Environ Dev Sustain
DOI 10.1007/s10668-008-9151-6

Artisanal fishers' ethnobotany: from plant diversity use to agrobiodiversity management

Nivaldo Peroni · Alpina Begossi · Natalia Hanazaki

Received: 14 March 2007 / Accepted: 3 August 2007

Abstract Artisanal fishers interact with plants in many ways, and with different intensities. In spite of being characterized by fisheries, Caiçaras use plants with varied degrees of management, since the less intensive management actions, extraction of forest products, until intensively management actions through the cultivation of the agrobiodiversity. This study presents the results of different research projects and includes the North and the South regions of São Paulo state coast. The objective is to characterize the diversity of extracted and cultivated species by traditional fishers at Southeastern region of Brazilian Atlantic forest. Ethnobotanical surveys revealed a high diversity of plants known and used, ranging up to a richness of 272 species known in two communities for the South coast, most of them being native. However, depending on the management intensity, this diversity can be rather particularized: we found 68 varieties of cassava (*Manihot esculenta* Crantz) at North region and 58 varieties at the South region, with exclusive vernacular names. Through an ethnobotanical perspective, we compare and discuss the different dynamic systems underlying the relationships between fishers and plants. The diversity of cultivated plants is analyzed in depth, focusing on the historical importance of agriculture

Readers should send their comments on this paper to: BhaskarNath@aol.com within 3 months of publication of this issue.

N. Peroni · A. Begossi
Fisheries and Food Institute (FIFO), Rua Coronel Quirino 1636, Campinas, SP 13025-002, Brazil

N. Peroni (✉)
Universidade Federal de Santa Catarina, ECZ/CCB/UFSC, Campus Universitário Trindade, Florianópolis 88010-970, Brazil
e-mail: peronin@gmail.com

A. Begossi
Fisheries Management and Training Program, PREAC-UNICAMP, Rua Coronel Quirino 1636, Campinas, SP 13025-002, Brazil

N. Hanazaki
Department of Ecology and Zoology, Center of Biological Sciences, Universidade Federal de Santa Catarina, Rua João Pio Duarte Silva 114 B 501, Florianópolis 88037-000, SC, Brazil

among people who are currently characterized as fishers. A schematic model is proposed to explain the dynamic systems operating in the relationships between fishers and plants.

Keywords Ethnobotany · Fishers · Atlantic forest · Traditional management · Agrobiodiversity

1 Introduction

Ethnobotany can be defined as the study of interactions between people and plants in dynamic systems (Alcorn 1995). Much attention has been given to studies investigating the diversity of plants used from the environment or the diversity of uses attributed to plants. Even deeper details have been studied regarding the ethnopharmacological aspects of medicinal plants known by a given society (Etkin 1998; Balick and Cox 1996), or even the ecological consequences of the extraction of a commercially used species (Uniyal et al. 2006; Mutchnick and McCarthy 1997). These studies usually stress native and non-cultivated plants recognized as important local resources. On the other side, some attention has also been given to cultivated plants, regardless of these plants being native or introduced. For example, farm systems, home gardens, orchards and agricultural plots have been investigated by ethnobotanists (Peroni and Hanazaki 2002; Bellon 1996; Caballero 1992).

For tropical regions, analyses encompassing both views are not easy to find in literature. However, local people often interact with plants in both ways: extracting plants from their surrounding environment, and thus depending on the available diversity with less intensive management actions, and cultivating the agrobiodiversity. When considering fisher peoples such as the Brazilian Caiçaras this is indeed the actual situation. Caiçaras live in the Southeastern Brazilian coast, and they historically depended on small-scale agriculture and fishing. Their livelihood has been rapidly changed, also due to the growing tourism in the areas near the coastline. They have a multiplicity of livelihood activities, depicted by fishing, farming, extraction of plant resources, and tourism-related activities (Hanazaki et al. 2007).

The term agrobiodiversity is related to the context of crop species influenced by human actions and activities. An important characteristic of such species is it high infra-specific diversity that characterizes their production systems, as being poly-specific and poly-varietal systems. Indigenous and traditional farmers have been the major agrobiodiversity keepers, and have been responsible to maintain the species and the practices that allow its continued evolution and generation of new varieties (Peroni and Martins 2000). Many of these practices have not been fully revealed to allow the understanding of how and why they occur, and what are its consequences in time and space for the generation of new varieties (Peroni 2004). Several traditional farmers live in marginal places characterized by the poor soil fertility, with accented relief and high declivity, and not favored by infra-structure (Ceccarelli 1994). In the Brazilian Atlantic forest, Caiçaras can be considered one of these marginalized traditional groups. Their itinerant swidden cultivation practices depend on forest areas and on inputs from vegetation burnings; thus, many farmers are using territories that are overlapping with areas prioritized for conservation (Fox et al. 2000). This feature is especially important in Brazil, a megadiverse country, and in areas of Atlantic forest, a highly menaced biome. Brazilian Atlantic forest is an ecosystem historically threatened by the post-Columbian colonization: it concentrates the biggest Brazilian cities and its original area was drastically reduced since the 16th century.

A growing number of ethnobotany and ethnoecology studies have been stressed the importance of local knowledge or ethnoecological knowledge for species conservation and for the use of these species as local resources (Schultes and von Reis 1995). In spite of the Neotropics being megadiverse in species, the understanding of the ecological basis of such relations is still weakly comprehended, and still less comprehended are the relations that can favor of amplify the diversity (Balée 1994). The local use and management of the cultivated species can be used as a model for both cases: to understand the conservation of genetic diversity as well as to understand the amplification of genetic diversity (Harlan 1992).

This study shows the results of different research projects that aim to characterize the diversity of extracted and cultivated species by traditional fishers of the Southeastern region of Brazilian Atlantic forest. Through an ethnobotanical perspective, we compare and discuss the different dynamic systems underlying the relationships between fishers and plants. A deeper analysis is done regarding cultivated diversity, stressing the historical importance of agriculture for people who are currently characterized by the fishery as their main economic activity.

2 Study site

This study includes the North and the South regions of São Paulo State coast. Both regions have remnants of Atlantic forest where Caiçara communities can be found. At the North of São Paulo coast region we included communities from the municipalities of São Sebastião and Ubatuba (23°47′ S–45°19′ W and 23°27′ S–45°00′ W). The communities from the South region occupies an area which extends for approximately 100 km between the municipalities of Iguape, Ilha Comprida and Cananéia (24°40′ S–25°10′ S and 47°20′ W–48°05′ W).

At the Southern part of São Paulo State coast the humid sub-tropical climate has annual average temperatures between 21 and 22°C, with no well-defined dry season, and annual precipitation varies from 170 to over 2,200 mm (Schaeffer-Novelli et al. 1990). At the Northern part of São Paulo state coast the tropical rainy climate constantly wet has annual average temperatures near 21°C, and annual precipitation near 2,600 mm (Talora and Morellato 2000). The predominant vegetation is dense rainforest of the Atlantic forest biogeographical domain, with sandy soils low in natural fertility in the lowlands near the coastline.

3 Collection and analysis of data

Fieldwork was carried out between 1998 and 2006, at North and South regions of São Paulo state coast. Communities included at the North coast were: Ubatumirim, Puruba, Sertão do Puruba, Ponta do Almada, and Vitória Island (municipalities of Ubatuba and São Sebastião). Communities included at the South coast were: Pedrinhas, São Paulo Bagre, Icapara, Aquários, Vila Nova, Praia do Leste, Sorocabinha, Ilha Grande, Subaúma, Porto Cubatão, Itapitangui, Prainha, Agrossolar, Papagaio, Juruvaúva, and Ubatuba (municipalities of Iguape, Cananéia, and Ilha Comprida, see also Peroni and Hanazaki 2002).

We used common tools for ethnographic data collection, through semi-structured questionnaires and a participatory plant research approach. Agrobiodiversity data collection was made through interviews about inter and intra-specific diversity regarding its cultivation, origin, and time of use, among others. Data collected in the fields were later complemented during open-ended interviews with members of the family unit, in order to improve our knowledge about how the farmers perceive the plants and how they categorize the varieties.

Specific information about cassava (*Manihot esculenta* Crantz) varieties was gathered in the cleared fields (swiddens) with the participation of the farmers. The criteria used to include each household as a familiar unit was the use of the same system of itinerant production for more than 5 years. Ethnobotanical data, including non-cultivated and extracted plants were collected through additional interviews with 17 key informants from Pedrinhas and São Paulo Bagre about known and used species, its place of occurrence and its uses. Botanical material was collected, identified, and deposited at UEC herbarium (Unicamp, Campinas, Brazil). Selected informants were identified by other interviewed inhabitants (see Hanazaki et al. 2007) as being the local experts about plant knowledge in these communities.

Complimentary ethnobotanical data were used for the North coast communities studied by Rossato et al. (1999) (e.g. Puruba, Sertão do Puruba, Vitória Island, Picinguaba and Casa de Farinha), Hanazaki et al. (2000) (e.g. Almada and Camburí), and Begossi et al. (1993) (Búzios Island); and for the South coast communities of Barra do Una, Grajaúna, Rio Verde and Praia do Una (Araújo 2001). The Central portion of São Paulo state coast was also investigated, but no traditional farmers were found there.

4 Atlantic forest and Caiçaras

Atlantic forest is the second largest Brazilian rain forest, after Amazon. Historical reasons, including the colonization of exploitation, and the exportation economy based on plantations of sugar-cane and coffee, are among the main factors that explain the remain of only 7% of the Atlantic forest original forest cover (Dean 1995). The current area is composed by a mosaic of forest patches, connected by a few ecological corridors (Martensen et al. 2003). The Caiçaras are also connected through intermarriages, and can be considered as a metapopulations (Begossi 2006).

In the coastal Atlantic forest area many traditional populations are present, including Caiçaras, whom directly depends on plant resources to compose their familiar economy (Hanazaki et al. 2000; Begossi 1998). Caiçaras agricultural activities are historically based on swidden cultivation. In this sense, Caiçaras are fishers and farmers and their production system is largely based on local indigenous knowledge. Isolated for a long period of time from the rest of the country by the mountain ranges surrounding the coast, they have low spatial mobility, being concentrated mostly in communities of various sizes (Diegues 1983; Mussolini 1953). With a complex land ownership structure, they do not always own their lands, which are sometimes shared in communal use (Sanches 2001; Begossi 1998). Swidden cultivation was the main farming activity until the first half of the twentieth century (Peroni and Hanazaki 2002; Dean 1995; Schmidt 1958).

The main economic activities among the Caiçaras today are fishing and tourism, with farming activities being limited exclusively to subsistence (Hanazaki and Begossi 2003; Begossi 1998). However, Caiçaras also use the native vegetation for multiple purposes, such as the extraction of medicinal plants, plants for handicrafts and construction, and ornamental plants for commerce (Begossi et al. 2000). Ethnobotanical surveys done in the North and South coasts of São Paulo state revealed a high richness of plants known and used, including both native and introduced species in different degree of domestication and management (Fig. 1, data from this study compared with data from Begossi et al. 1993; Rossato et al. 1999; Hanazaki et al. 2000; Araújo 2001). This richness varied from 57 plants for Vitória Island (North) up to 272 plants for São Paulo Bagre and Pedrinhas (South). The number of interviews varied in each community. We observed a general trend towards the increasing richness of plants cited according to the increased number of

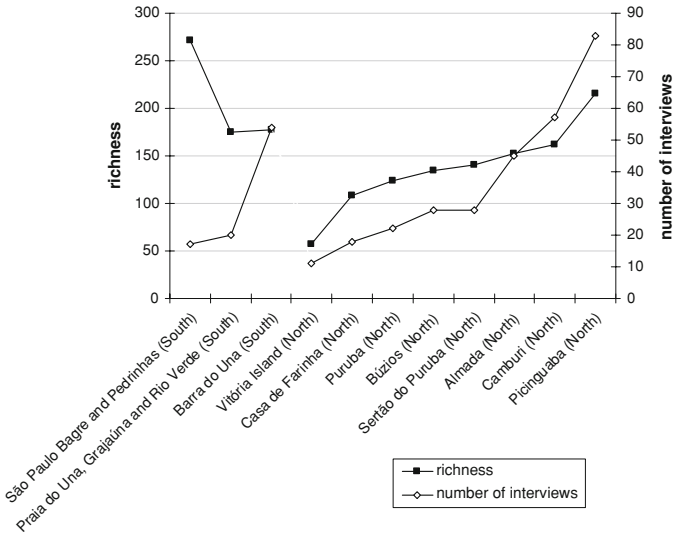

Fig. 1 Number of plants cited in the ethnobotanical surveys with Caiçaras from the North and South parts of São Paulo state coast, Brazil. Data from this study and compiled from Rossato et al. (1999), Hanazaki et al. (2000), Araújo (2001), Begossi et al. (1993)

interviewees for the communities at the North region (communities studied by Begossi et al. 1993; Rossato et al. 1999; Hanazaki et al. 2000). The exception observed for São Paulo Bagre and Pedrinhas is due to the different methodological approach used in these communities, interviewing key informants instead of sampling the population for interviews regardless their supposed plant knowledge. Different patterns observed at the other two South communities are related to different degrees of proximity with urban centers and with protected areas, discussed by Araújo (2001).

Botanical families usually cited in ethnobotanical surveys are Lamiaceae, Asteraceae and Myrtaceae. Lamiaceae and Asteraceae contribute mainly with medicinal species, such as *Mentha* × *piperita* L., *Plectranthus* sp., *Plectranthus barbatus* Andr., *Melissa officinalis* L., *Salvia splendens* (Sellow) Roem. & Schult., *Matricaria chamomilla* L., *Aquilegia millefolium* L., and *Mikania* spp. Myrtaceae contributes with native and introduced trees such as *Myrcia rostrata* DC., *Psidium guajava* L., *Eugenia moraviana* O. Berg, and *Gomidesia schaueriana* O. Berg. (Begossi et al. 1993; Rossato et al. 1999; Hanazaki et al. 2000; Araujo 2001, and data from the present study). Analyzing data collected through 449 interviews at 12 Caiçara communities, Begossi et al. (2002) found that the most cited medicinal plants were mostly introduced, such as *M. officinalis*, *Lippia citriodora* H.B.K., *Vernonia condensata* Baker, *Coleus barbatus* Benth, *Chenopodium ambrosioides* L., *C. album* L., *Foeniculum vulgare* Gaertn, *Cymbopogon citratus* (DC.), *M. piperita* L., *M. spicata* L., *Citrus sinensis* (L.) Osbeck, *Cunila spicata* L., and *M. chamomilla* L.

To illustrate the proportion of native and introduced species, for data collected at Pedrinhas and São Paulo Bagre (South), the majority of the 213 species which origin could be determined is native (62%). Introduced species corresponds to 21%, and cosmopolitan species or native invaders account for 17%. Native plants were cited due to its use for handicrafts, construction, as ornamentals, or as edible (producing edible fruits to both people and native animals) (Fig. 2). Medicinal species include both native (52%) and introduced (20%) and cosmopolitan invaders or native invaders (28%). Plants with both

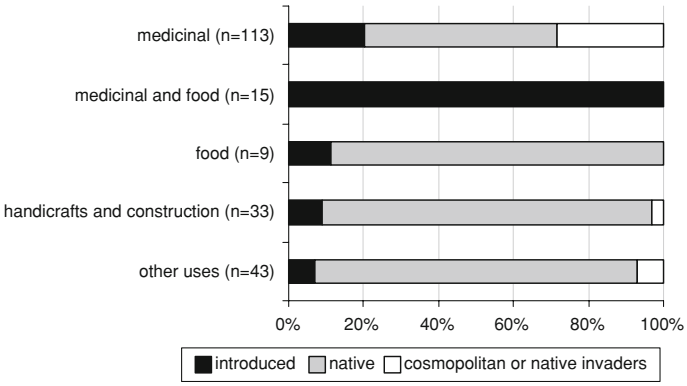

Fig. 2 Main uses and percentages of 213 plant species classified as being introduced, native, or cosmopolitan or native invaders, identified by 17 key informants rom São Paulo Bagre and Pedrinhas, South coast of São Paulo state

medicinal and edible characteristics were all introduced (Fig. 2). Begossi et al. (2002) and Bennett and Prance (2000) discussed the importance of introduced plants in local pharmacopoeias, for Amerindians as well as for mixed people like Brazilian Caboclos and Caiçaras.

However, this picture presents an overview of the species known and used for multiple purposes, and with different management degrees. Hanazaki et al. (2005) discussed different management categories for plants used by Caiçaras, varying from plants with little or no management (collected from native vegetation); plants facilitated by human management (occurring from the borders of native vegetation until anthropogenic areas, agricultural fields, orchards or home gardens); infrequently cultivated plants (occurring in anthropogenic areas, agricultural fields, orchards or home gardens); and frequently cultivated plants (occurring in agricultural fields, orchards or home gardens).

The majority of the plants contributing to the richness illustrated on Fig. 1 belong to the first management category, or at most to the second one. These plants are not used frequently, such as medicinal plants or plants for handicrafts and construction. A small number of species are facilitated by human management, and in this category we stress the importance of the growing extractive activities focusing ornamental plants for commerce, especially in the South part of São Paulo state. Ornamental plants extraction is a growing economic activity. The main resources collected are many Briophyte species (including *Schlotheimia rugifolia* (Hook.) Schwaegr., *Campylopus lamellinervis* (C. Muell.) Mitl., *C. trachyblepharon* (C. Muell.) Mitl., *Syrrhopodon leprieuirii* Mont., *Sphagnum recurvum* P. Beauv. and *S. capillifolium* (Ehrh.) Hedw.), and ferns (*Rumohra adiantiformis* (G. Forst.) Ching). A brief discussion of the extraction of non-timber forest resources can be found in Begossi et al. (2000). Other activities related to fisheries can also include the extraction of plant species, such as the building of canoes and fishing traps. There are many fixed fishing traps in the estuarine region of the South coast of São Paulo state, which depend on a considerable amount forest resources (stakes, poles and bamboos) (Oliveira 2007). In other parts of Brazilian Atlantic forest, extraction of non-timber forest resources is an important and intense economic activity, which is influenced by (and also cause influences to) the ecological dynamics of succession (Baldauf et al. 2007).

Analyzing in depth the latter management category (frequently cultivated plants), the scenario depicted by the richness of plants known and used is insufficient. The agricultural

systems in São Paulo state coast are currently characterized by cultivation of cassava (*Manihot esculenta* Crantz), yams (*Dioscorea* spp.) and sweet potatoes (*Ipomoea batatas* Poir.) as the main crops. However, many varieties of these species can be managed in a restricted area. For example, Peroni and Hanazaki (2002) found 261 varieties of the 53 crop species among 33 Caiçara farmers, illustrating this poly-specific and poly-varietal characteristic (Table 1).

The analysis of agrobiodiversity allows us to formulate questions to explicit the relationships between fisher-farmers, plant species, and the environment. Questions related to the maintenance of varieties have been widely discussed, emphasizing Amazonian people (see, for example, Kerr and Clement 1980; Martins 2001; Pinton and Emperaire 1999). These studies have shown the maintenance of a high number of species and varieties under cultivation, as well as a wide use of the environment to its reproduction. On Atlantic forest

Table 1 Species and varieties cultivated by 33 Caiçara households from 16 communities at Cananéia-Iguape region, South coast of São Paulo state, Brazil (modified from Peroni and Hanazaki 2002)

Crop	Scientific name	Family	NV[a]	Origin[b]
Mandioca	*Manihot esculenta* Crantz	Euphorbiaceae	51	Neotropics
Batata-doce	*Ipomoea batatas* Poir.	Convolvulaceae	21	Neotropics
Cará	*Dioscorea* spp.	Dioscoreaceae	21	Africa and Neotropics
Banana	*Musa X paradisiaca* L.	Musaceae	20	Asia
Cana	*Saccharum officinarum* L.	Poaceae	18	Africa
Feijão	*Phaseolus vulgaris* L.	Fabaceae	5	Neotropics
Arroz	*Oryza sativa* L.	Poaceae	3	Asia
Taiá	*Xanthosoma sagittifolium* Schott	Araceae	3	Neotropics
Abóbora	*Cucurbita pepo* L.	Cucurbitaceae	2	Neotropics
Milho	*Zea mays* L.	Poaceae	2	Neotropics
Abacaxi	*Ananas comosus* Merr.	Bromeliaceae	1	Neotropics
Araruta	*Maranta arudinacea* L.	Marantaceae	1	Neotropics
Inhame[c]	*Xanthosoma* sp. 2	Araceae	1	Neotropics
Mangarito	*Xanthosoma* sp. 1	Araceae	1	Neotropics
Melancia	*Citrullus lanatus* (Thunb.) Matsum. e Nakai	Cucurbitaceae	1	Africa
Pepino	*Cucumis sativus* L.	Cucurbitaceae	1	Africa
Tomate	*Lycopersicon esculentum* Mill	Solanaceae	1	Neotropics
Other[d]			36	
Total			189	

[a] NV = number of varieties

[b] According to Brücher (1992)

[c] Can also correspond to *Dioscorea* sp. and *Colocasia esculenta* L.

[d] Other species: almeirão (*Cichorium endivia* L.); cajú (*Anacardium occidentale* L.); abacate (*Persea americana* Mill.), acelga (*Beta vulgaris* L. var. *cicla* L.), alface (*Lectuca sativa* L.), alho (*Allium sativum* L.), amendoim (*Arachis hypogaea* L.), ata (*Annona squamosa* L.), bucha (*Luffa* spp.), cabaça (*Lagenaria vulgaris* Ser.), café (*Coffea arabica* L.), cebola (*Allium cepa* L.), couve (*Brassica oleraceae* L. var. *acephala* DC.), graviola (*Annona muricata* L.), inhame (Colocasia esculenta) jaca (*Artocarpus integrifolia* L.), jiló (*Solanum gilo* Raddi), laranja (*Citrus sinensis* (L.) Osbeck), limão (*Citrus aurantifolia* Swingle), mamão (*Carica papaya* L.), manga (*Mangifera indica* L.), maracujá (*Passiflora edulis* Sims), palmito (*Euterpe edulis* Mart.), pimentão (*Capsicum annuum* L.), pitanga (*Eugenia uniflora* L.), salsinha (*Petroselinum sativum* L.), uva (*Vitis vinifera* L.), abacaxi-do-mato (*Ananas* sp.), açafrão or safroa (not identified), cenoura (*Daucus carota* L.), couve flor (*Brassica oleracea* L.), pepinel (maxixe) (*Cucumis anguria* L.), quiabo (*Hibiscus esculentus* L.), and vagem (Leguminosae, not identified)

region, studies focusing the agriculture of Fisher-farmers such as Caiçara people had been done by Adams (2000), Peroni and Hanazaki (2002), Peroni and Martins (2000), Sanches (2001), Peroni et al. (2007). These studies show correspondences and homologies between farming people in Brazil, especially regarding Caiçaras from Atlantic forest and Caboclos from the Amazon.

Under the point of view of the landscape management, itinerant agriculture can keep coherence on the way species and environments are managed, with inter-relationships between cultivation activities and the evolutionary dynamics of the species (Peroni and Martins 2000; Martins 2001; Peroni et al. 2007). As well as at Amazonian swiddens, at Caiçara swiddens there is an heterogeneous assemblage of species, determining patterns of composition due to the farmer's ability of combine different ecological characteristics: in a single swidden co-exist species with different architecture (plant height, types of branching, foliar composition), suggesting the use of different strata of luminosity. According to Martins (2001), different root systems also exploit different depths in the soil, suggesting patterns of association below the ground level. In this way, species association minimizes competition and maximizes the use of limited resources (light, water and nutrients) (Martins 2001).

5 Agrobiodiversity at the North and South coasts of São Paulo state

Comparing the agrobiodiversity at the North and South coasts of São Paulo state, the two studied regions differ in some aspects such as the production destiny. At the South there is a predominance of direct subsistence agricultural activities, while at the North there are both communities with some subsistence agricultural activities and communities with an emphasis to flour production directed to commerce (Table 2). At North region cassava is also a part of the local economy, along with bananas (*Musa* spp.), in addition to being used for household consumption.

In the agricultural communities from the North region, farmers cultivate poly-varietal crops with a predominance of cassava and banana (*Musa* spp.). Through data collected in the interviews we summed a total of 156 citations of 68 varieties of cassava with exclusive vernacular names at North region. The separation between sweet ("doces", "mansas" or "*aipins*") from bitter ones ("amargas" or "*mandioca brava*") do not present a strong dichotomy as in other regions of São Paulo state coast (Peroni et al. 2007), since the suffix "*aipim*" is not necessarily used to name a sweet variety (*ipin*). There is a predominance of bitter varieties (62%), despite the occurrence frequencies among farmers indicated that sweet varieties are better shared. The varieties free listing analysis revealed that in average 7 varieties per local were cited ($3 \leq n \leq 16$), revealing a high average of varieties per sample unit when compared to other places in Brazil (Emperaire and Peroni 2007).

At North region, despite the preference for bitter varieties for flour processing, the most frequent varieties were the sweet ones, which can be used after cooking. However, flour is processed with a pool of varieties, including bitter and sweet ones, and with no preference for a specific type of flour. Cassava flour is the main product made in the studied places, mainly in Ubatumirim. Regarding varieties salience, the first four ones were sweet: "*Ipi-preto*", "*Amarelinha*", "*Santista*", and "*Vassourinha*". Thirty-two varieties were cited per more than one farmer, while the other 34 were cited only once (corresponding to singletons), demonstrating that more than 50% of the cultivated varieties are rare.

At the South coast there were 160 citations of 58 varieties with exclusive vernacular names. In the average, farmers cited 7 varieties per local ($2 \leq n \leq 13$), with a clear separation between sweet and bitter varieties. South coast farmers prefer to use sweet

Table 2 General characteristics of the two studied regions at the São Paulo state coast, Brazil, focusing on the different environments

	South	North
Distance from communities to the coast line	0 km	0–3 km
Coast characteristics	Large coastal plain influencing the formation of a single large estuarine region with flat relief	Narrow coastal plain, with river mouths consisting in small and restricted estuaries; mountains near the coastline
Main economy activities	Fishing, tourism, plant extraction	Tourism, fishing, agriculture (in some cases)
Main crop	Cassava	Banana and cassava
Use category of the closest governmental conservation area[a]	Sustainable use	Integral protection
Distance to paved road	0–3 km	1–3 km
Distribution of agriculturists (householders)	Disperse	Grouped

[a] Based on Brazilian official management and conservation categories (SMA 1998)

varieties, since the bitter varieties management needs subsequent phases for flour processing. The flour processing activities were unstructured along the time, mainly because the lack of manpower and changing economic activities (Peroni and Hanazaki 2002). Sweet varieties can be eaten cooked and most of them have a short cycle to be harvested. The most salient varieties were: "*aipim vassourinha*"; "*mandipoia*" (bitter); "*cascuda*" (bitter) and "*aipim manteiga*". Most varieties can be considered rare because they were cited by only one farmer (74%).

A schematic map was built in order to summarize the differences between North and South coast regarding agrobiodiversity and the factors influencing conservation and loss of varieties in both regions (Fig. 3). South region is currently characterized by an intense loss of varieties (Peroni and Hanazaki 2002). In contrast, in North region there are some particularities associated to the cassava flour market and to the local organization of farmers towards the defense of their ownership to use traditional areas (Devide 2004; Raimundo 2001). Traditional farmers were not found at the central part of São Paulo State coast indicating the low probability to find agrobiodiversity there, probably because of the high degree of urbanization.

There was a weak correspondence between morphological characteristics and the folk dichotomous classification that divides cassava varieties in bitter and sweet. At the South region, the suffix "*aipim*" is an explicit language marker of sweet varieties, while at the North this suffix is not necessarily used to name a sweet variety. The cassava diversity is centered within groups, making the regional differences less expressive. The absence of richness differences between North and South regions points out continuity in the varieties distribution along São Paulo state coast.

Both in the North and South regions the policies for conservation of agrobiodiversity are not coped with the policies for biological conservation and it have different implications. At the South region, the farmers are overlapped with sustainable use conservation units, which have some flexibility in allowing agricultural practices. However, there are others pressures towards agrobiodiversity loss at the South region, related to factors such as

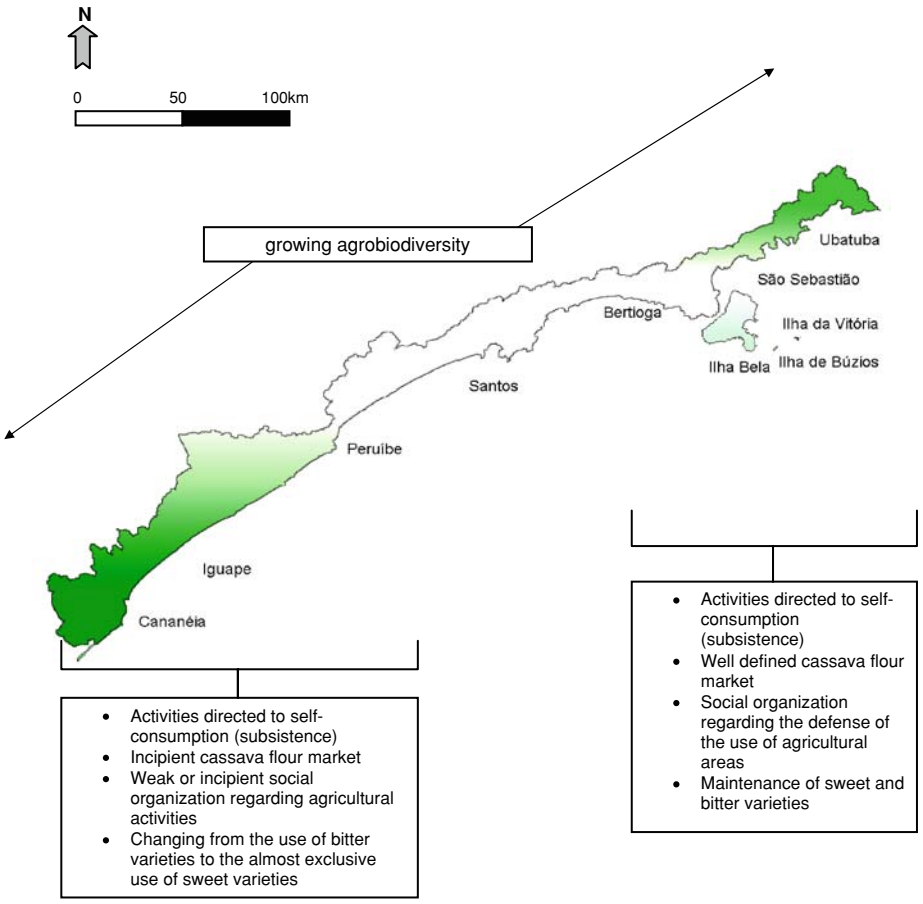

Fig. 3 Analytic representation of the distribution of cassava varieties along the São Paulo state coast. Darker colors indicate a higher probability to find varieties, based on the average number of varieties in each region.

economic changes, land tenure conflicts and lack of valorization of the traditional agriculture knowledge (Hanazaki et al. 2007; Peroni and Hanazaki 2002). The scenario at the North region involves environmental conflicts, because the use category of the closest governmental conservation area is of integral protection, for biodiversity conservation purposes. At North region, agricultural production directed to commerce of cassava flour implies in constant pressures towards forest areas for swidden cultivation practices, challenging the biological conservation aims. However, the agrobiodiversity conservation depends on these practices, and the high incidence of rare varieties cannot be neglected.

The cassava agrobiodiversity cultivated by Atlantic forest farmers is medium to high when compared to Amazonian sites, which corresponds to its probable center of origin.

Considering the agrobiodiversity, the results shown in this paper stresses the characteristic of a poly-varietal agricultural system in which the greatest part of the cultivated diversity is concentrated within groups. This characteristic reinforces the needs for in situ and *on farm* approaches, regionally distinct and adjusted for specific contexts, in order to assure the agrobiodiversity conservation.

The information about species use and management are scant, although its complexity to satisfy use and management strategies coped with biological conservation is needed, because traditional farmers are usually seen as restraints for biological conservation of forested areas (Redford and Padoch 1992; Brandon et al. 1998). A simpler and problematic alternative has been to impede the continuity of farmers' activities, having as consequences the interruption of their agricultural activities and the genetic erosion in the context of agrobiodiversity (Peroni and Hanazaki 2002). The risks of loosing species and varieties have been more and more increased due to factors related to conflicts on species conservation and on the establishment of conservation areas without the human direct influence.

6 Dynamic systems operating in the relationships between fishers and plants

Schematic models facilitate the comprehension of complex systems and aim to systematize the relationships among inter-related components. In an ethnobotanical context, for example, such representations could show the relationships of spatial distribution related to management actions, where the physic structure of a system can be exposed (Hanazaki et al. 2007). Figure 4 shows the functional relationships inside a system of multiple plant uses and management directed to different purposes. The model is a simplification of use categories related to two causal variables: the intensity or frequency of use and the management degree of plant species.

Along this article, we moved from the first category (I) toward the last one (IV), emphasizing that fisher-farmers manage an assemblage of species from different use categories and with different degrees of use and management. The four boxes from Fig. 4 can be exemplified by groups of plants according to their purposes, such as medicinal plants

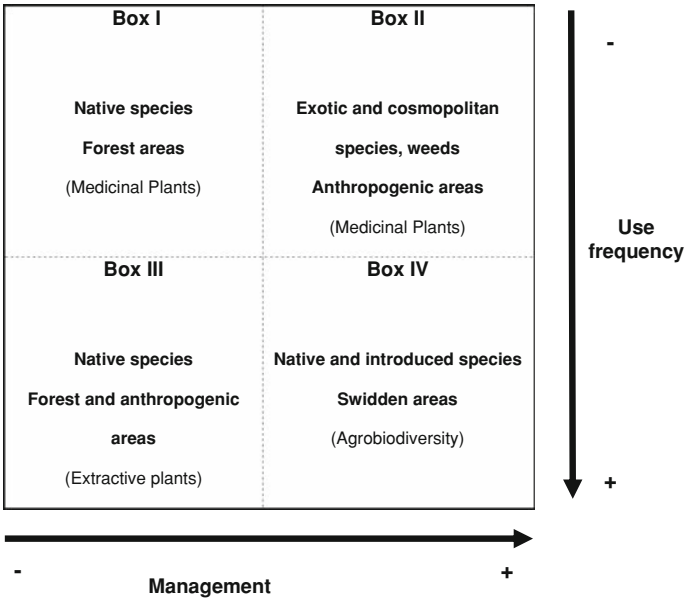

Fig. 4 General model of main categories of plants related to its use intensity (frequency of use) and management degree, for plants used by fisher-farmers from southeastern Brazilian coast

and plants for food. Medicinal plants, and plants use for both medicine and food (usually trees with edible fruits), for example, can be found in Box I when corresponds to infrequently used native species, such as quina (*Quina glaziovii* Engl.) and bacupari (*Garcinia gardneriana* (Planch. & Triana) D.Zappi), and also with a low degree of management. According to Clement's discussion of plant domestication (Clement 1999), the plants in this category are wild ones in pristine landscapes.

Medicinal plants can also be found in Box II, such as many cosmopolitan or native invader species which occupies anthropogenic environments. Examples of these species are quebra-pedra (*Phyllanthus* spp.), erva-moura (*Solanum americanum* Mill.), and erva-de-santa-maria (*Chenopodium ambrosioides* L.). This pattern described for Box II reflects the association between anthropogenic habitats and weeds used as medicinal plants (Stepp 2004; Stepp and Moerman 2001), and approaches to the incidentally co-evolved plants in promoted or, in some cases, managed landscapes (Clement 1999).

Examples of species with a low management degree but with high use intensity, or frequently used ones, are the species extracted for commercial purposes (Box III, Fig. 4). Briophyte species, ornamental ferns (*Rumohra adiantiformis* (G. Forst.) Ching) and some species from Myrtaceae family extracted to build fish traps in the South coast (Oliveira 2007) can fit this category. The management actions, when present, are incipient, and can vary among extractors. For an Atlantic forest region at Rio Grande do Sul, Baldauf et al. (2007) described different types of extractors, with different degrees of management actions, since the simple gathering of leaves until actions to stimulate its sprouting. This is the case of incidentally co-evolved to incipiently domesticated species in managed or fallow landscapes (Clement 1999). At North region, species belonging to Box III were not observed.

The increase of the management degree is related to an increase in the manipulation degree of ecological organization levels in which human actions and activities takes place. The manipulation of species populations, sometimes isolated, occur in a lower management degree, while intensive actions and activities can happen in a higher level of communities of species. Thus, the increase in the management degree is directly related to different organization levels, from populations to communities (Box IV, Fig. 4). Following Clement (1999), these species can be considered the semi-domesticated or domesticated ones, in cultivated swidden-fallow areas. The opening of a swidden cultivation area illustrates an activity of gap opening inside the forest, introducing a dynamic disturbance factor in the surrounding plant community. In the case of the agrobiodiversity cultivated inside these swiddens, the management level is high, and the influences of such actions are quite complex (Martins 2001; Peroni and Martins 2000). Even considering that cultivation actions do not have a direct relationship with domestication degree, or that species submitted to cultivation are not necessarily domesticated (Harlan 1992), in this model the agrobiodiversity comprehends species with a high domestication level and a high intraspecific diversity. Agrobiodiversity adds, thus, a vertical component to this model, since the management activities amplifies the intra-populational diversity of species inside swidden areas. Among fisher-farmers, the plant species with high intensity of management are those used within the context of swidden areas, such as cassava (*Manihot esculenta* Crantz.), species from Araceae family (genus *Xanthosoma* and *Colocasia*), sweet potatoes (*Ipomoea batatas* Poir), and banana (*Musa* spp.) (Peroni and Hanazaki 2002). Species belonging to Box IV are also good candidates for on-farm conservation, following the discussions of Bellon et al. (2003), considering its contribution to genetic diversity of the crop populations and their increasing utility to farm households.

North and South contrasts regarding Caiçara ethnobotany are marked by the diminishing agricultural activities at South, coped with an apparent increase on the use of plants extracted for commerce. By the other hand, at the North coast, we can still find places of maintenance for farmer activities. In the proposed model, ethnobotany of fisher-farmers from North and South coasts both rely on Boxes I and II, but Box III is more related to South and Box IV is related mainly, but not exclusively, to North.

Ethnobotany of fisher-farmers deals with a complex of relationships between people and plants. With this model, we synthesize such complex in a small part of those relationships. It is important to notice that this proposed framework owns a dynamic component, when a temporal dimension is considered. In addition to external economic changes affecting local livelihoods (Hanazaki et al. 2007) among Caiçara fisher-farmers the inter-related activities are more or less intensified according to the availability and seasonability of the resource, to the acceptance of such resource on local markets, and to the dynamic of the knowledge about the resource.

Acknowledgements We are grateful to the Brazilian agencies that provided financial support to this research: FAPESP 03/13688-9 (N. Peroni); FAPESP 04/02301-9 e 01/05263-2 and CNPq productivity scholarship (A. Begossi). Finally, we are very grateful to all interviewed people from the Caiçaras' communities.

References

Adams, C. (2000). As roças e o manejo da Mata Atlântica pelos caiçaras: uma revisão. *Interciencia, 25*, 143–150.

Alcorn, J. (1995). The scope and aims of ethnobotany in a Developing World. In R. E. Schultes & S. von Reis (Eds.), *Ethnobotany, evolution of a discipline* (pp. 23–39). Portland: Dioscorides Press.

Araújo, L. G. (2001) Diversidade de uso de recursos vegetais em duas comunidades Caiçaras da Estação Ecológica Juréia – Itatins, litoral sul de São Paulo. Dissertation, Universidade Estadual Paulista Júlio de Mesquita Filho, Brazil.

Baldauf, C., Hanazaki, N., & Reis, M. S. (2007). Caracterização etnobotânica dos sistemas de manejo de samambaia-preta (*Rumohra adiantiformis* (G.Forst) Ching- Dryopteridaceae) utilizados no sul do Brasil. *Acta Botanica Brasilica, 21*, 823–834.

Balée, W. (1994). *Footprints of the forest*. New York: Columbia University Press.

Balick, M. J., & Cox, P. A. (1996). *Plants, people and culture*. New York: Scientific American Library.

Begossi, A. (1998). Resilience and neotraditional populations: the Caiçaras of the Atlantic forest coast and Caboclos of the Amazon (Brazil). In C. Folke & F. Berkes (Eds.), *Linking ecological and social systems: Management practices and social mechanisms for building resilience* (pp. 129–157). Cambridge: Cambridge University Press.

Begossi, A. (2006). The ethnoecology of Caiçara metapopulations (Atlantic forest, Brazil): Ecological concepts and questions. *Journal of Ethnobiology and Ethnomedicine, 40*, 2–9.

Begossi, A., Hanazaki, N., & Peroni, N. (2000). Knowledge and use of biodiversity in Brazilian hot spots. *Environment, Development and Sustainability, 2*, 177–193.

Begossi, A., Hanazaki, N., & Tamashiro, J. Y. (2002). Medicinal plants and the Atlantic forest (Brazil): Knowledge, use and conservation. *Human Ecology, 30*, 281–299.

Begossi, A., Leitão-Filho, H. F., & Richerson, P. J. (1993). Plant uses at Búzios Island. *Journal of Ethnobiology, 13*, 233–256.

Bellon, M. R. (1996). The dynamics of crop infraespecific diversity: A conceptual framework at the farmer level. *Economic Botany, 50*, 26–39.

Bellon, M. R., Berthaud, J., Smale, M., Aguirre, J. A., Taba, S., Aragón, F., Díaz, J., & Castro, H. (2003). Participatory landrace selection for on-farm conservation: An example from the Central Valleys of Oaxaca, Mexico. *Genetic Resources and Crop Evolution, 50*, 401–416.

Bennet, B. C., & Prance, G. T. (2000). Introduced plants in the indigenous pharmacopoeia of northern South America. *Economic Botany, 54*, 90–102.

Brandon, K., Redford, K. H., & Sanderson, S. F. (1998). *Parks in Peril: People, politics, and protected areas*. Covelo: Island Press.

Brücher, H. (1992). *Useful plants of neotropical origin (and their wild relatives)*. Berlin: Springer-Verlag.
Caballero, J. (1992). Maya homegardens: Past, present and future. *Etnoecológica, 1*, 35–54.
Ceccarelli, S. (1994). Specific adaptation and breeding for marginal conditions. *Euphytica, 77*, 205–219.
Clement, C. R. (1999). 1492 and the loss of Amazonian crop genetic resources. I. The relation between domestication and human population decline. *Economic Botany, 53*, 188–202.
Dean, W. (1995). *With broadax and firebrand: The destruction of the Brazilian Atlantic forest*. Berkeley: University of California Press.
Devide, A. C. P. (2004). Sertão do Ubatumirim e o plano de manejo do Prque estadual da Serra do Mar: caracterização sócio-ambiental. Mestrado (Thesis), UFLA, Lavras (MG).
Diegues, A. C. (1983). *Pescadores, camponeses e trabalhadores do mar*. São Paulo: Ática.
Emperaire, L. & Peroni, N. (2007). Traditional management of agrobiodiversity in Brazil: A case study of Manioc. *Human Ecology, 35*, 761–768.
Etkin, N. L. (1998). Indigenous patterns of conserving biodiversity: Pharmacologic implications. *Journal of Ethnopharmacology, 63*, 233–245.
Fox, J., Troung, D. M., Rambo, A. T., Tuyen, N. P., Cuc, L. T., & Leisz, S. (2000). Shifiting cultivation: A new old paradigm for managing tropical forests. *BioScience, 50*, 521–528.
Hanazaki, N., & Begossi, A. 2003. Fishing and niche dimension for food consumption of Caiçaras from Ponta do Almada (Brazil). *Human Ecology Review, 7*, 52–62.
Hanazaki, N., Castro, F., Oliveira, V. G., & Peroni, N. (2007). Between the sea and the land: The livelihood of estuarine people in Southeastern Brazil. *Ambiente e Sociedade, 10*, 121–136.
Hanazaki, N., Peroni, N., & Begossi, A. (2005). Edible and healing plants in the ethnobotany of native inhabitants of the Amazon, Atlantic forest areas of Brazil. In A. Pieroni & L. L. Price (Eds.), *Eating and healing—traditional food as medicine* (pp. 251–271). Binghamton: Haworth Press.
Hanazaki, N., Tamashiro, J. Y., Leitão-Filho, H. F., & Begossi, A. (2000). Diversity of plant uses in two Caiçara communities from Atlantic forest coast, Brazil. *Biodiversity and Conservation, 9*, 597–615.
Harlan, J. R. (1992). *Crops and man*. Madison: American Society of Agronomy, Crop Science Society of America.
Kerr, W. E., & Clement, C. R. (1980). Práticas agrícolas de conseqüências genéticas que possibilitaram aos índios da Amazônia uma melhor adaptação às condições ecológicas da região. *Acta Amazônica, 10*(2), 251–261.
Martensen, A. C., Pimentel, R. G., & Metzger, J. P. (2003). Impacts of forest deforestation and fragmentation on the understory bird community in the Atlantic Rain Forest of Brazil. Paper presented at the 18th Annual Symposium of the International Association for Landscape Ecology, Banff.
Martins, P. S. (2001). Dinâmica evolutiva em roças de caboclos amazônicos. In I. C. G. Vieira, J. M. C. Silva, D. C. Oren, & M. A. e DÍncao, (Eds.), *Diversidade biológica e cultural da Amazônia* (pp. 369–384). Belém: Museu Paraense Emílio Goeldi.
Mussolini, G. (1953). Aspectos da cultura e da vida social do litoral brasileiro. *Revista de Antropologia*, *1*, 81–97.
Mutchnick, P. A., & McCarthy, B. C. (1997). An ethnobotanical analysis of the tree species common to the subtropical moist forests of the Peten, Guatemala. *Economic Botany, 51*, 158–183.
Oliveira, F. C. (2007). Etnobotânica da exploração de espécies vegetais para confecção do cerco-fixo na região do Parque Estadual Ilha do Cardoso, SP. Dissertation, Universidade Federal de Santa Catarina.
Peroni, N. (2004). Ecologia e genética da mandioca na agricultura itinerante do litoral sul paulista: uma análise espacial e temporal. PhD. Dissertation, Campinas (BR), UNICAMP.
Peroni, N., & Hanazaki, N. (2002). Current and lost diversity of cultivated varieties, especially cassava, under swidden cultivation systems in the Brazilian Atlantic forest. *Agriculture, Ecosystems and Environment, 92*, 171–183.
Peroni, N., Kageyama, P. Y., Begossi, A. (2007). Molecular differentiation, diversity, and folk classification of "sweet" and "bitter" cassava (*Manihot esculenta*) in Caiçara and Caboclo management systems (Brazil). *Genetic Resources and Crop Evolution, 54*, 1333–1349.
Peroni, N., & Martins, P. S. (2000). Influência da dinâmica agrícola itinerante na geração de diversidade de etnovariedades cultivadas vegetativamente. *Interciência, 25*, 22–29.
Pinton, F. & Emperaire, L. (1999). Pratiques agricoles et commerce du manioc sur un front de colonisation (Amazonie brésilienne). In S. Bahuchet, D. Bley, H. Pagezy, & N. Vernazza-Licht (Eds.), *L'Homme et la forêt tropicale. Travaux de la Societé dÉcologie Humaine* (pp. 347–362). Éditions de Bergier.
Raimundo, S. 2001. Nos bananais de Ubatuba (SP): dilemas e desafios para a gestão de unidades de conservação de proteção integral com comunidades tradicionais residentes. Mestrado (Thesis), USP, São Paulo, (SP).
Redford, K., & Padoch, C. (1992). *Conservation of Neotropical forests*. New York: Columbia University Press.

Rossato, S. V., Leitão-Filho, H. H., & Begossi, A. (1999). Ethnobotany of caiçaras of the Atlantic forest coast (Brazil). *Economic Botany, 53*, 377–385.

Sanches, R. A. (2001). Caiçara communities of the Southeastern coast of São Paulo state (Brazil): Traditional activities and conservation policy for the Atlantic rain forest. *Human Ecology Review, 8*, 52–64.

Schaeffer-Novelli, Y., Mesquita, H. S. L., & Cintrón-Molera, G. (1990). The Cananéia Lagoon estuarine system, São Paulo, Brazil. *Estuaries, 13*, 193–203.

Schmidt, C. B. (1958). *Lavoura Caiçara*. Rio de Janeiro: Serviço de Informação Agrícola.

Schultes, R. E., & von Reis, S. (1995). *Ethnobotany, evolution of a discipline*. Portland: Dioscorides Press.

SMA. Secretaria do Meio Ambiente do Estado de São Paulo. (1998). *Atlas das unidades de conservação ambiental do Estado de São Paulo*. São Paulo: Metalivros.

Stepp, J. R. (2004). The role of weeds as sources for pharmaceuticals. *Journal of Ethnopharmacology, 92*, 163–166.

Stepp, J. R., & Moerman, D. E. (2001). The importante of weeds in ethnopharmacology. *Journal of Ethnopharmacology, 75*, 19–23.

Talora, D. C., & Morellato, P. C. (2000). Phenology of coastal-plain forest tree from Southeastern Brazil. *Revista Brasileira de Botânica, 23*, 13–26.

Uniyal, S. K., Kumar, A., Lal, B., & Singh, R. D. (2006). Quantitative assessment and traditional uses of high value medicinal plants in Chhota Bhangal area of Himachal Pradesh, western Himalaya. *Current Science, 91*, 1238–1242.