3	Z-4	Z-5	Z-6	Z-7	Z-8	Z-9	Z-10
Z-1	6.148127	24.59251	24.59251	Fe	0.90318	0.124125	0.039625	0.128872	-0.19531	0.014021	0.014873	-0.08658	0.070883	-0.00899
Z-2	3.837217	15.34887	39.94138	Co	0.791085	0.47	0.013643	-0.18192	0.112304	-0.13051	-0.03123	-0.06197	-0.04554	0.047796
Z-3	3.070642	12.28257	52.22394	V	0.777198	0.41956	0.061548	0.116147	-0.17762	0.026622	-0.02898	0.083731	0.120646	-0.09533
Z-4	1.830476	7.321906	59.54585	Zn	0.736172	0.025358	0.378541	0.110491	-0.05843	-0.09915	-0.01987	-0.12425	-0.22465	0.181913
Z-5	1.525304	6.101215	65.64707	Mn	0.727507	-0.18109	-0.11676	0.168224	-0.17164	0.064964	-0.06342	-0.25188	-0.13015	0.226551
Z-6	1.106391	4.425564	70.07263	Cd	0.707122	0.261616	-0.13251	0.194638	-0.142	-0.29284	0.118038	0.148307	0.050329	-0.19722
Z-7	0.993797	3.975188	74.04782	Ba	-0.49454	0.443711	0.412843	0.124903	-0.0469	0.032543	0.057635	-0.41242	0.113862	-0.0484
Z-8	0.889136	3.556543	77.60436	P	-0.57364	0.537197	0.197125	0.160466	-0.0908	-0.12481	-0.11132	0.123677	-0.02304	-0.06684
Z-9	0.852442	3.40977	81.01413	K	-0.59995	0.418034	0.294536	0.091514	-0.05991	0.111278	0.11079	-0.24508	0.215418	-0.1522
Z-10	0.679445	2.717779	83.73191	Na	-0.63674	0.173375	-0.46961	0.297448	-0.05791	0.148798	0.135442	-0.02388	-0.15153	0.138418
Z-11	0.606944	2.427776	86.15968	Al	-0.67414	0.373723	0.184914	-0.1801	0.075649	-0.20576	-0.15389	-0.00676	-0.09974	0.253138
Z-12	0.54101	2.16404	88.32373	Mg	0.152655	0.835126	-0.2288	0.031395	0.162262	-0.16341	0.02426	0.038306	-0.16254	0.166143
Z-13	0.432588	1.730351	90.05408	Sr	-0.4641	0.658365	-0.13529	0.057862	-0.10636	-0.06112	-0.00467	-0.09688	0.127717	0.054156
Z-14	0.384705	1.538819	91.59289	Ni	0.35041	0.607712	-0.15892	-0.36001	0.481196	0.113416	0.020213	0.065924	0.040035	-0.07554
Z-15	0.318285	1.273141	92.86604	As	-0.01703	0.072727	0.659948	0.152623	0.045073	-0.07755	0.2925	0.048325	-0.12411	-0.36927
Z-16	0.305527	1.22211	94.08815	Hg	-0.05738	-0.14876	0.657404	-0.31026	0.144069	0.038502	-0.30855	-0.09579	-0.00694	0.229839
Z-17	0.280916	1.123664	95.21181	Cu	0.303061	0.500684	0.644286	-0.22436	0.134718	-0.16795	-0.0304	-0.02014	-0.05378	-0.00139
Z-18	0.267107	1.068428	96.28024	Ca	-0.09858	0.602561	-0.61978	0.26498	0.020733	-0.07722	0.097221	0.081167	-0.09673	0.107895
Z-19	0.218811	0.875244	97.15548	Sb	0.125391	0.028074	0.143374	0.728148	0.389544	0.146754	-0.29505	-0.04104	0.174177	0.05831
Z-20	0.189108	0.756433	97.91191	Ti	0.300039	0.404969	0.056692	0.184806	-0.49924	0.403996	-0.32931	-0.03818	0.185245	-0.00886
Z-21	0.153079	0.612316	98.52423	Be	-0.08433	0.266348	-0.01134	-0.49675	-0.6382	0.219128	0.191852	-0.09539	-0.21538	0.032804
Z-22	0.136622	0.546486	99.07072	Cr	0.241146	0.277463	-0.28657	-0.42726	0.365482	0.582561	-0.04026	0.036581	0.090252	-0.11756
Z-23	0.099708	0.398834	99.46955	Pb	0.126977	0.039512	0.345968	0.367029	0.263923	0.430541	0.371198	-0.08316	-0.42717	0.064735
Z-24	0.075995	0.303979	99.77353	Au	0.084831	0.031688	0.458625	0.021941	-0.06804	0.115114	0.47979	0.394171	0.449016	0.409386
Z-25	0.056618	0.22647	100	S	-0.27728	0.190795	0.375401	0.123874	-0.20037	0.198558	-0.33064	0.560601	-0.30451	-0.06504

Eig vec	Eigen vector									
	Z-1	Z-2	Z-3	Z-4	Z-5	Z-6	Z-7	Z-8	Z-9	Z-10
Fe	0.364253	0.063365	0.022613	0.095253	-0.15814	0.01333	0.014919	-0.09182	0.076773	-0.01091
Co	0.319045	0.239933	0.007786	-0.13446	0.090932	-0.12408	-0.03133	-0.06572	-0.04933	0.057985
V	0.313444	0.214184	0.035124	0.085847	-0.14382	0.02531	-0.02907	0.088798	0.130671	-0.11565
Zn	0.296899	0.012945	0.216022	0.081667	-0.04731	-0.09426	-0.01993	-0.13177	-0.24332	0.220692
Mn	0.293404	-0.09244	-0.06663	0.124338	-0.13898	0.061761	-0.06362	-0.26712	-0.14096	0.274846
Cd	0.285182	0.133554	-0.07562	0.143862	-0.11497	-0.2784	0.118406	0.157281	0.054511	-0.23926
Ba	-0.19945	0.226512	0.235597	0.092319	-0.03798	0.030939	0.057815	-0.43738	0.123324	-0.05871
P	-0.23135	0.274237	0.112493	0.118604	-0.07352	-0.11866	-0.11167	0.131161	-0.02496	-0.08108
K	-0.24196	0.213404	0.168083	0.067641	-0.04851	0.105792	0.111135	-0.25991	0.233318	-0.18464
Na	-0.2568	0.088507	-0.26799	0.219851	-0.04689	0.141463	0.135864	-0.02532	-0.16412	0.167925
Al	-0.27188	0.190784	0.105525	-0.13311	0.061253	-0.19562	-0.15437	-0.00717	-0.10803	0.307101
Mg	0.061566	0.426328	-0.13057	0.023205	0.131383	-0.15535	0.024336	0.040624	-0.17605	0.20156
Sr	-0.18717	0.336092	-0.0772	0.042767	-0.08612	-0.05811	-0.00469	-0.10274	0.13833	0.0657
Ni	0.141321	0.310234	-0.09069	-0.2661	0.389622	0.107825	0.020276	0.069913	0.043362	-0.09165
As	-0.00687	0.037127	0.378613	0.112807	0.036495	-0.07372	0.293412	0.05125	-0.13442	-0.44799
Hg	-0.02314	-0.07594	0.375161	-0.22932	0.116652	0.036604	-0.30951	-0.10159	-0.00752	0.278834
Cu	0.122225	0.255597	0.367675	-0.16583	0.109081	-0.15967	-0.03049	-0.02136	-0.05825	-0.00168
Ca	-0.03976	0.307605	-0.35369	0.195853	0.016788	-0.07341	0.097524	0.086079	-0.10477	0.130895
Sb	0.05057	0.014331	0.081819	0.538192	0.315412	0.13952	-0.29597	-0.04352	0.188651	0.070741
Ti	0.121006	0.206735	0.032352	0.136594	-0.40424	0.384081	-0.33034	-0.04049	0.200639	-0.01075
Be	-0.03401	0.135969	-0.00647	-0.36716	-0.51674	0.208326	0.19245	-0.10116	-0.23328	0.039797
Cr	0.097254	0.141644	-0.16354	-0.3158	0.295929	0.553843	-0.04039	0.038795	0.097752	-0.14262
Pb	0.05121	0.020171	0.197433	0.27128	0.213697	0.409317	0.372355	-0.08819	-0.46267	0.078534
Au	0.034212	0.016177	0.261724	0.016217	-0.05509	0.10944	0.481285	0.418024	0.486328	0.496657
S	-0.11183	0.0974	0.21423	0.091558	-0.16224	0.18877	-0.33167	0.594525	-0.32982	-0.0789

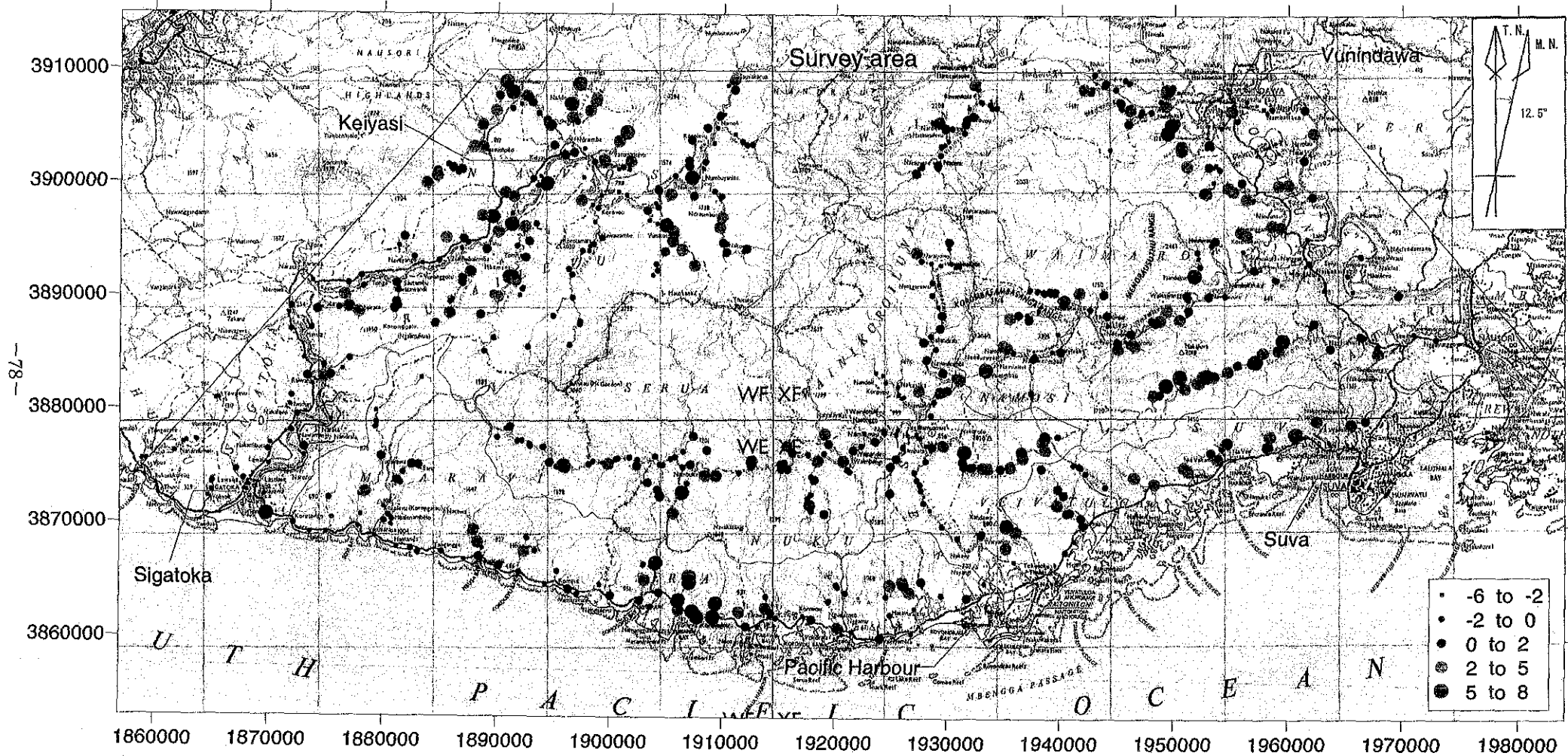


Fig.II-2-4-(1) PCA Score of geochemical analysis of the stream sediment samples (Z-1) (1:500,000)

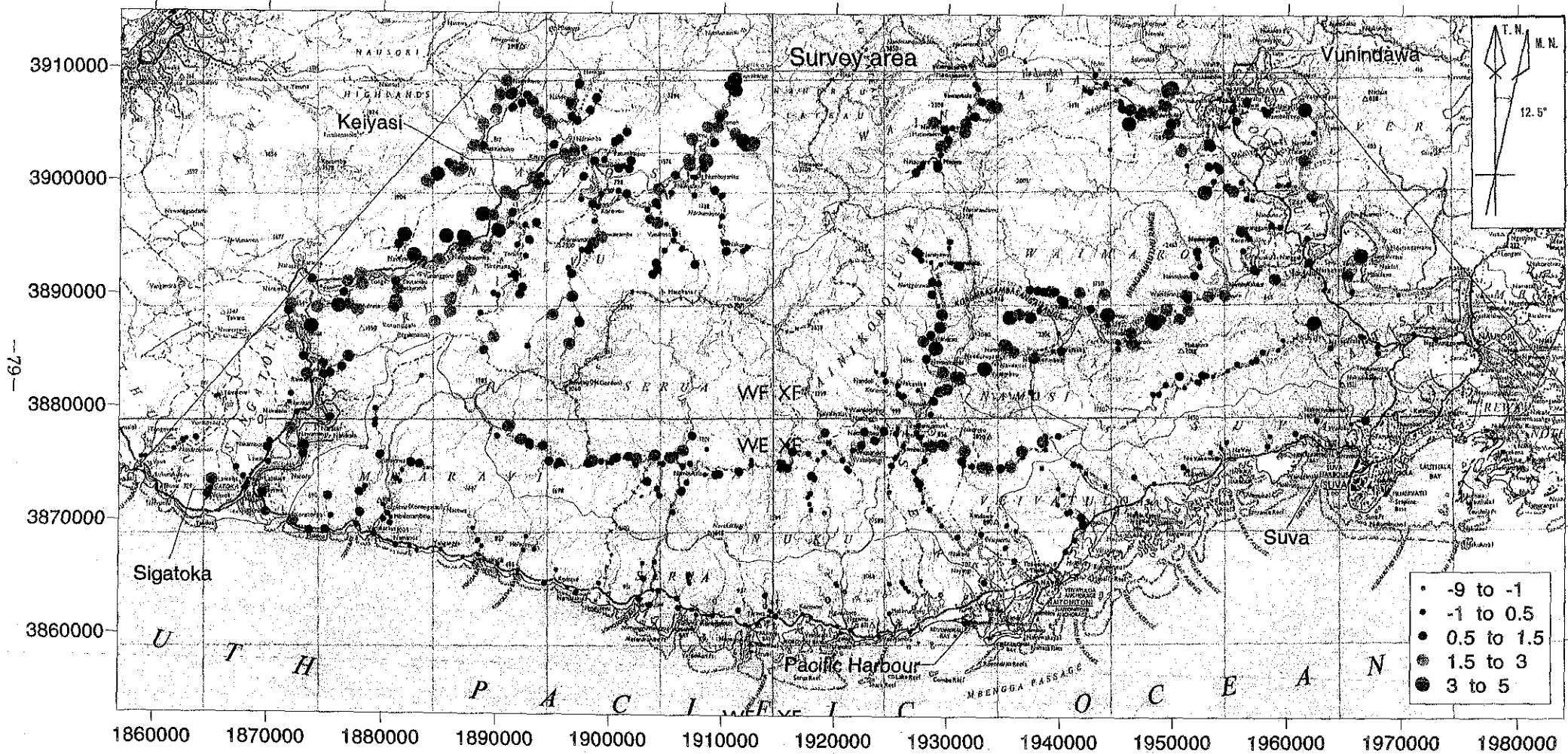


Fig.II-2-4-(2) PCA Score of geochemical analysis of the stream sediment samples (Z-2) (1:500,000)

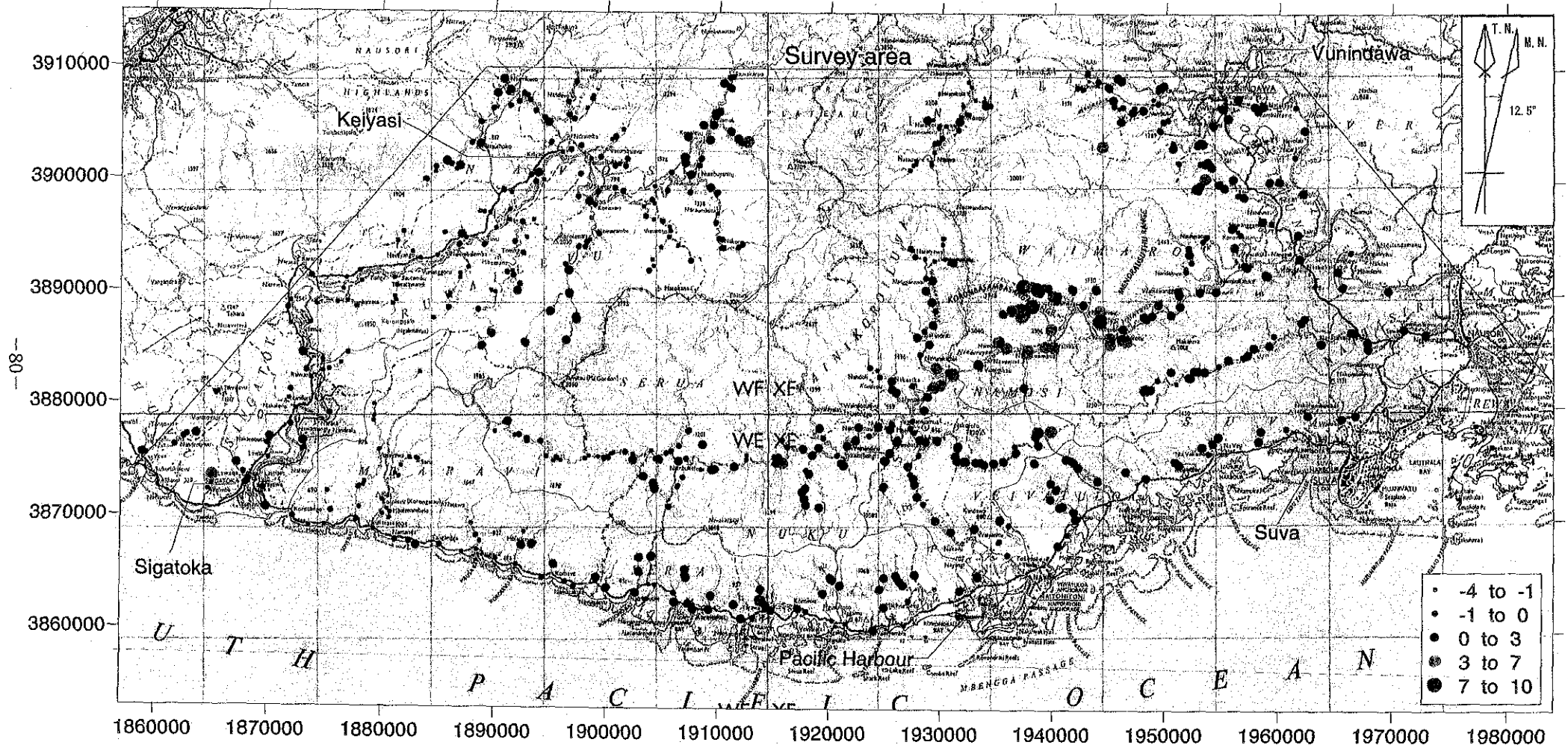


Fig.II-2-4-(3) PCA Score of geochemical analysis of the stream sediment samples (Z-3) (1:500,000)

[Z- 2] (Fig.II-2-4-(2))

The second principal component contributes approximately 15.3% of original variability. The factor loadings of Mg, Sr, Ni, Ca, P, Cu, Co, Ba, V, K and Ti are positive. There are no elements that have especially strong negative factor loadings. The areas of positive scores are the right bank of middle stream of Sigatoka River, upper stream of Sigatoka River and the margin of Sovi River basin. According to the geological map, basic - intermediate volcanic rocks are distributed in hinterlands of these rivers

[Z- 3] (Fig.II-2-4-(3))

The third principal component contributes approximately 12.3% of original variability. The factor loadings of As, Hg, Cu, Au and Ba are positive, and these elements have a relation with Cu-Au mineralization. The factor loading of Ca is negative. The areas of positive scores are Namosi Region where porphyry Cu-Au deposits exist.

2 - 3 - 4 Geochemical concentration feature of each river drainage system

TableII-2-5 shows the basic statistic values of chemical analysis of each drainage system. Geochemical feature of each drainage system is as follows.

(1) Geochemical feature of Rewa River drainage system

Rewa River drainage system is divided generally to Main Rewa River, Wainimala River, Sovi River, Waidina River and Waimanu River. According to Table II-2-5, logarithmic averages of Au, Hg, As, Ba, Be, Co, Cr, Cu, Fe, K, Pb, S, Ti, V and Zn are higher than those of other drainage systems. These elements are characteristic of hydrothermal deposits. This harmonizes with the fact that many known deposits of Cu-Au, Au-Zn and Cu-Zn exist in upper stream of Waidina River and upper stream of Waimanu River.

(2) Geochemical feature of Navua River drainage system

Navua River drainage system is divided generally to Main Navua River, Wainikoroiluva River, Wainikovu River, Veinuga River and Waionamoli River. According to Table II-2-5, logarithmic averages of Al, Mo and Sb are somewhat higher than those of other drainage systems. As for other elements, V, Cr, Fe, Zn, As, Cd and Au are high similarly to other drainage systems. Navua River drainage system is secondly influenced by hydrothermal deposits after Rewa River drainage system.

(3) Geochemical feature of Sigatoka River drainage basin

Sigatoka River drainage system is divided generally to Main Sigatoka River, Namada River, Busa Creek, Yalavou Creek, Nasikawa Creek and Nasa Creek. According to TableII-2-5, logarithmic averages of Mg, Ca and Cd are higher than those of other drainage systems. Logarithmic averages of Sr, Na, Ni and P are somewhat higher than those of other drainage systems. High averages of Ca and Mg may reflect limestones which exist around Sigatoka River drainage system. Averages of Cd are high in all drainage systems, but they are especially high in Sigatoka River drainage system, that may be because pH of the river water in Sigatoka River drainage system is somewhat higher than that of other drainage systems.

Table II-2-5 Basic statistics of stream sediment samples from each drainage system

Elements	Unit	Detection limit	Rewa R. System				Navua R. System				Sigatoka R. System				Coastal R. System			
			Under detection limit(%)	Max value	Minimum value	Log. Average (m)	Under detection limit(%)	Max value	Minimum value	Log. Average (m)	Under detection limit(%)	Max value	Minimum value	Log. Average (m)	Under detection limit(%)	Max value	Minimum value	Log. Average (m)
Au	ppm	0.001	53.942	7.28	0.0005	0.0496	63.682	0.575	0.0005	0.015	51.736	0.086	0.0005	0.0031	62.857	0.253	0.0005	0.0073
Hg	ppm	0.01	23.651	0.14	0.005	0.0155	26.866	0.05	0.005	0.0118	71.875	0.12	0.005	0.0073	25.143	0.15	0.005	0.0146
Ag	ppm	0.5	99.585	1.6	0.25	0.2556	99.502	9	0.25	0.2935	99.653	0.7	0.25	0.2516	96.571	0.7	0.25	0.2614
Al	%	0.01	0	9.58	2.65	6.0225	0	11.15	2.52	6.5146	0	9.08	0.79	6.28	0	9.36	2.6	5.9823
As	ppm	5	86.722	105	2.5	5.9647	91.045	21	2.5	3.2761	97.222	27	2.5	2.7361	98.286	28	2.5	2.7029
Ba	ppm	10	1.6598	570	5	123.61	0	270	20	85.224	0	560	20	102.95	0.5714	200	5	60.943
Be	ppm	0.5	6.2241	3.1	0.25	1.5932	41.791	3.2	0.25	0.8269	27.083	7.4	0.25	1.2198	21.714	2.2	0.25	0.7314
Bi	ppm	2	65.975	32	1	3.0083	85.075	17	1	1.791	78.472	16	1	1.7569	91.429	10	1	1.3029
Ca	%	0.01	0	3.88	0.09	1.567	0	5.39	0.22	1.8674	0	11.55	0.6	3.0363	0	9.83	0.19	1.6698
Cd	ppm	0.5	34.855	8.8	0.25	1.5556	19.9	10.4	0.25	1.7955	10.069	14.8	0.25	2.7977	41.714	6.9	0.25	1.2431
Co	ppm	1	0	125	7	41.207	0	95	5	31.413	0	132	9	38.559	0	91	4	29.04
Cr	ppm	1	0	5010	19	359.17	0	2381	23	290.57	0	1691	18	187.58	0	1017	15	164.91
Cu	ppm	1	0	640	5	80.676	0	156	2	46.652	0	128	9	36.635	0.5714	108	0.5	30.266
Fe	%	0.01	0	25	4.53	15.51	0	25	4.36	13.088	0	25	3.75	13.684	0	25	3.46	12.571
K	%	0.01	0	1.71	0.06	0.5604	0	0.97	0.06	0.4405	0	1.88	0.07	0.5345	0	1.04	0.05	0.3114
Mg	%	0.01	0	3.73	0.44	1.4876	0	3.12	0.29	1.3702	0	4.64	0.31	1.8485	0	2.85	0.12	1.1265
Mn	ppm	5	0	4530	404	2134.9	0	4770	631	1918	0	10000	731	1847	0	6740	642	2261
Mo	ppm	1	88.382	29	0.5	1.5788	64.179	23	0.5	2.5398	71.528	11	0.5	1.0104	76	9	0.5	1.0371
Na	%	0.01	0	2.91	0.14	0.9836	0	3.08	0.16	1.1318	0	2.96	0.18	1.3058	0	3.59	0.15	1.2518
Ni	ppm	1	0	141	1	26.332	0	102	4	25.403	0	98	5	28.33	0	85	2	19.686
P	ppm	10	10.788	1100	5	289.38	6.9652	990	5	248.61	0	1240	10	306.98	13.143	470	5	112.09
Pb	ppm	2	7.8838	38	1	7.9461	42.289	39	1	5.8259	25	35	1	5.9549	19.429	25	1	6.5086
S	%	0.01	41.494	2.66	0.005	0.0681	21.891	0.59	0.005	0.0373	36.806	1.91	0.005	0.038	50.857	2.76	0.005	0.0559
Sb	ppm	5	70.954	25	2.5	4.861	41.294	22	2.5	6.5448	50.694	24	2.5	6.1632	50.857	17	2.5	5.1057
Sr	ppm	1	0.4149	421	0.5	110.4	1.4925	629	0.5	123.13	1.7361	1072	0.5	180.23	11.429	1494	0.5	85.006
Ti	%	0.01	0	2.18	0.27	0.9232	0	1.71	0.4	0.8969	0	1.82	0.39	0.875	0	1.89	0.13	0.7485
V	ppm	1	0	2030	140	591.91	0	1920	109	516.35	0	1750	91	590.8	0	2199	23	461.34
W	ppm	10	6.2241	20	5	12.303	18.905	30	5	10.398	22.569	30	5	10.747	20.571	30	5	11.029
Zn	ppm	2	0	1440	55	231.76	0	555	43	185.03	0	463	52	180.4	0	756	56	203.6

Valid sample number : 905 241

201

288

175

Value under detection limit is represented by 0.5*det_lim

(4) Geochemical feature of Coastal Rivers

Coastal Rivers are distributed in a range of approximately 10 km width from the south coastline of Viti Levu Island. These rivers are relatively small and not connected each other as a same drainage system. According to Table II-2-5, logarithm average of Mn is somewhat higher than those of other drainage systems. There is no element which shows especially high average in comparison with other drainage systems. On the contrary, averages of Mg, P, K, Ni, Sr and Ba shows especially lower values than those of other water systems.

2 - 4 Discussions

Fig.II-2-5 shows standardized logarithmic averages (logarithmic averages divided by crustal averages) of stream sediment analysis value in each river drainage system. Vertical axis is logarithm axis. In horizontal axis, elements are alined in order of atomic number. Geochemistry of stream sediments reflects basically the geology of upper stream side of the sampling point. In addition, anomaly distributions are different between high mobility element and low mobility element even if these origins are same. Even one river flows through several geology in this survey area. Therefore, it is somewhat difficult to discuss geochemical distribution categorizing each river drainage system.

The characteristic of the element concentration of each drainage system is summarized as follows. Rewa River drainage system is the most strongly influenced by hydrothermal deposits and Cu, Zn, As, Cd, Sb and Au show anomalies. Navua River drainage system is also influenced by hydrothermal deposits after Rewa River drainage system and Zn, Cd, Sb and Au show anomallies. Sigatoka River drainage system is influenced by sedimentary rocks such as limestone and Ca and Mg show higher values than those of other drainage systems, though they are the crustal average levels. In Sigatoka River drainage system, Cd and Sb also show high values similarly to other drainage systems. As for Coastal rivers system, Mg, P, K, Ni, Sr and Ba show lower values than those of other drainage systems.

As a tendency common to all drainage systems, S, Ti, V, Cr, Mn, Fe, Zn, As, Cd, Sb and Au show high values as compared with the abundance of elements in average crustal rocks. From the fact that some samples include much magnetite, there is a possibility that high values of Co, V, Zn, Mn and Cd, which are easy to coexist with Fe, have relations to high contents of magnetites in the samples. In all drainage systems, Cd, Sb and Au show especially high value in comparison with the abundance of elements in average crustal rocks. The anomalies of Cd and Sb are scattered in all the survey area, therefore it is suggested that the background value itself is high and also the content of these elements in igneous rocks nearby is high. On the other hand, Au shows more limited distribution of anomalies, such as Namosi region - upper stream of Waimanu River in Rewa River drainage system and Wainikovu River in Navua River drainage system, where exist influence of hydrothermal deposits. As (arsenic) anomly distribution is similar to that of Au. In all drainage systems, Be, Na, Al, P, K, Ni, Sr, Ba, Hg and Pb show lower values than the crustal average, and especially P, K, Ni, Sr and Ba are low.

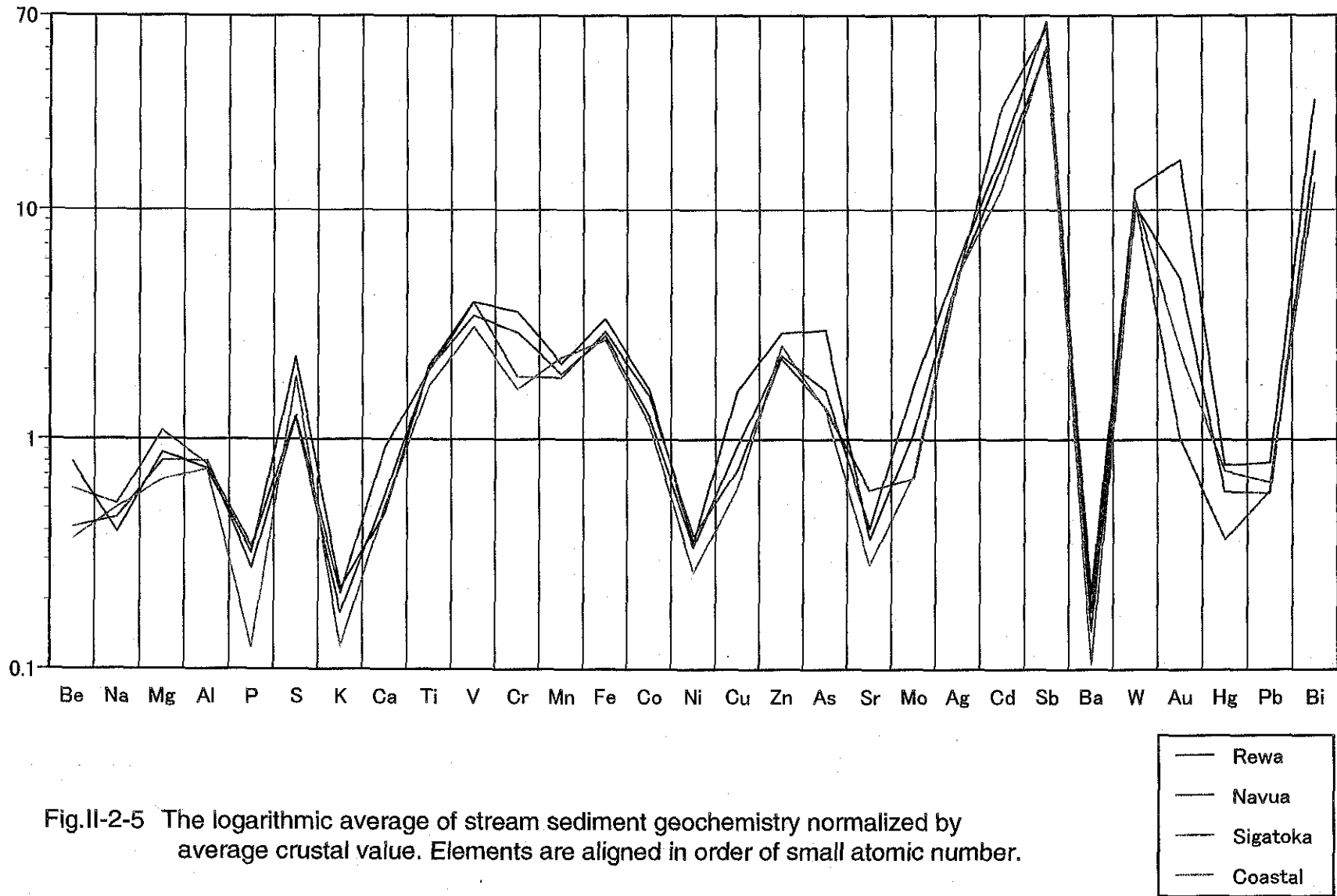


Fig.II-2-5 The logarithmic average of stream sediment geochemistry normalized by average crustal value. Elements are aligned in order of small atomic number.

Chapter 3 Fauna and flora survey

3 - 1 Objectives

In order to understand the habitat condition of fauna and the present condition of flora in the survey area, following items are executed; collection and rearrangement of existing literatures and field survey of fauna and flora.

3 - 2 Suvey methods

3 - 2 - 1 Fauna surveys

Existing literature were collected and rearranged concerning animals, especially terrestrial Vertebrate (Birds, Mammals, Reptiles and Amphibians) in the survey area paying attention to rare and endangerd species. Field survey of Fauna was executed around Waivaka mineral occurence in Namosi Region. The field survey area belongs to ecosystem of tropical rain forest (Lowland rain forest). Lowland rain forest is the most widely distributed in whole survey area.

The field survey was executed for 5 days from December 9 to 13. In regard to Birds and Bats, visual inspection was done on road and path. Small mammals such as mouse and mongoose were caught using trap. Reptiles and Amphibians were caught during daytime search.

A Scholar of Environmental consultants (FIJI) Ltd. was entrusted with the field survey. Classification regarding rare species is based on Red List Categories which were adopted in December 1994 in IUCN.

3 - 2 - 2 Fish & benthos sampling

As for sampling and chemical analysis of fish & benthos, freshwater eels and corbiculas which people in inland sometime eat were sampled and chemically analyzed. The samples were pulverized after drying and analyzed (28 elements) at Australian ALS Environmental Co. Ltd. The number of samples is 26 (eel: 5, corbicula: 21).

3 - 2 - 3 Flora survey

Existing literatures were collected and rearranged concerning plants in the survey area paying attention to rare and endangerd species. Field survey of Flora was executed in the same area as Fauna survey. The field survey was executed for 5 days from December 9 to 13. Visual inspection and sampling were done on road and path. The survey area was selected as to represent for whole survey area. In assessing plant distribution patterns, a 6m x 60m Belt Transect was used. The name, relative position, bole height, crown height and width of shrubs and trees with height > 3m and diameter at breast height (dbh) > 10cm within the transect were recorded.

A Scholar of the University of the South Pacific was entrusted with the field survey. Classification regarding rare species is based on Red List Categories which were adopted in December 1994 in IUCN.

3 - 2 - 4 Vegetation distribution survey

Classification of vegetation distribution was done based on vegetation distribution map made from the pseudo color image that acquired from the optical sensor of ASTER. The vegetation distribution of the survey area is classified largely to 5 vegetation territories from the image interpretation through a viewpoint of color and distribution. Ground truth survey was executed at 10 points representative for these 5 territories. In the ground truth survey, vegetation landscape pictures were taken and vegetation densities, soils and condition of the site were recorded.

3 - 3 Results

3 - 3 - 1 Fauna survey

Fauna survey took up Vertebrates in Fiji Inland, especially Birds, Mammals, Reptiles and Amphibians. Origin of animals in Fiji Islands is presumed to derive from overseas and settle because Fiji Islands is volcanic island. Many animals were presumed to come from west side through Papua New Guinea, Australia, New Caledonia, Vanuatu and Solomon Island etc. Because the animal migration were against the southeast trade wind, birds whose flight ability were high had a advantage and have succeeded in propagation in comparison with other animals. Representative birds in Fiji are Rails, Pigeons, Parrots, Flycatchers and Honey eaters.

As for Fiji fauna in Fiji, approximately 150 species of Birds are recorded so far. Among those, native species counts 57. Furthermore Among those, endemic species counts 26 (46%). Mammals consist entirely of bats. Native species counts 6 and endemic species counts 1 Among those. Wild pigs, cats, mice and mongooses consist of all introduced species. As for Reptiles, native species counts 27, Among those, endemic species counts 8 (30%). Iguana counts 2 species, Skink counts 12 species, Gecko counts 10 species and Snake counts 3 species. Amphibians consist of only frog. Native species counts 2 and these are both endemic species.

In general, introduced species were brought around villages and western reclaimed hills accompanied with human activities. On the other hand, native species tend to be preserved in the tropical rain forest that is widely distributed in the survey area.

(1) Fauna

A list of fauna which deals with Vertebrates of the South East Viti Levu area (manily tropical rain forest) is shown in Table II-3-1. Bird counts 51 species, Mammal counts 11 species, Reptile counts 19 species and Amphibians counts 3 species. Total 84 species are distributed in the area. Among those, Masked Shining Parrot and Pink-billed Parrotfinch are endemic species.

Definition of rare species and endangered species is based on Red List Categories which were adopted in December 1994 in IUCN. The Categories defined Endemicity and Introduced and naturalised species and national conservation status.

Table II-3-1 Preliminary List of Terrestrial Vertebrates of South East Viti Levu

(shaded species – endemic to Viti Levu)

English name	Scientific name	Introduced, Endemic, Threat Status
BIRDS (鳥類)		
Reef Heron	<i>Egretta sacra</i>	
White-faced Heron	<i>Ardea novaehollandiae</i>	Recent Spontaneous Arrival
Pacific Black Duck	<i>Anas superciliosa</i>	
Wandering Whistling Duck	<i>Dendrocygna arcuata</i>	Extinct
Fiji Goshawk	<i>Accipiter rufitorques</i>	Endemic
Pacific Harrier	<i>Circus approximans</i>	
Peregrine Falcon	<i>Falco peregrinus</i>	At Risk in Fiji
Barred-wing Rail	<i>Nesoclopeus poecilopterus</i>	Endemic, Extinct ?
Sooty Crake	<i>Porzana rabuensis</i>	Data Deficient
White-browed Crake	<i>Poliolimnas cinereus</i>	Conservation Concern in Fiji
White-throated Pigeon	<i>Columba vitiensis</i>	
Spotted Turtle-dove	<i>Streptopelia chinensis</i>	Introduced
Friendly Ground-dove	<i>Gallicolumba stairii</i>	Vulnerable
Barking Pigeon	<i>Ducula latrans</i>	Endemic
Many-coloured Fruit-dove	<i>Ptilinopus perousii</i>	
Golden Dove	<i>Ptilinopus luteovirens</i>	Endemic
Collared Lory	<i>Phigys solitarius</i>	Endemic
Red-throated Lorikeet	<i>Charmosyna amabilis</i>	Endemic, Endangered
Masked Shining Parrot	<i>Prosopeta personata</i>	Endemic, Vulnerable
Red/Kadavu Parrot	<i>P. tabuensis/splendens</i>	Introduced
Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>	
Long-tailed Cuckoo	<i>Eudynamis taitensis</i>	Migrant
Barn Owl	<i>Tyto alba</i>	
Eastern Grass Owl	<i>Tyto longimembris</i>	Extinct
White-rumped Swiftlet	<i>Collocalia spodiopygius</i>	
White-collared Kingfisher	<i>Todiramphus chloris</i>	
Polynesian Triller	<i>Lalage maculosa</i>	
Red-vented Bulbul	<i>Pycnonotus cafer</i>	Introduced
Island Thrush	<i>Turdus poliocephalus</i>	
Long-legged Warbler	<i>Trichocichla rufa</i>	Endemic, Data Deficient
Fiji Bushwarbler	<i>Cettia ruficapilla</i>	Endemic
Streaked Fantail	<i>Rhipidura spilodera</i>	
Slaty Monarch	<i>Mayrornis lessoni</i>	Endemic
Lesser Shrikebill	<i>Clytorhynchus vitiensis</i>	
Black-faced Shrikebill	<i>Clytorhynchus nigrogularis</i>	Vulnerable
Vanikoro Broadbill	<i>Myiagra vanikorensis</i>	
Blue-crested Broadbill	<i>Myiagra azureocapilla</i>	Endemic
Scarlet Robin	<i>Petroica multicolor</i>	

English name	Scientific name	Introduced, Endemic, Threat Status
Golden Whistler	<i>Pachycephala pectoralis</i>	
Fiji White-eye	<i>Zosterops explorer</i>	Endemic
Silvereye	<i>Zosterops lateralis</i>	
Orange-breasted Myzomela	<i>Myzomela jugularis</i>	Endemic
Wattled Honeyeater	<i>Foulehaio carunculata</i>	
Giant Forest Honeyeater	<i>Gymnomyza viridis</i>	Endemic, Vulnerable
Fiji Parrotfinch	<i>Erythrura pealii</i>	Endemic
Pink-billed Parrotfinch	<i>Erythrura kleinschmidti</i>	Endemic, Endangered
Red Avadavat	<i>Amandava amandava</i>	Introduced
Polynesian Starling	<i>Aplonis tabuensis</i>	
Fiji Woodswallow	<i>Artamus mentalis</i>	Endemic
Pacific Golden Plover	<i>Pluvialis fulva</i>	migrant
Wandering Tattler	<i>Heteroscelus incanus</i>	Migrant
MAMMALS (哺乳類)		
Pacific flying fox	<i>Pteropus tonganus</i>	
Samoan flying fox	<i>Pteropus samoensis</i>	Vulnerable
Long-tailed fruit bat	<i>Notopterus macdonaldi</i>	
Sheath-tailed bat	<i>Emballonura semicaudata</i>	
Feral cat	<i>Felis domesticus</i>	Introduced
Feral pig	<i>Sus scrofa</i>	Introduced
Polynesian rat	<i>Rattus exulans</i>	Introduced
Black or Ship rat	<i>Rattus rattus</i>	Introduced
Brown or Common rat	<i>Rattus norvegicus</i>	Introduced
House mouse	<i>Mus musculus</i>	Introduced
Indian Mongoose	<i>Herpestes auropunctatus</i>	Introduced
REPTILES (爬虫類)		
Banded iguana	<i>Brachylophus fasciatus</i>	
Pacific boa	<i>Candoia bibronii</i>	
Giant forest gecko	<i>Gehyra vorax</i>	
Oceanic gecko	<i>Gehyra oceanica</i>	Introduced
Stump-toed gecko	<i>Gehyra mutilata</i>	Introduced
Mourning or Pacific gecko	<i>Lepidodactylus lugubris</i>	Introduced
Mann's Gecko	<i>Lepidodactylus manni</i>	Endemic
Tree gecko	<i>Hemiphyllodactylus typus</i>	Introduced
House gecko	<i>Hemidactylus frenatus</i>	Introduced
Fox gecko	<i>Hemidactylus garnotti</i>	
Slender toed gecko	<i>Nactus pelagicus</i>	
Moth skink	<i>Lipinia noctua</i>	
Black skink	<i>Emoia nigra</i>	Extinct
Barred skink	<i>Emoia trossula</i>	Extinct
Green tree skink	<i>Emoia concolor</i>	Endemic

English name	Scientific name	Introduced, Endemic, Threat Status
Blue-tailed Copper-striped skink	<i>Emoia impar</i>	
Brown-tailed Copper-striped skink	<i>Emoia cyanura</i>	
Bronze-headed skink	<i>Emoia parkeri</i>	Endemic
Pacific Snake-eyed skink	<i>Cryptoblepharus eximius</i>	
AMPHIBIANS (両生類)		
Fiji ground frog	<i>Platymantis vitianus</i>	Extinct
Fiji tree frog	<i>Platymantis vitiensis</i>	Endemic
Marine or Cane toad	<i>Bufo marinus</i>	Introduced

(2) Field survey

A neighborhood of Waivaka mineral occurrence in Namosi Region was selected as the field survey area. The area belongs to the ecosystem of tropical rain forest. In this survey, Red-throated Lorikeet, Friendly Ground-dove and Pink-billed parrotfinch were observed intensively. The survey area is shown in Fig.II-3-1. Appendix 7 shows Scientific name, English name, Fiji name, Classification importance and Comment of the species which were observed and presumed to inhabit in the field survey area. PH-2 are photographs of these species.

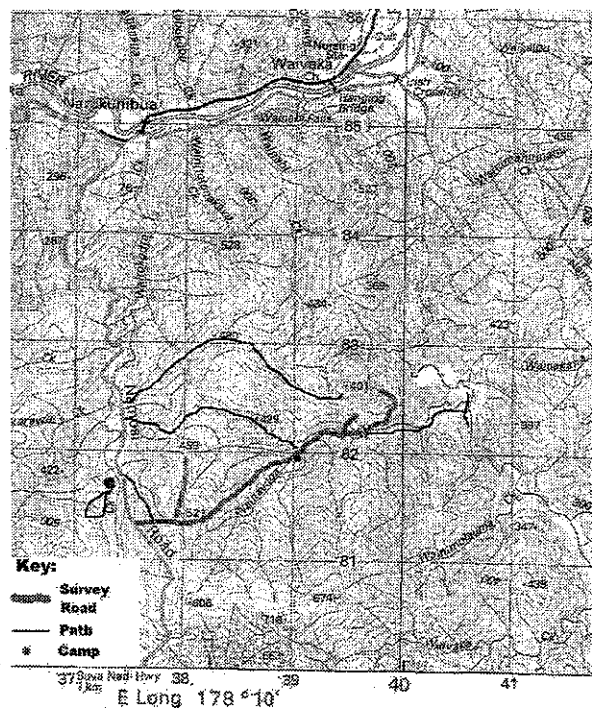


Fig.II-3-1 Location of survey trails in the waivaka catchment

Result of the field survey of each animal classification is as follows.

1) Birds

As for Birds, 34 species were recognized. Pink-billed Parrotfinch: *Erythrura kleinschmidtia* which is an endemic species of Viti Levu Island was recognized 11 times.

2) Reptiles

As for Reptiles, 3 species were recognized. *Emoia mokosariniveikau* was recognized, which is a kind of Skink recognized only in Vanua Levu Island. In addition, *Bolo Ogmodon vitiensis* was recognized, which is a small burrowing snake of endemic species in Viti Levu Island.

3) Amphibians

As for Amphibians, 2 species were recognized. *Bufo marinus* of introduced species and rarely observed *Platymantis vitiensis* (small Fiji tree frog) were recognized.

4) Mammals

As for Native Mammals, 2 species of Fruit bat or Flying fox were recognized including the rarer Samoan flying fox *Pteropus samoensis*.

As for Introduced Mammals, Black rat *Rattus rattus* was captured as mice. Moreover, Mongoose (*Herpestes auropunctatus*) was observed. Wild cat (*Felis domesticus*) could not be captured. As for Wild pig, *Feral pigs* were observed in the forest.

(3) Results of fauna survey

As for fauna in Fiji Islands, Birds is most abundant approximately 150 species and Reptiles, Mammals and Amphibians follow in order of abundance. Fauna of South East Viti Levu counts total 84 species including introduced species. As for breakdown of 84, Birds 51 species, Mammals 11 species, Reptiles 19 species, Amphibians 3 species.

As a result of the survey in tropical rain forest, 34 species of Birds were recognized. Most of Birds, which had been expected in the tropical rain forest, were recognized without disturbance. Therefore the area was concluded as rich in biodiversities and an important nature conservation area. It is noteworthy that Pink-billed parrotfinch was recognized, that is a worldwide rare species and endemic species of Viti Levu Island. *Friendly Ground Dove* and *Peregrine Falcon* couldn't be recognized. These birds are endangered species which are registered in (Threatened).

As for Reptiles, 3 species were recognized. It is noteworthy that *Emoia mokosariniveikau* was recognized, which is a kind of Skink recognized only in Vanua Levu Island.

As for Amphibians, 2 species were recognized. As for Native Mammals, 2 species of large bats were observed. As for Introduced Mammals, mice and mongooses were recognized.

Modeling this field survey, Environmental Impact Assessment as to animals (FS) will be necessary to the area that is expected to be developed in the future. As for Birds, an extensive survey will be necessary regarding Pink-billed parrotfinch, Long-legged Warbler, Red-throated Lorikeet, Friendly Ground Dove and Eastern Grass Owl.

This survey was not sufficient for Amphibians and Native Mammals. Further and continuous survey will be necessary in addition to this survey to the area that are expected to be developed

in the future. Furthermore, nighttime survey, cave survey, survey for animals and aquatic vertebrates in the cave are necessary for Amphibians.

3 - 3 - 2 Fish & Benthos sampling

As for sampling and chemical analysis of fish & benthos, eels (*Anguilla marmorata*) and freshwater shellfish (corbiculas: *Batissa violacea*) were sampled and chemically analyzed. The both animals have close relation with inland food chain and captured and eaten by people.

The samples were pulverized after drying and analyzed (28 elements) at Australian ALS Environmental Co. Ltd.

The number of samples is 26 (eel: 5, corbicula: 21). The analytical elements are Au, Al, Sb, As, Ba, Be, Bi, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, P, K, Ag, Na, Sr, Ti, W, V and Zn.

Sampling location is shown in Fig.II-3-2. Description of the sample is shown in Table II-3-2. All fishes were captured around Namosi Region. As for shellfish, 7 samples were from Rewa River, 9 samples were from Sigatoka River and 5 samples were from Navua River and small Coastal Rivers. Total are 21 samples.

Table II-3-2 Location of fish and shellfish samples

Sample No.	Items	Locality
F001	Fish	Namosi, Lower stream of Waidina
F003	Fish	Namosi, Upper stream of Waidina
F005	Fish	Namosi, Wainavuga
F002	Fish	Namosi, Waisoi
F004	Fish	Namosi, Waivaka
SF006	Shellfish	Coastal River
SF007	Shellfish	Coastal River(Nabukabesi)
SF008	Shellfish	Coastal River(Nabukabesi)
SF009	Shellfish	Navua River
SF010	Shellfish	Navua River
SF001	Shellfish	Rewa River
SF002	Shellfish	Rewa River
SF003	Shellfish	Rewa River
SF004	Shellfish	Rewa River
SF005	Shellfish	Rewa River
SF020	Shellfish	Rewa River
SF021	Shellfish	Rewa River
SF011	Shellfish	Sigatoka River
SF012	Shellfish	Sigatoka River
SF013	Shellfish	Sigatoka River
SF014	Shellfish	Sigatoka River
SF015	Shellfish	Sigatoka River
SF016	Shellfish	Sigatoka River
SF017	Shellfish	Sigatoka River
SF018	Shellfish	Sigatoka River
SF019	Shellfish	Sigatoka River

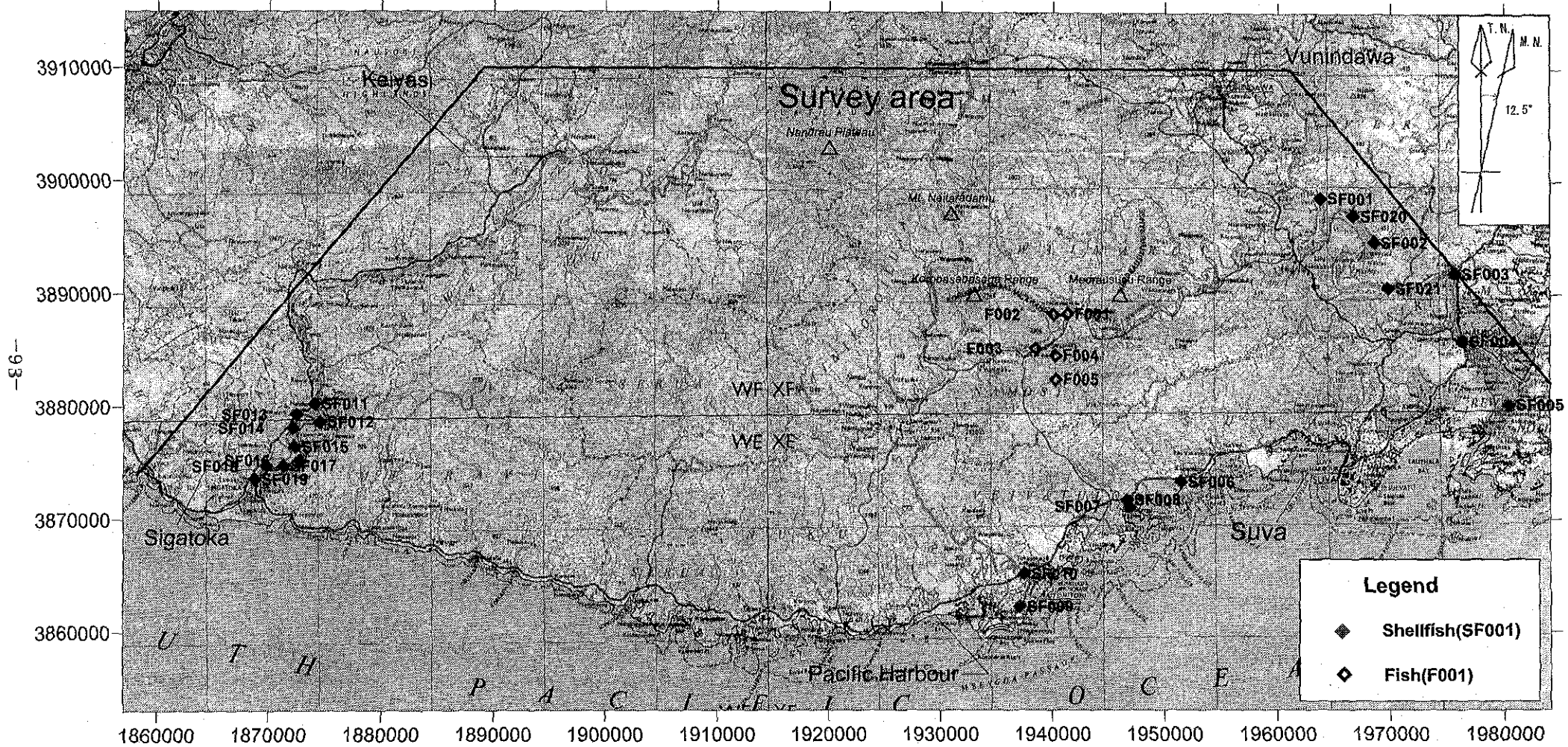


Fig1-3-2 Location map of the fish and shellfish samples(1:500,000)

(1) Result of analysis and discussion

Statistics of each analysis values are shown in Table II-3-3 and Fig.II-3-3. As for an analysis value lower than detection limit value, a half of that value is adopted in the statistical processing. Because sample population was not so big and variance of each sample was relatively large, threshold values were not calculated. Therefore, average, median, minimum and maximum value were calculated as to all samples, only fish samples, only shellfish samples and respective area of shellfish samples. Au, Be, Bi and Sb values of most samples were below detection limit values. Details of analysis values are shown in Appendix 8.

As a result of analysis of fishes and shellfishes, variances of element concentrations are relatively small between fish and shellfish or each sampling location. Ca, Mg, Na, K as major elements and B and Sr as trace elements concentrate relatively to fishes. On the contrary, Fe and Al as major elements and As, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Ti and V as trace elements concentrate relatively to shellfishes. As for shellfish, variances of element concentrations of Rewa River and Sigatoka River are relatively small, however variances of element concentrations of Coastal Rivers are somewhat high. This is because samples from Coastal Rivers were not picked up from same river. In comparison with the values of R.L.smith (1996) (concentration reference value per 1 kg of fish), As and Cd concentrations are relatively higher.

Reference value

heavy metal element	Concentration reference value per 1 kg of fish ¹	Concentration reference value per 1 kg of dry soil ²
As	0.41mg	50mg
Ba	95mg	
Cd	0.68mg	9mg
Cr	6.8mg	
Cu	54mg	
Hg	0.41mg	3mg
Mo	6.8mg	
Ni	27mg	
Pb		600mg

1. R.L. Smith/Toxicology 106(1996)

2. Environmental standard value of soil pollution in Japan

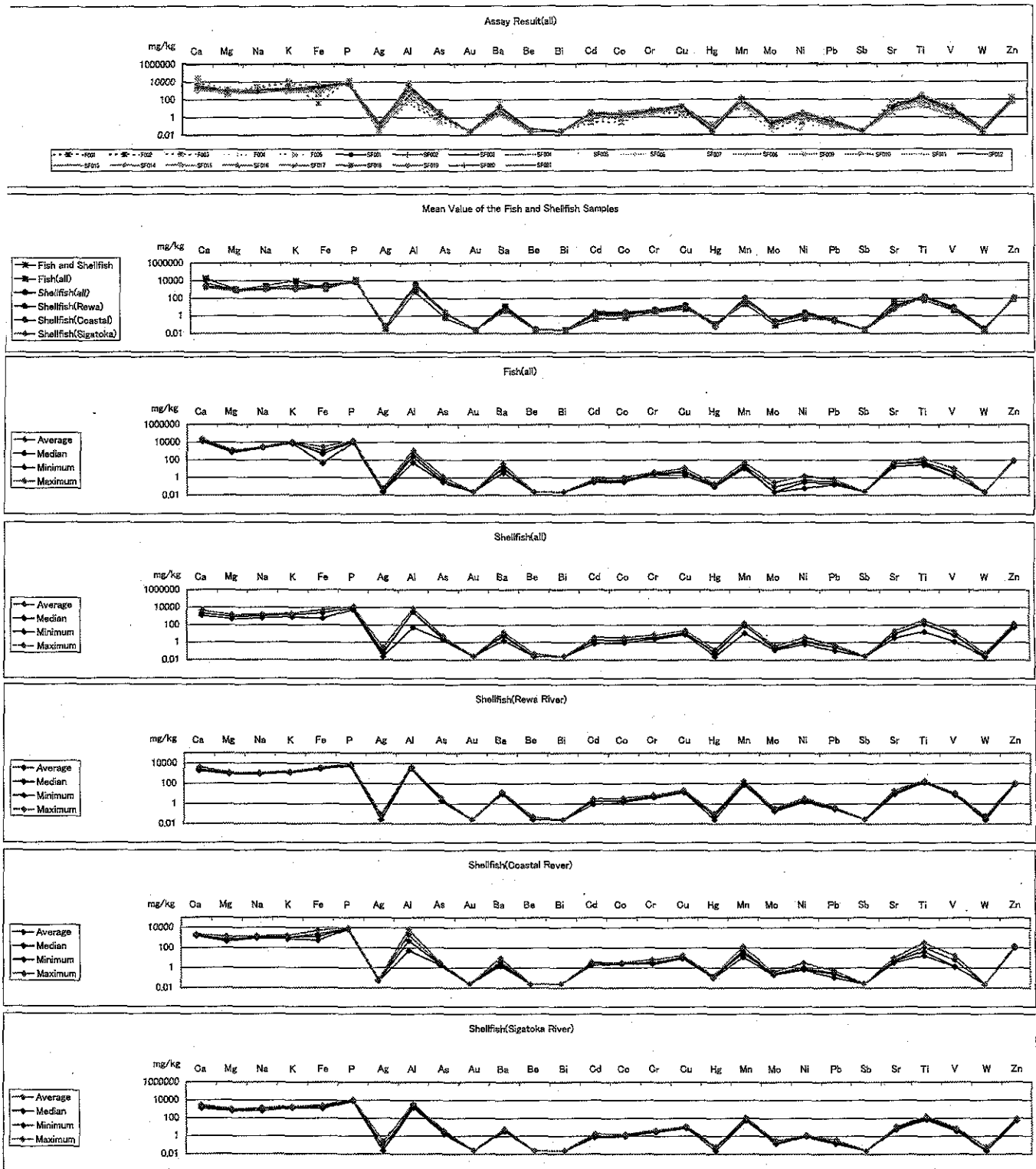
(August 23, 1991the Environmental Agency of Japan, notification 46)

Table II-3-3 Geochemical statics of the fish and shellfish samples

Item	Ca	Mg	Na	K	Fe	P	Ag	Al	As	Au	Ba	Be	Bi	Cd	Co	Cr	Cu	Hg	Mn	Mo	Ni	Pb	Sb	Sr	Ti	V	W	Zn	
Fish and Shellfish	Average	5,160	829	1,342	3,019	2,088	9,191	0.06	2,497	2.20	0.025	8.42	0.028	0.025	1.52	1.65	3.70	11.24	0.08	69.64	0.19	1.31	0.30	0.025	14.56	117.21	6.14	0.030	84.46
	Median	2,190	836	1,070	1,545	2,065	8,915	0.06	2,750	2.18	0.025	6.44	0.025	0.025	1.12	1.41	3.31	10.70	0.07	65.05	0.20	1.12	0.28	0.025	10.07	127.50	6.25	0.025	82.40
	Minimum	1,140	430	606	777	40	5,500	0.03	51	0.27	0.025	1.64	0.025	0.025	0.28	0.31	2.30	1.69	0.03	10.40	0.03	0.06	0.11	0.025	3.32	17.60	1.25	0.025	50.00
	Maximum	22,500	1,280	3,030	11,100	5,290	15,500	0.26	7,120	4.44	0.025	38.00	0.050	0.025	3.55	3.57	6.67	22.20	0.18	165.00	0.40	3.51	0.66	0.025	62.70	337.00	16.60	0.060	143.00
Fish	Average	18,020	971	2,660	9,728	1,066	13,320	0.03	583	0.57	0.025	13.49	0.025	0.025	0.43	0.59	2.76	5.96	0.13	22.48	0.09	0.47	0.34	0.025	37.18	62.14	3.93	0.025	81.12
	Median	20,200	1,020	2,590	9,780	475	13,700	0.03	247	0.31	0.025	10.50	0.025	0.025	0.33	0.39	2.73	3.69	0.12	14.30	0.03	0.28	0.21	0.025	38.60	48.00	1.25	0.025	81.10
	Minimum	11,300	646	2,260	7,220	40	9,600	0.03	51	0.27	0.025	3.66	0.025	0.025	0.28	0.31	2.30	1.69	0.09	10.40	0.03	0.06	0.16	0.025	17.00	28.10	1.25	0.025	73.60
	Maximum	22,500	1,180	3,030	11,100	2,890	15,500	0.06	1,250	1.39	0.025	38.00	0.025	0.025	0.62	1.09	3.52	11.70	0.18	61.60	0.28	1.51	0.66	0.025	62.70	147.00	11.00	0.025	89.20
Shellfish	Average	2,099	795	1,028	1,421	2,326	8,208	0.07	2,916	2.58	0.025	7.22	0.026	0.025	1.78	1.91	3.92	12.49	0.07	80.87	0.22	1.51	0.29	0.025	9.17	130.32	6.66	0.031	85.25
	Median	2,050	814	1,040	1,370	2,250	7,930	0.06	3,040	2.24	0.025	6.16	0.025	0.025	1.62	1.69	3.65	11.30	0.06	87.60	0.20	1.16	0.29	0.025	9.62	138.00	6.80	0.025	84.80
	Minimum	1,140	430	606	777	522	5,500	0.03	52	1.80	0.025	1.64	0.025	0.025	0.71	0.89	2.41	7.75	0.03	11.50	0.13	0.62	0.11	0.025	3.32	17.60	1.25	0.025	50.00
	Maximum	4,200	1,280	1,450	1,970	5,290	11,700	0.26	7,120	4.44	0.025	15.90	0.050	0.025	3.55	3.57	6.67	22.20	0.15	165.00	0.40	3.51	0.58	0.025	20.70	337.00	16.60	0.060	143.00
Shellfish (Rewa)	Average	2,631	927	981	1,291	3,159	6,676	0.07	4,013	2.30	0.025	12.53	0.029	0.025	1.92	2.17	4.99	16.41	0.06	105.64	0.24	2.32	0.37	0.025	12.61	163.29	9.04	0.039	90.60
	Median	2,430	953	1,040	1,250	2,980	6,720	0.07	4,120	2.22	0.025	11.60	0.025	0.025	1.85	2.06	4.77	14.50	0.06	93.90	0.21	2.28	0.36	0.025	11.30	152.00	9.10	0.025	90.30
	Minimum	1,740	796	843	1,140	2,550	5,500	0.03	3,040	1.80	0.025	9.73	0.025	0.025	0.82	1.44	3.86	12.80	0.03	75.70	0.18	1.57	0.29	0.025	8.29	128.00	7.20	0.025	78.00
	Maximum	4,200	1,100	1,110	1,520	3,790	7,930	0.08	4,880	3.31	0.025	15.90	0.050	0.025	2.82	3.57	6.67	22.20	0.10	165.00	0.34	3.51	0.46	0.025	20.70	194.00	10.90	0.060	108.00
Shellfish (Coastal)	Average	1,784	644	1,162	1,092	2,187	7,962	0.06	2,121	2.66	0.025	3.82	0.025	0.025	2.85	2.84	3.43	11.63	0.12	48.30	0.26	1.15	0.29	0.025	5.22	121.54	5.79	0.025	116.18
	Median	1,640	450	1,130	1,090	1,310	7,370	0.06	494	2.57	0.025	2.59	0.025	0.025	3.01	2.89	2.52	10.50	0.13	30.80	0.21	0.72	0.26	0.025	4.56	45.20	1.25	0.025	109.00
	Minimum	1,460	430	941	777	522	6,790	0.05	52	1.96	0.025	1.64	0.025	0.025	1.79	2.51	2.41	8.43	0.10	11.50	0.20	0.62	0.11	0.025	3.32	17.60	1.25	0.025	97.90
	Maximum	2,160	1,280	1,450	1,620	5,290	9,460	0.07	7,120	3.75	0.025	9.29	0.025	0.025	3.55	3.32	6.31	17.50	0.15	128.00	0.40	2.94	0.58	0.025	9.84	337.00	16.60	0.025	143.00
Shellfish (Sigatoka)	Average	1,859	777	989	1,704	1,756	9,537	0.07	2,504	2.76	0.025	4.97	0.025	0.025	1.08	1.18	3.36	9.92	0.05	79.70	0.18	1.07	0.23	0.025	8.69	109.56	5.30	0.029	63.91
	Median	1,820	790	1,070	1,660	1,890	9,710	0.03	2,690	2.40	0.025	5.39	0.025	0.025	0.98	1.15	3.17	10.40	0.06	66.70	0.16	1.10	0.21	0.025	8.41	107.00	5.80	0.025	63.10
	Minimum	1,140	620	606	1,310	1,140	7,600	0.03	1,510	1.83	0.025	3.46	0.025	0.025	0.71	0.89	2.73	7.75	0.03	54.00	0.13	0.82	0.14	0.025	5.41	70.60	3.40	0.025	50.00
	Maximum	2,720	955	1,320	1,970	2,580	11,700	0.26	3,730	4.44	0.025	6.75	0.025	0.025	1.95	1.49	4.69	12.70	0.07	107.00	0.29	1.35	0.39	0.025	12.10	167.00	7.90	0.060	78.80

(LOR: Ca Mg Na K Fe:5mg/kg, P:50mg/kg, Al:2.5mg/kg, Ti:0.1mg/kg, V:2.5mg/kg, Other elements:0.05mg/kg)

(All Assay Results are shown by mg/kg)



(LDR: Ca Mg Na K Fe:5mg/kg, P:50mg/kg, Al:2.5mg/kg, Ti:0.1mg/kg, V:2.5mg/kg, Other elements:0.05mg/kg)
(All Assay Results are shown by mg/kg)

Fig.II-3-3 Geochemical statics of the fish and shellfish samples

3 - 3 - 3 Flora survey

Origin of flora in Fiji Islands is presumed to derive from overseas because Fiji Islands is volcanic island. 90% among plant species in Fiji are common to those of Papua New Guinea and 65 - 75% among plant species of Fiji are common to Queensland Province of northern Australia and islands of West Melanesia (New Caledonia, Vanuatu and Solomon). 10% among plant species in Fiji are endemic to Fiji. The seeds of these spermatophytes were introduced to Fiji from overseas, approximately 10% by typhoon and approximately 3% by ocean. Remaining 87% were accompanied with Birds (Pigeon and Dove) and Bats.

Ratio of endemic species among vascular bundle plants in Fiji Islands is presumed to be 23% - 35%. The ratio of endemic species sometime reaches to 60% especially in widely distributed native tropical rain forest. The ratio of endemic species reaches to around 60% in tropical rain forest of Serua Province and Namosi Province representative of the Viti Levu South area. 100% among native palm flora (28 species) is endemic species.

As for vascular bundle plant of Fiji, approximately 1028 genus and approximately 2530 species are recorded. These species consist of 301 species of Ferns (Pteridophyte) and 2225 species of Seed plants (Spermatophyte). Among those, 63% (1592 species) are Native species. Among Native species, 56% (892 species) are endemic species. Remaining 37% (936 species) are introduced species. Among introduced species, 34% (319 species) were naturalized to Fiji. It is not published but presumed that more than 1500 species of plants have been introduced to Fiji since 1980. These introduced species include more than 100 species of Palms, many Orchids, ornamental plants and weeds.

Bamboos that are used for rafts called BiliBili are introduced species. Crops such as Dalo, Cassava and Yaqona are also introduced species.

(1) Flora

In the South East Viti Levu area, 81 species of vascular bundle plants are recorded as rare species and endangered species. These 81 species are listed in Table II-3-4. The more details are shown in Appendix 9. This list are extracted from vascular bundle plant list of Fiji National Biodiversity Strategy and Action Plan (BSAP) and authorized as Threatened species and Protected species. 81 species are all native species. Among those, 69% (56 species) are endemic species.

31 species of rare and endangered plants were recorded in neighborhood of Waivaka South and Waisoi which were selected as field suvey area of this time.

Table II-3-4 Preliminary list of rare and endangered plant of South East Viti Levu
(CE:Critical Endangered Species,E:Endangered Species,TH:Threatened,DD:Data Dificient)

Species	Endemic/ Native	Statu s
<i>Acmopyle sahniana</i> Buchh. & N. E. Gray	E	CE
<i>Agathis macrophylla</i>	I	E
<i>Agrostophyllum megalurum</i> Reichenb.	I	TH
<i>Alyxia erythrosperma</i> Gillespie	E	DD
<i>Angiopteris opaca</i> Copel.	E	TH
<i>Appendicula bracteosa</i> Reichenb.	I	DD
<i>Asplenium induratum</i> Hook.	E	DD
<i>Astronidium floribundum</i> A. C. Sm.	E	DD
<i>Astronidium pallidiflorum</i> A. C. Sm.	E	DD
<i>Astronidium saulae</i> A. C. Sm.	E	DD
<i>Atuna elliptica</i> (Kostermans) Kostermans	E	TH
<i>Balaka macrocarpa</i> Burret	E	CE
<i>Balaka microcarpa</i> Burret	E	E
<i>Blechnum gibbum</i> (Labill.) Mett.	I	DD
<i>Bulbophyllum polypodioides</i> Schltr.	I	TH
<i>Bulbophyllum samoanum</i> Schltr.	I	TH
<i>Bulbophyllum sessile</i> (Koen) J.J. Sm.	I	TH
<i>Calophyllum amblyphyllum</i>	E	E
<i>Carruthersia macrantha</i> A. C. Sm.	E	TH
<i>Casearia fissistipula</i> A. C. Sm.	E	TH
<i>Cleistanthus micranthus</i> Croizat	E	TH
<i>Cleistocalyx seemannii</i> (A. Gray) Merr. & Perry var. <i>punctatus</i> Merr. & Perry	E	DD
<i>Coelogyne lycastoides</i>	I	DD
<i>Cryptocarya laucifolia</i> A. C. Sm.	E	TH
<i>Ctenopteris vodonaivalui</i> Brownlie	E	DD
<i>Ctenopteris vomaensis</i> Brownlie	E	DD
<i>Cyathea affinis</i>	I	E
<i>Cyathea plagiostegia</i> Copel.	E	DD
<i>Cyphosperma "naboutini"</i>	E	CE
<i>Cyrtandra cyathibracteata</i> Gillet	E	TH
<i>Dennstaedtia flaccida</i>	I	E
<i>Diospyros elliptica</i> var. <i>opaca</i> A. C. Sm.	E	DD
<i>Discocalyx amplifolia</i> A. C. Sm.	E	TH
<i>Discocalyx crinita</i> A. C. Sm.	E	TH
<i>Elaeocarpus ampliflorus</i> A. C. Sm.	E	TH
<i>Elaeocarpus pittosporoides</i> A. C. Sm.	E	DD
<i>Elaphoglossum basitruncatum</i> Brownlie	E	DD
<i>Eleocarpus chionanthus</i> A. C. Sm.	E	DD
<i>Flacourtia mollipila</i> Sleumer	E	TH

Species	Endemic/ Native	Status
<i>Flickingeria comata</i> (Bl.) A. Hawkes	I	TH
<i>Freycinetia vitiensis</i> Seem.	E	TH
<i>Garnoti villosa</i> Swallen	E	DD
<i>Glochidion atalotrichum</i>	E	CE
<i>Grammitis vitiensis</i> Brownlie	E	DD
<i>Gulubia microcarpa</i> Essig	E	V
<i>Heterospathe phillipsii</i> Sp. Nov. Fuller & Dowe	E	E
<i>Lindsaea gueriniana</i> (Gaud.) Desv.	I	DD
<i>Lindsaea moorei</i> (Hook.) Fourn.	I	DD
<i>Lunathyrium gillespiei</i> (Copel.) Brownlie	E	DD
<i>Lycopodium serratum</i> Thunb.	I	TH
<i>Malaisia scandens</i> (Lour.) Planch.	I	TH
<i>Malaxis platychlila</i>	E	DD
<i>Mapania parvibractea</i> (C. B. Clarke) T. Koyama	I	TH
<i>Memecylon inseparatum</i> A. C. Sm.	E	DD
<i>Metroxylon vitiense</i> (H.A. Wendl.) H.A. Wendl. ex Hook.	E	V
<i>Neovitchia storckii</i> (H.A. Wendl.) Becc.	E	E
<i>Octarrhena oberonioides</i> (Schltr.) Schltr.	I	DD
<i>Pandanus sonicola</i> A. C. Sm.	E	DD
<i>Parkia parri</i> Horne ex Baker	E	DD
<i>Passiflora barclayi</i> (Seem) Mast.	I	TH
<i>Peperomia namosiana</i> Yuncker	E	DD
<i>Pleocnemia elagans</i> (Copel.) Holtt.	E	TH
<i>Pleocnemia leuzeana</i> (Gaud.) Presl	I	TH
<i>Podocarpus affinis</i> Seem.	E	EN
<i>Pomatocalpa vaupelii</i> (Schltr.) J. J. Sm.	I	TH
<i>Psychotria bullata</i> A. C. Sm.	E	TH
<i>Psychotria magnifica</i> (Gillespie) Forsberg	E	TH
<i>Psychotria scitula</i> A. C. Sm.	E	DD
<i>Psychotria valleculata</i> A. C. Sm.	E	TH
<i>Psychotria vomensis</i> Gillespie	E	TH
<i>Pteris vittata</i> L.	I	TH
<i>Schizaea fistulosa</i> Labill.	I	DD
<i>Schoenus achaetus</i> (T. Koyama) T. Koyama	I	CE
<i>Serianthes melanesica</i> var. <i>meeboldii</i> Fosberg	E	DD
<i>Syzygium simillimum</i> Merr. & Perry	E	TH
<i>Tapeinosperma babuscense</i> Mez.	E	TH
<i>Tarenna joskei</i> (Horne ex Baker) A. C. Sm.	E	TH
<i>Terminalia capitanea</i>	E	V
<i>Tmesipteris truncata</i> (R. Br.) Desv.	I	TH
<i>Zeuxine vieillardii</i> (Reichenb) Schltr.	I	TH

(2) Classification of flora

Flora in Fiji is classified to characteristic 9 ecosystems based on topography and climate etc. Among those, 8 ecosystems are distributed in the survey area.

- Smaller Island Vegetation (mangrove, bush and grass)
- Mangrove Forest and Shrubs (on large islands) (mangrove forest and bush)
- Coastal Vegetation (mangrove, bush and grass)
- Freshwater Wetland Vegetation (swamp)
- Lowland Rain Forest (tropical rain forest)
- Upland Rain Forest (highland tropical rain forest)
- Cloud Forest (wet rain forest)
- Grassland Vegetation (grassy plain)

Summary of each ecosystem is as follows. Photographs of parts of ecosystems are shown in PH-3.

1) Smaller island vegetation (mangrove, bush and grass)

This forest system is distributed in small islands with altitude below 100 m, such as Nasoata and Valolo Islands in which alluvial soils of intermediate to basic volcanic rocks are distributed, estuary of Rewa River, Nukulau offshore of Laucala Bay, Makuluva Island, islands offshore of Lami, Naqara and Serua Islands of Serua Province. This ecosystem is characterized by mangrove, bush and grass. And it is subdivided into as follows

1a: Coastal Strand Vegetation

This is characterized by Shrubs, Creepers, Herbs, Grasses.

1b: Mangrove Vegetation

Species of mangroves consists of *Rhizophora samoensis*, *Rhizophora stylosa*, *Xylocarpus granatum*, *Heritiera littoralis*, *Excoecaria agallocha* and *Bruguiera gymnorrhiza*.

1c: Coastal flora and Mangrove flora, which are recognized in tropical rain forest along coast.

2) Mangrove Forest and Shrubs (on large islands) (mangrove forest and bush)

Mangroves are often distributed in delta or coastal swamp, such as from Rewa Delta, Laucala Bay and Suva Harbour to Lami, from Namuka Harbour to Lobau village of Namosi, Navua and Deuba delta, Korovou Bay, Yarawa Bay, Samanua Bay, Vunivia Bay and Samoso Bay etc.

The area of mangroves is 38,543 ha in Fiji and the area is approximately 6450 ha in the SouthViti Levu area. This is 16.7% of all mangroves of Fiji. Species of mangrove consists of *Bruguiera gymnorrhiza*, *Rhizophora samoensis*, *Rhizophora stylosa*, and hybrid *Rhizophora X selala* In addition, *Lumnitzera littorea*, *Heritiera littoralis*, *Xylocarpus granatum* and *Excoecaria agallocha* are coexisting with Creepers and Ferns.

3) Coastal Vegetation (mangrove, bush and grass)

This forest system consists of flora similar to Smaller Island Vegetation (mangrove, bush and grass).

Zonal vegetation of herbs - shrubs - hibiscus is known in the coast. In the case of sandy coast, Herbs - Creepers - Sedges - Grass are followed by Shrubs - Trees.

4) Freshwater Wetland Vegetation (swamp)

This system is characteristic of the South Viti Levu and distributed in upper streams of Rewa, Navua River and Sigatoka River. Swamp is important from the viewpoint of biodiversity.

4 a: Bonatoa swamp

This swamp is largest swamp in Fiji and distributed in Rewa delta. Sedges, Moss, Ferns and *Pandanus pyriformis* are characteristic.

4 b: Melimeli swamp

This swamp is distributed in Navua delta to the west of mangrove. Ferns, Sedges, Shrubs and Trees (*Hibiscus tiliaceus*) are characteristic.

4 c: Vunimoli swamp

This swamp is distributed in Navua delta where Pacific Harbour town is located. Palms (*Metroxylon vitiensis*), Ferns, Sedges, Moss, Shrubs and small Trees (*Hibiscus tiliaceus*) are characteristic.

5) Lowland rain forest (tropical rain forest)

Such forest type is found in area below 600m in elevation. Most of this type of forest have been logged and are targeted for agricultural development and human habitation. All timber tree plantations (Mahogany) on the South Viti Levu were once native lowland rain forest. Very few intact lowland rainforest remain in Namosi (Southwest of Mt.Voma - Wailutulevu catchment, Wainavadu catchment), Serua and Naitasiri (Sovi Basin, Southeast of Mt. Nauluvatu - Waisomo catchment, upper Waimanu Catchment - East of Wainadoi). At Mt. Korobaba, 310 plant species were recorded along 1km transect and 426 plant species were recorded in an area of 6km². Such high diversity of plant species is common in lowland rainforest systems. At times agglomerations of certain species results in monodominant canopies and such system are rarely extensive. Examples of such monodominant canopies are *Gymnostoma vitiense* and *Dacrydium nidulum* forests between Wainiqanake and Veivatuloa in Namosi, *Fragraea gracilipes* and *Dacrydium vitiensis* forests in Waisoi and *dakua-Agathis macrophyllum* in Sovi Basin. Climbers and epiphytic ferns are in general.

In disturbed forests, Creepers are recognized. Area that are regularly burned and cleared for cultivation is vegetated by native bamboo (*Schizostachyum glaucifolium*, *Piper aduncum* or *Miscanthus floribundus*).

6) Upland Rain Forest (highland tropical rain forest)

Such forest systems can be observed near the south coasts on ridges and in wind exposed mountaintops. The forest is stunted at 400m asl as on Mt. Korobaba, but generally distributed above 600m asl. Structurally and floristically the forest resembles a Montane rain forest in which crown height of tree is low. *Agathis podocarpus* is dominant species in this forest type. There are many (often dominate) broad-leaved tree species mixed in this forest type. They include most species found in low land rain forests like the canopy trees *Endospermum macrophyllum*, *Myristica castaneifolia*, *Calophyllum vitiense*, *Dysoxylum richii*, *Garcinia pseudoguttifera*, *Garcinia myrtifolia*, *Astronidium sp.*, *Syzygium sp.*; the sub-canopy trees such as *Girroniera celtidifolia*, *Alstonia vitiense*, *Ficus vitiense*, *Podocarpus affinis*, *Paphia vitiense*, *Alpinia sp.*, *Weinmannia sp.* and *Metrosideros collina*. Creepers, epiphytic Ferns, Shrubs and

small tree are vegetating between big plants.

7) Cloud Forest (wet rain forest)

The mountaintops and ridges above 600m asl near the coast and those areas above 900m inland are almost always covered in clouds. The forest structure overall is stunted with moss covered tree trunks a common feature of plant growth in such area. Very little is known floristically about the cloud forest. The only detailed studies about such forest type were done on Mt. Koroturanga on Taveuni 1210m and on Waisoi at 789m. Such forest type is also called Quasi - Cloud Montane forest type and is very different from all other forest types in terms of its overall floristic composition and structure. On Waisoi, *Acmopyle sahniana*, *Schoenus achaetus*, *Tmesipteris truncata* and *Alpinia macrocephala* were plant species not found elsewhere in Waisoi. Other tree species commonly found here include the endemic palm *Clinostigma exorrhizum*, *Podocarpus affinis* (most common), *Metrosideros collina*, *Dacrydium nidulum*, *Calophyllum cerasiferum*, *Alphitonia franguloides*, *Aglaia vitiensis*, *Agathis macrophyllum* and *Macaranga magna*.

8) Grassland Vegetation (grassy plain)

The dry zone is found on the leeward coast towards Sigatoka town and mostly extends from sea level up to about 500m towards the interior. It seems likely that they were once covered with light forest but repeated burning by the early settlers has reduced them to their present condition. The vegetation cover usually includes the introduced grass *Pennisetum polystachyon*, *Paspalum orbiculare*, *Panicum maximum* and *Sporobolus diander*, the fern *Pteridium esculentum* and *Dicranopteris linearis*, the shrubs *Decaspermum vitiense* and *Dodonaea viscosa*, the small trees *Morinda citrifolia*, *Alphitonia zizyphoides*, *Mussaenda raiateensis*, *Causarina equisetifolia* and *Pandanus odoratissimus*. Along the seasonal dry creek bed in gullies the common tree species include *Albizia saman*, *Aleurites moluccana*, *Albizia labbeck*, *Leucaena leucocephala*, *Psidium guajava*, *Cerbera manghas*, *Mangifera indica*, *Dysoxylum richii* and *Piper aduncum*.

Other Natural Ecosystems of Importance

Sago Palm Swamp is distributed along Navua River. It is peculiar that this swamp consists only of the tree *Metroxylon vitiensis*.

(3) Field survey

Neighbourhood of Waivaka mineral occurrence in Namosi region was selected as the flora field survey area same as animal phase survey. This area belongs to tropical rain forest that is prevailing most widely in the whole survey area. The survey locations are shown in in Fig.II-3-4.

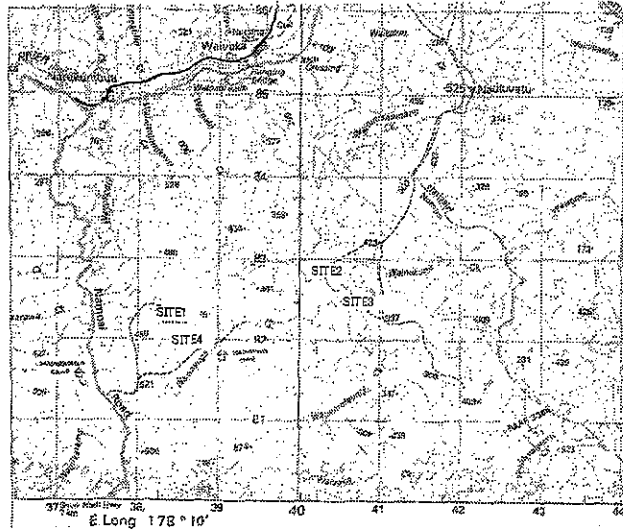


Fig.II-3-4 Location map of the survey sites in waivaka south

As a result of the field survey, trees such as yaka (*Dacrydium nidulum* and *Dacrydium nausoriense*) and dakua (*Agathis macrophylla*) are observed, which represents the tropical rain forest in Fiji. Besides, plants such as Bryophytes, Algae, Lichens and Fungi were recognized.

Approximately 230 species of plants were sampled in this survey. The plants consist of Ferns, Gymnosperms, Dicots and Monocots. 173 species were recognized in the samples. The survey result of vascular bundle plants is shown in Table II-3-5. The detailed list is shown in Appendix 10 and photographs of the principal plants were shown in Ph-3.

TableII-3-5 Classification summary of the vascular plants identified in Waivaka South

order (目)	family (科)	genus (属)	species (種)
Fern (シダ類)	12	18	29
Gymnosperms (裸子植物)	3	3	7
Dicots (双子葉植物)	41	68	106
Monocots (单子葉植物)	8	25	31
total (計)			173

The largest family is Orchidaceae of Monocots, which occupies 10% of all. Secondly, Rubiaceae of Dicot occupies 6% of all. 100% of plants (173 species) in Fiji are native species regardless of its origin. Among those, 60% (104 species) are endemic species and 40% (69 species) are indigenous species. Ratio of endemic species is high. Among those, 11% (9 species) are presumed to be rare species.

In addition, 12 introduced species were recognized (shown in Table II-3-6).

Table II-3-6 Invasive species list for Waivaka South

Family	Botanical Name	Abundance
Piperaceae	<i>Piper aduncum</i>	Locally common along creeks
Bignoniaceae	<i>Spathodea campanulata</i>	Uncommon in disturbed areas
Myrtaceae	<i>Psidium guajava</i>	Uncommon in paddocks
Zingerberaceae	<i>Hedychium gardnerianum</i>	Locally common under bamboo stands in disturbed areas
Cyperaceae	<i>Kyllinga polyphylla</i>	Locally common along streams as far as Wainavuga
Mimosaceae	<i>Mimosa pudica</i>	Locally common in disturbed areas
Solanaceae	<i>Solanum torvum</i>	Locally common in disturbed areas
Melastomataceae	<i>Cldemia hirta</i>	Common especially in disturbed areas
Verbenaceae	<i>Lantana camara</i>	Uncommon in disturbed area (esp. in paddocks)
Passifloraceae	<i>Passiflora foetida</i>	Common in disturb areas
Convolvulaceae	<i>Merremia peltata</i>	Common especially in disturbed areas
Asteraceae	<i>Mikania micrantha</i>	Common especially in disturbed areas

1) Rare species

31 rare species were recognized around Namosi of South Viti Levu area among all 81 rare species. 9 rare species of Table II-3-7 were recognized in the survey of Waivaka south, which occupy approximately 5% of this area.

Table II-3-7 List of the origin and conservation status of Waivaka South

Species (種)	Origin (起源)	Preservation (保全状態)	
		¹ IUCN 1997	² Others
<i>Agathis macrophylla</i>	Native	Vulnerable	Vulnerable
<i>Appendicula bracteosa</i>	Native		Rare, Data deficient
<i>Astronidium saulae</i>	Endemic		Rare, Data deficient
<i>Cyrtandra cyathibracteata</i>	Endemic	Threatened	Rare
<i>Elaeocarpus chionanthus</i>	Endemic		Rare, Data deficient
<i>Flickingeria comata</i>	Endemic		Rare, Data deficient
<i>Malaxis platychlila</i>	Endemic		Rare, Data deficient
<i>Pandanus sonicola</i>	Endemic		Rare, Data deficient
<i>Podocarpus affinis</i>	Endemic	Endangered	Vulnerable

¹ Those which are based on Red List Categories adopted in IUCN.

² Brownlie (1977), Smith (1979-91), Doyle (1998), Tuiwawa (1999).

2) Ecosystem of each topographical division

The survey area is divided topographically to 3 divisions: hill section (420 m), slope section (350 m) and flat plain by river (250 m). The survey was executed at 4 sites that belong to respective divisions. Yaka, dakua are dominant in hill section (420 m). Plants of slope section (350 m) are represented by Plants such as damanu (*Calophyllum*), kaudamu (*Myristica*), yasiyasi (*Cleistocalyx*, *Syzygium*) and bau (*Palaquim fidjiense*, *Palaquim porphyreum*). Plants of flat plain by river (250 m) are represented by kauvula (*Endospermum macrophyllum*) and sa (*Parinari insularum*).

The forest of the survey area is regarded as typical tropical rain forest (Lowland Rain Forest) in terms of the spatial distribution of the canopy layers, species density and common species composition.

Ecosystem of each topographical division is as follows. Model of vegetation structure of each division is shown in Appendix 11.

Site 1. Ridge Top Forest – high elevation (520m asl)

The height of this Ridge top forest (see Figure 2) was less compared to the mid elevation ridge top forest assessed in Site 3. The forest varies in height from 5 to 28 m. A sub-canopy layer was noticed between 9 to 15 m and canopy between 15 to 27 m. There are no gaps in the forest cover. The mean dbh of trees in the transect was 20.8 cm and this ranged from 10m to 56cm. A total of 61 trees (with dbh >10cm) was accounted for in the assessed area of 360 sq. m. The five most common trees were *Palaquium hornei*, *Haplolobus floribundus*, *Syzygium effusum*, *Dacrycarpus imbricatus*, and *Calophyllum vitiensis* and they made up 50% of the trees assessed in the plot.

Site 2. Slope Forest Type – mid elevation (350m asl)

The height of the slope forest type (see Figure 3) was less compared to the creek flat forest, varying in height from 9 to 25 m with an occasional emergent attaining heights up to 38m. A sub-canopy layer was noticed between 8 to 15 m and canopy between 15 to 24 m. There were no gaps in the forest cover. The mean dbh of trees in the transect was 18.2 cm and this ranged from 10 to 40cm. A total of 37 trees (with dbh >10cm) was accounted for in the assessed area of 360 sq. m. The five most common trees were *Parinari insularum*, *Myristica chartacea*, *Syzygium effusum*, *Gonystylus punctatas* and *Calophyllum amblyphyllum* and they made up 50% of the trees assessed in the plot.

Site 3. Ridge Top Forest Type – mid elevation (265m asl)

This ridge forest (see Figure 4) is like the river flat forest which has trees that are among the tallest in Fiji with the height varying from 5 to 32 m. The canopy was closed with a sub-canopy layer at c. 10 to 17 m and canopy layer between 17 to 30 m (see Figure 4). The mean dbh of trees in the transect is 18.8 cm and this ranged from 10m to 53cm. A total of 56 trees (with dbh >10cm) was accounted for in the assessed area of 360 sq. m. The eight most common trees were *Parinari insularum*, *Myristica chartacea*, *Syzygium fijiense*, *Myristica gillespieana*, *Endospermum macrophyllum*, *Haplolobus floribundus*, *Palaquium poryphereum* and *Calophyllum amblyphyllum* and they made up 50% of the trees assessed in the plot.

Site 4. Creek-flat Forest (250m asl.)

The Creek flat forest varied in height from 25 to 32 m.(see Figure 5). There were three canopy

layers occurring at 20m to 30 m, 15m to 20 m and between 10m to 15 m (understorey with trees of dbh <10cm) with no breaks in the canopy cover. The mean dbh of trees in the transect is 29.3 cm and this ranged from 10cm to 73cm. Some of the largest trees encountered in the survey were noticed in the forest type. A total of 23 trees (with dbh >10cm) was accounted for in the assessed area of 360 sq. m. The reason for the low density is there were lots of large trees in the area assessed. The four most common trees were *Parinari insularum*, *Garcinia myrtiflora*, *Gonystylus punctatas* and *Calophyllum amblyphyllum* and they made up 50% of the trees assessed in the plot.

(4) Result of flora survey

As for vascular bundle plant of Fiji, approximately 1028 genus and approximately 2530 species are recorded. These species consist of 301 species of Ferns (Pteridophyte) and 2225 species of Seed plants (Spermatophyte). Among those, 63% (1592 species) are Native species. Among Native species, 56% (892 species) are endemic species. Remaining 37% (936 species) are introduced species. Among introduced species, 34% (319 species) were naturalized to Fiji. In the South East Viti Levu area, 81 species of vascular bundle plants are recorded as rare species and endangered species.

In the field survey, the tropical rain forest consists of Ferns, Gymnosperms, Dicots and Monocots. The largest family is Orchidaceae of Monocots, which occupies 10% of all. Secondly, Rubiaceae of Dicot occupies 6% of all. 100% of plants (173 species) in Fiji are native species regardless of its origin. Among those, 60% (104 species) are endemic species and 40% (69 species) are indigenous species. Ratio of endemic species is high. Among those, 11% (9 species) are presumed to be rare species.

On the basis of this field survey, similar survey is necessary for the area where future development is supposed, periodically once per quarter year for example in March, July and September. As for flora survey, the survey for introduced species is necessary in addition to native trees.