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BOTANIC GARDENS AND THEIR ROLE IN PLANT BIODIVERSITY CONSERVATION

Kebun Raya dan Peranannya dalam Pelestarian Keanekaragaman Hayati Tumbuhan

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RINGKASAN

Kebun raya telah memainkan peranan penting dalam kebudayaan dan peradaban manusia. Kebun raya dalam arti koleksi spesimen tumbuhan hidup tumbuh dan berkembang untuk berbagai tujuan, antara lain: pendidikan, rekreasi, ekonomi, obat-obatan dan berbagai tujuan ilmiah lainnya. Dalam bidang konservasi, kebun raya di Indonesia, bersama-sama dengan arboreta, Taman Hutan Raya, dan kebun koleksi lainnya, berfungsi sebagai tempat konservasi eksitu bagi sumberdaya tumbuhan. Namun peranan ini nampaknya masih jauh dari yang diharapkan, khususnya menyangkut upaya pelestarian keanekaragaman genetik tumbuhan dan pemanfaatan sumberdaya tumbuhan yang berkesinambungan, bahkan saat ini beberapa kebun raya cenderung berubah fungsi sekedar sebagai taman rekreasi.

Berdasarkan hal di atas, reevaluasi konsep, tujuan dan bagaimana mencapai tujuan kebun raya bagi konservasi ragam-hayati tumbuhan sangat diperlukan, baik di tingkat lokal, nasional maupun internasional. Dalam hal ini, reevaluasi harus didasarkan atas pertimbangan-pertimbangan ekologi. Beberapa konsep ekologi tumbuhan yang penting dipertimbangkan antara lain: spesies sebagai unit ekologi, populasi yang *viable*, genetika populasi, interaksi spesies dan variasi geografis. Reevaluasi ini akan menghasilkan pendekatan baru bagi pengelolaan kebun raya di Indonesia.

INTRODUCTION

William Conway (1988) once wrote: "In the preservation of biological diversity (biodiversity), the use of technology is a last resort. When the preservation of ecosystems falters, their fragments may have to be cared for piece by piece". However, further he said that intensive care and biotechnology can preserve some diversity that would otherwise be lost. But the greatest dimension of such preservation is depressingly slight compared with that which can be or could have been sustained in adequately designed and protected nature reserves and by understanding accomodation outside preserved areas.

The role of *ex situ* conservation technologies for biodiversity preservation then should be clearly defined. It should be understood that *ex situ* conservation is an ancillary to *in situ* conservation, not an alternative (Ashton, 1988, 1987). However, determining the role of Botanic Gardens in the conservation of plant biodiversity should not be based merely on botanical considerations, but it should strongly consider the ecological characteristics, which will further, determine the genetic diversity of the plant populations in a certain geographical region. Re-evaluation of concept, objectives and how to achieve the objectives of Botanic Gardens are then required and should be

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directed to make the concept clearer in the conservation network, whether at local, national or international level.

Indonesia is a very species-rich country, and although it occupies only 1.3% of the world's land area, it possesses up to 17% of the total number of species in the world. Precise numbers are hard to obtain for most taxonomic groups, but at a minimum Indonesia can be said to have about 11% of the world known flowering plants. Many Indonesian plant species are widely distributed and occupy a range of different habitats, often involving adaptation to local conditions reflected in different genetic make-up between various populations (Indonesian Biodiversity Country Study, 1992). Examples include *Pometia pinnata* which has at least 8 formae throughout its distribution range (Jacobs, 1962), *Bambusa vulgaris* and *Syzygium moluccanum*.

Indonesia's extreme-rich plant biodiversity creates a very hard and large task in conserving its existence and the genetic resources contained in each species. What then is the specific role for Botanic Gardens - a refuge of last resort, a high-risk refuge, perhaps of no escape (Ashton, 1988) - in conservation of plant biodiversity?. Instead of this question, however, the role of Botanic Gardens in biodiversity conservation has been declared to be absolutely vital (Declaration of Gran Canaria, 1987), but many scientific considerations still have to be involved and searched for to provide a sufficient basis for their management. This paper offer an alternative concept on how to achieve the objectives of plant biodiversity conservation in Botanic Gardens.

EX SITU CONSERVATION: SPECIAL REQUESTS

Ex situ conservation is simply defined as the management (or conservation) of genetic resources or species outside their natural habitat. *Ex situ* conservation methods include gene banks or cold storage facilities and other methods of cryobiological preservation of plant and animal materials, mass reservoir, and collections of individual resource stocks maintained in zoos, arboreta, Botanic Gardens, aquaria, plant or animal introduction and propagation facilities, and, for microorganisms, type culture collection.

Although it is typically a simple task to remove some wild germplasm resources (or genetic resources) from their native environments and place them in appropriate *ex situ* environments, it is impractical, if not impossible, to preserve the entire gene pool of a population, much less an entire species, by *ex situ* means. By carefully and systematically sampling the germplasm resources within a gene pool of a wild species, a significant proportion of the genetic diversity available can be adequately sampled for *ex situ* conservation (Oldfield, 1989).

From the definition of *ex situ* conservation, if Botanic Gardens were to have a significant role in the conservation of plant biodiversity, at least at the level of species and genetic diversity, there should be clear objectives which include some special requirements, namely:

1. **Search for appropriate techniques in the selection of plant collection to ensure that any collection represents rare, common, important genetic characters and highest genetic variability of a species.**
2. Establish mechanisms that allow each collection is possible to be used for the purpose of re-introduction into the wild.
3. Improve network for conserving plant biodiversity among the Botanic Gardens at national and international levels.
4. Establish cooperation between the Botanic Gardens and other institutions which are involved to *in situ* and other *ex situ* conservation of plant biodiversity.
5. Improve the role of Botanic Gardens in research, primarily aimed to obtain better techniques for managing wild populations *in situ*, and in education to increase public awareness.

The points 1 and 2 will be the focus of this paper, while the other points have been discussed by many authors (see Bramwell *et al.*, 1987; Oldfield, 1989; Ashton, 1988; Global Biodiversity Strategy, 1992).

THEORITICAL BASIS FOR *EX SITU* CONSERVATION OF PLANT BIODIVERSITY

One of the consequences of a population approach to the biology of plants is that it focuses attention at the level of individual behaviour; the population has no meaning except as the summed activities of its individuals and their interactions. Individual plants differ from each other and their difference may affect population control: "the population dynamics is continually confounded in the population genetics". Similar remarks have been made by many others to argue for a closer fusion between population ecology and population genetics (cited from various researchers after Meijden, 1989). Because it would be virtually impossible to purge all recessive deleterious alleles, large populations are necessary to keep the level of inbreeding low and maintain high levels of heterozigosity for deleterious alleles. Many populations maintained as few individuals over several generations would collapse, and most of the others would be fixed for midly deleterious genes that would impair their reproductive capacity (Ledig, 1986).

How many individuals then are necessary to maintain the full genetic integrity of a plant species of the tropical rain forests in perpetuity?. It is generally agreed that most genes do not vary at the population, or even species, level. Most variable alleles are sufficiently abundant to be adequately conserved without danger of chance extinction through random drift in artificial populations as small as 50 to 100 randomly selected individuals (Ashton, 1988). Refer to animal geneticist and considering plant breeding systems in the tropical rain forests, Whitmore (1990) suggested: "a simple but extremely crude rule-of-thumb is that a minimum population of 50 breeding adults maintains fitness in the short term, thus preserving a species frozen at one instant of time. To prevent continual loss of genetic diversity (genetic erosion) over the long term, and therefore to conserve the potential for continuing evolution, requires a big population, and a minimum of 500 breeding adults has been sugested to be necessary. This viable population of 50/500 rule is only a very rough approximation and can differ widely between species. They certainly need to be increased to allow ecotypic differentation (as occurs in many plants) for overlapping generations and restricted gene flow". Only a small amount of gene exchange is necessary to prevent drift and the decay of variation within populations (Ledig, 1986).

The genetic mechanisms underlying the maintenance, increase and loss of biodiversity proceed at the scale of the breeding population. For *ex situ* conservation planning, the unit of the breeding population is therefore clearly desirable on biological grounds. For very rare and local endemic species, this should not prove as serious a problem as among widespread and variable species, because they are generally confined to a view populations and restricted habitat ranges in which out-breeding opportunities are already severely limited. Where widespread, variable species are to be conserved, a strong case can be made for preserving infraspecific variation, particularly when eventual re-introduction into the wild is visualized (Ashton, 1988).

Although the number of individual as suggested by Whitmore (and some other authors, see Ashton, 1988) is true, we are still faced another problem, that is how they should be distributed. Is it enough to maintain genetic integrity of individual species without conserve another species that have a great association or affinity with this species. Therefore, the answer lies in the understanding of plants demography and the species association concept.

Taxonomic species, as usually used for the basis of plant collection, are not ecological tools; that is, they are not very precise indicators of a relatively narrow set of environmental ranges. Some wide-ranging species have been subdivided into regional variants (subspecies or variety), but even then the ranges often cover heterogenous areas. The concept of ecotype, in term of a group whose differences are genetically fixed, which exists in a unique habitat, and which is part of a continuous cline (a continuum of environmental gradient) of gradation (Barbour, *et al.*, 1987), is therefore very useful to be adopted as the basis of Botanic Gardens collection. Samples for conservation in Botanic Gardens need to be taken from a range of populations represent all ecotypes included and many geographic regions, therefore, if genetic variability to be adequately represented.

Ex situ conservation of small samples can be expected to lead inevitably to unpredictable genetic change. Hybridization between different population samples grown for more than one generation in isolation, and more particularly between samples from different populations, will increase the rate of these changes. The proportion of fit genotypes in progeny intended for re-introduction into the wild can thereby be greatly reduced, especially if the original wild donor populations are already small and decline, and hence already suffering an accumulation of deleterious gene combinations. For these reasons, we still lack the knowledge of establish genetically representative population samples in cultivation (Ashton, 1988).

However, attemp to establish a new role of Botanic Gardens in plant biodiversity conservation, especially conserving plant genetic diversity at species level, should be started at the near future. By carrefully and systematically sampling the genetic characters within a gene pool of a wild species, and establishing a mechanism that allow periodical genetic rejuvenation, a significant proportion of the genetic diversity available in nature can be adequately conserved in the Botanic Gardens.

TOWARD ESTABLISHING THE NEW ROLE OF BOTANIC GARDENS IN PLANT BIODIVERSITY CONSERVATION

Arboreta and Botanic Gardens are less satisfactory for *ex situ* conservation because each species is represented by view individuals (see also Figure 1). The Botanic Gardens of the humid tropics were established as centres of trial and introduction but have become increasingly less relevant to the need of agriculture and forestry. Botanic Gardens world-wide have recently awoken from a long slumber to realize that they may have a role to play in conservation, if only they can precisely define it (Whitmore, 1990). By the Declaration of Gran Canaria (Bramwell, *et al.*, 1987), they have made a start to co-ordinate their activities on conservation. In 1987 the Botanic Gardens Conservation Secretariat was established by IUCN to help coordinate their activities in plant biodiversity conservation (Collins, *et al.*, 1991).

Ex situ conservation can never conserve more than a tiny fraction of the species richness in the forests (Whitmore, 1990). However, if the appropriate techniques can be applied and the selection processes of individual collected are carried out in the right way, the *ex situ* conservation will be very helpful and valuable in the conservation of plant biodiversity. Figure 2 offers alternative that might be useful in establishing the new role of Botanic Gardens in plant biodiversity conservation, include attempt to produce individuals with high genetic variability and fitness ready for re-introduction into the wild.

Ex situ conservation in Botanic Gardens is characterized by a possibility to used its collection, in term of stock populations, for the purpose of re-introduction into the wild. Hence, Botanics Gardens have to maintain the genetic variability of its living specimens. However, Botanic Gardens should select only high priority species, namely: endangered and/or endemic species, species have or potentially have a great commercial value, important medicinal plants species, and species important in human cultures. Instead of that, many investigations concerning to population genetics to determine genetic variability, plant breeding system, plant demography, distribution pattern, species association and habitat variations, should be strongly stressed and recommended to be carried out by the Botanic Gardens itself and many other institutions related to plant biodiversity conservation.

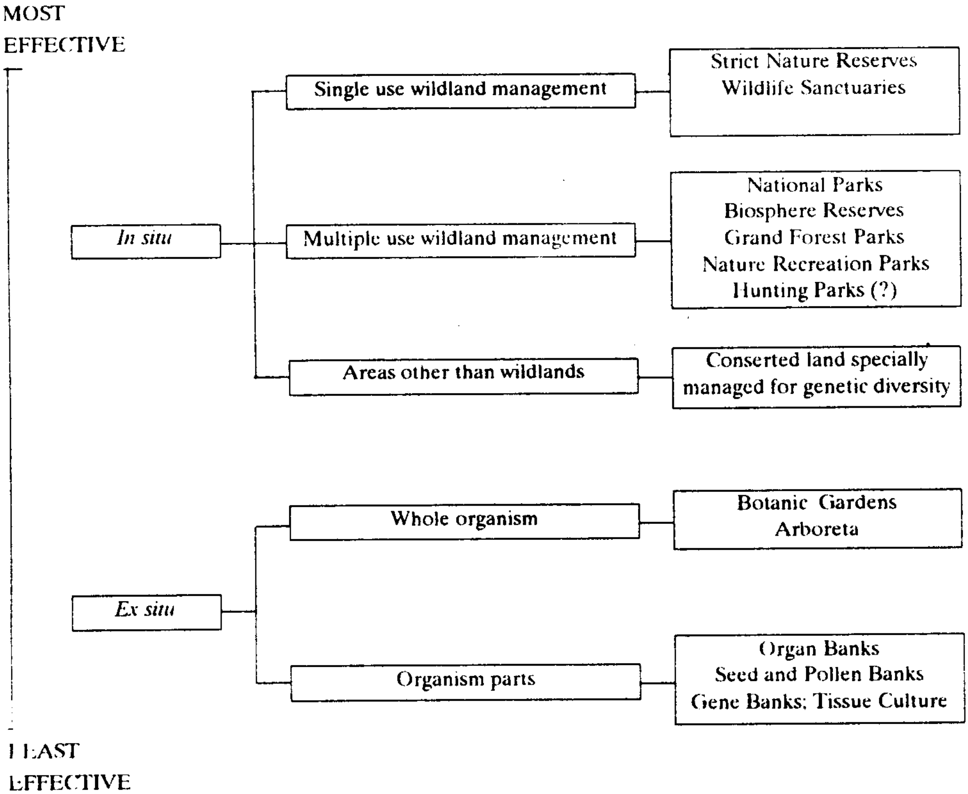

Figure 1. Different ways plant genetic diversity can be conserved (after Whitmore, 1990. Slightly modified)

Figure 2 also shown a very intensive and hard tasks and may be very expensive system. However, if the role of Botanic Gardens in the conservation of plant biodiversity would has a significant meaning, the system should be declared as one of the highest priority. As the tropical rain forest disappear through time, and consequently many species will be gone forever, if we do not start now, then it will be too late to function Botanic Gardens as one of the resorts of biodiversity conservation. However, attempts to increase the role of Botanic Gardens will be achieved only if we care to learn enough how they maintain their diversity in nature.

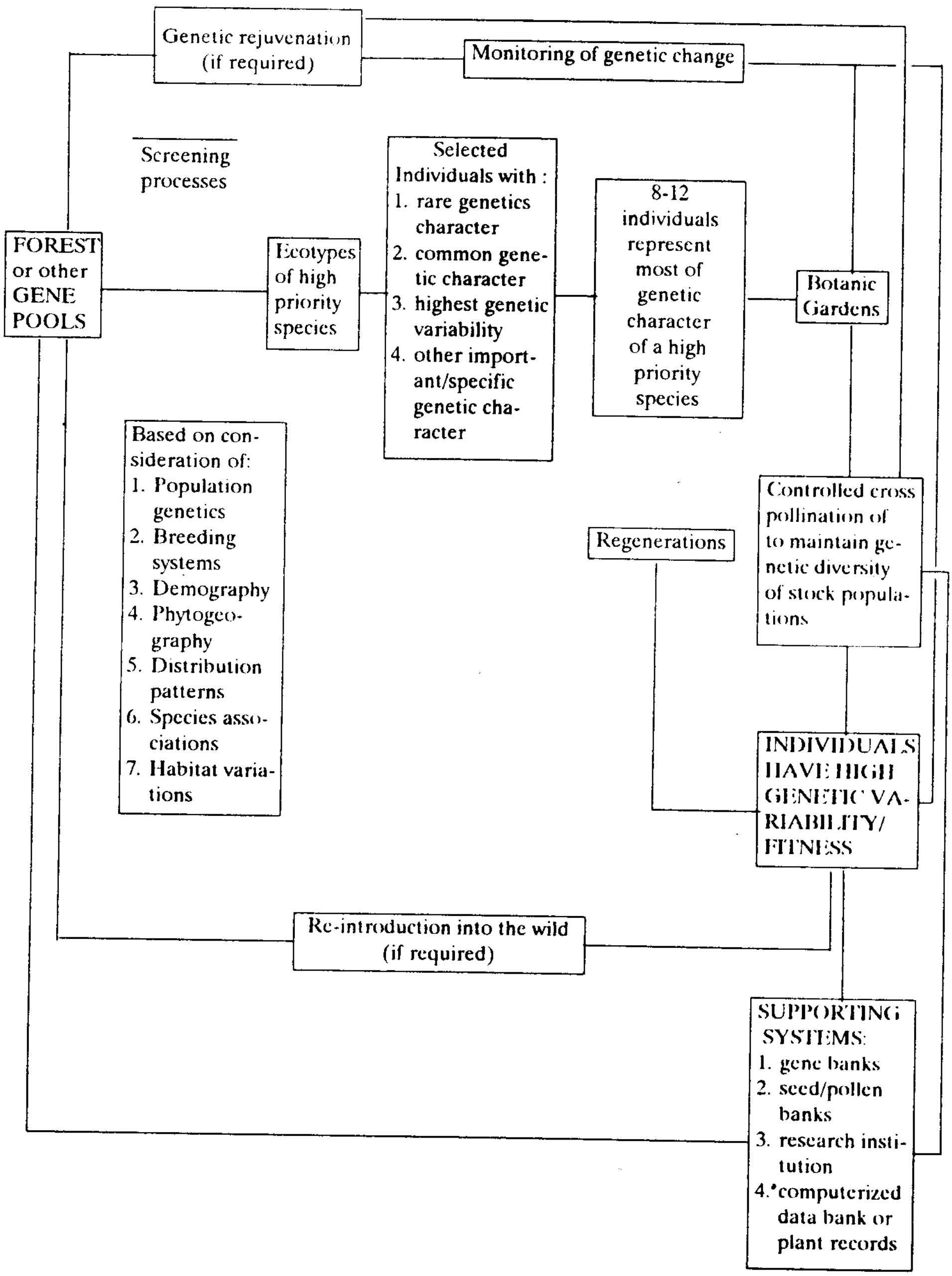

Figure 2. Alternative approach to establish a significant role of Botanic Gardens in plant biodiversity conservation

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