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What is a herb?
(with examples from the tropical "Savanna" of Brazil and the humid temperate zone of Poland)

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1. INTRODUCTION

In qualitative descriptions of the vegetation of a region, and in more quantitative phytosociological studies, an important attribute is the physiognomy of the stand. One aspect of physiognomy is structure, or the distinguishing of visibly distinct layers or strata, and the determination of the ranges of cover and height of each. The grossest distinction is between a "woody layer" (when this is present) and a ground layer. The woody layer may also include non-woody scrub forms like trunkless cacti, and persistent hard- or succulent-leaved tufts that rest on the ground, that is, acaulescent forms of palms, cycads, bromeliads, *Agave, Alöe, Yucca, Nolina, Sansevieria, Xanthorrhoea* etc., when these are large enough to stand out from the ground layer. "Ground layer" is used here in the wide sense, including what is often called the "field layer", as well as the more strict ground layer of plants which rise only a few centimeters from the soil surface. This wide sense of ground layer is often called the "herb layer", but in general it is best not to use this term since the layer often includes definitely woody plants such as *Vaccinium, Empetrum, Salix, Epigaea*, etc., only a few centimeters tall. Also, and this is the point of this paper, most dicotyledonous plants that are usually considered to be herbs are really woody plants in the sense that their stems contain secondary wood. So it becomes necessary to define "herb" more fully.

2. DEFINITIONS AND CHARACTERIZATION OF HERBS

2.1. DEFINITIONS

During many years of collecting and making species counts in the cerrado and other vegetation types of Brazil, I have come gradually to notice that in most dicotyledonous species generally termed "herbs" in plant descriptions and herbarium labels, the aerial stems have an internal, completely closed cylinder of secondary wood, i.e. derived from a continuous cambium cylinder, and therefore the stem is not really herbaceous. A real herbaceous stem of a dicot, at a particular level up from the base, would be one without secondary wood, having only primary xylem in separate vascular bundles, which may or may not have each a strand or sheath of fibers. (This represents the extreme of evolutionary reduction from the original woody stem. In some groups, like *Berberidaceae* and some *Compositae*, woodiness seems to be secondarily derived from herbaceous ancestors).

In the following account we will consider only those portions of a stem that are mature, i.e. that have stopped elongating. In terms of the woodiness of its stems, it is necessary to distinguish: 1) the basal and distal parts of a mature stem; 2) woodiness in the middle and at the end of the growing season; 3) the growth form in a particular year and the form it will have in later years; 4) growth form of the plants in relation to the environment; 5) the form of the plant in hand and the most woody form the species usually attains; 6) the most woody form the species usually attains and the more woody or taller form attained at least in some regions. In this paper we will be concerned only with the stems of a single plant at a particular moment and in a particular environment, and what the growth form is when considered for a particular whole year, not what different form it may have in later years. It is also necessary to distinguish between annual plants and perennial plants with annual stems. "Perennial" includes "breviperennial" in which the plant as a whole or a single stem lives only a few years, and "longiperennial" in which the plant or stem lives many years. When a plant always has live aerial stems, during the whole year and from one year to the next, whether these be herbaceous, semiwoody, or completely woody, it is necessary to distinguish between 1) the case of each of these stems continuing alive for only one year or less, but different stems dying at different times so that there are always live stems present, and 2) the case of each stem (or the majority of them) living for several years.

In looking up definitions of herbs and herbaceous plants, we find that authors apparently mean to say the same thing, but the words they use do not always say the same thing. Almost no author of a flora or general account of angiosperms goes into histological details. They all use a negative attribute, stating that the above-ground stem is not woody, but do not define what they mean by woody. Thus, as a mere sampling:

- GRAY (1879, p. 50): "Herbs are plants in which the stem does not become woody and persistent, but dies annually or after flowering down to the ground at least."
- FERNALD (1950, p. 1576): "Herb. A plant with no persistent woody stem above ground".
- LAWRENCE (1951, p. 755): "Herb. Plant naturally dying to the ground; without persistent stem above ground; lacking definite woody firm structure."
- BENSON (1957, p. 656): "Herb. A non-woody plant, at least one which is not woody above ground level."
- FERREN et al. (1979, p. 374, in key): Plants with no persistent woody stem above the ground. Herbaceous plants, ...".

Authors in other languages give similar definitions. It is clear that "stem" in these definitions means aerial stems (not rhizomes, tubers, xylopodia, etc., but it is not clear whether stolons (runners) are also included.

"Persistent" in these definitions obviously means that the aerial stem lives over more than one growing season, and thus over the intervening unfavourable season and therefore unless it is a winter annual, it lives for more than one year. In dicots the persistent aerial stem generally forms new shoots each growing season but this does not occur in many monocots. Persistent pachycaul plants like palms do not form new shoots but the old one continues to grow. These definitions efficiently distinguish a herb, as defined, from a persistent shrub or tree, and from the classical conception of a semishrub (Halbstrauch), which has stems with a distal herbaceous part that dies during the unfavourable season, and a persistent living basal part that produces new shoots in the following growing season. But on a world scale, problems arise with these definitions in respect to other growth forms not usually taken into consideration by humid temperate zone authors: 1) perennial plant with purely herbaceous aerial stems which are perennial; 2) perennial plant with aerial, basally woody (with or without bark) and distally herbaceous stems in which the whole stem including the woody part dies to the ground each year, leaving the plant without a visible aerial portion for part of the year, and new shoots reappear only from underground parts the following growing season;

3) perennial plant with aerial stems woody to the tip and with no bark or bark only basally, and which die to the ground completely each year, leaving the plant without a visible aerial portion for part of the year, and new shoots reappear only from underground parts the following growing season; 4) perennial plant with aerial stems woody to the tip and with bark to the tip, which die wholly to the ground each year, leaving the plant without a visible aerial portion for part of the year, and new shoots reappear only from underground parts the following growing season; 5) annual plant with stems woody at the base and herbaceous distally, and with no bark or bark only at the base, and dies completely to the ground within the year, and reproduces only from seed; 6) annual plant with stems woody from the base to the tip, and with no bark or bark only at the base, and which dies completely to the ground within the year, and reproduces only from the seed; 7) perennial plant with woody rhizomes in which no vegetative stem appears above the ground, and the leaves arise separately from the ground (not in tufts with petioles enrolled one within the other forming a pseudostem); the only stems which appear above the soil surface are those in the inflorescence; 8) perennial plant in which the vegetative stem or stems are below the soil surface but an aerial pseudostem is visible, made up of enrolled and overlapping petiole bases: *Musa* and some small palms. In the case of the palms of this type, this stage may be only temporary, a woody trunk appearing above ground in later years, as in *Syagrus flexuosa* and *S. comosa* in Central Brazil, or it may be permanent, lasting during the whole life of the plant, as in *S. petraea.*
Biennial plants, not mentioned in this list, may be pure herbs or occur in some of the problematic forms, especially 2 and 3.

2.2. CHARACTERIZATION OF HERBACEOUS GROWTH FORMS

The first of these problematic growth forms is represented by *Heliconia* and other Scitaminales with true aerial stems in the humid Tropics. Forms 2, 3, 4, 7, and 8 (acaulescent palms) definitely occur in the Brazilian cerrado, especially 3, which makes up at least 80% of the over 2000 ground layer species in this vegetation; forms 5 and 6 also probably occur sparsely. All these forms also occur in other tropical "savanna" regions, such as the Venezuelan llanos and sub-Saharan Africa. Forms 2, 5 and 6 occur occasionally in the temperate North American, European, and East Asian floras, such as form 2 without bark (example, *Phyteuma betonicifolium* in northwestern Italy); form 5 without bark (*Melandrium noctiflorum* in Poland); form 6 with bark at the base at

the end of the growing season (*Helianthus annuus* in North America). But by far the most common is form 3. Most perennial dicotyledonous "herbs" of the humid temperate zone are of this form, without bark or a small amount of bark produced at the very base of the stem at the end of the growing season in some species.

As for form no. 1, BENSON (1957) does not mention persistence, so his definition could include *Heliconia*. GRAY's definition (1879) also includes *Heliconia* because he says that the aerial stems of a herb die annually *or* after flowering. The aerial stems of *Heliconia* do not die annually, they are briviperennial, but they do die after flowering and fruiting. LAWRENCE's definition (1951) would exclude *Heliconia* because he says a herb has no persistent aerial stem. The definition of FERNALD (1950) and of FERREN et al. (1979) could include *Heliconia* because they say a herb has no persistent *woody* stem, so strictly speaking, it could have a persistent *herbaceous* stem. But these last two sources obviously did not mean this since their works treat plants of the temperate zone only, where erect, aerial, perennial herbaceous stems do not occur. It may be possible, and the point should be investigated, that there can occur in the temperate zone persistent purely herbaceous stems without any secondary wood, that creep just above the soil surface (and so are "aerial" stems) and are covered with snow in the winter. Therefore, the definition of herb by these authors may not refer to plants of the world as a whole, but only to their own humid temperate region.

As for the problematic growth forms 2 to 6, they are not considered at all in GRAY's definition because he requires that the aerial stems of a herb be both not persistent and non-woody, while these forms are not persistent but *are* woody (have a closed cylinder of secondary wood) at least basally. LAWRENCE's definition would exclude them from herbs because they do have a "definitely woody firm structure". BENSON's definition also excludes them. But the definitions of FERNALD and of FERREN et al., as given, would include forms 2 to 6 as herbs because although they are woody, the aerial stems are not persistent.

Problematic forms 7 and 8 are also not considered by the authors cited. Form 7 are "geoxylic plants". They are often called "geoxylic shrubs" because other species of the same genus (when they are not monotypic) are true shrubs and trees. Examples in the cerrado are *Andira humilis* and *Chrysophyllum soboliferum*. The leaves and inflorescences disappear each year and appear again at the beginning of the rains in September, so the plant is not persistent above ground, but "persistent" cannot be applied positively or negatively to the veg-

etative stems, which are all completely subterranean.
Form 8 would also cause difficulties if we tried to apply the definitions for "herb" cited above. This form fits GRAY's definition because form 8 does not have an aerial woody and persistent vegetative stem, but for the reason that there is no real aerial vegetative stem at all and so it cannot die annually. It would fit the definition of a herb of FERNALD and of FERREN et al. It would not fit LAWRENCE's definition because he says a herb is a plant naturally dying to the ground (each year), which is not true of *Musa* or of any palm. It would fit BENSON's definition of a herb as a plant not woody above ground level. Banana "trees" are indeed often called "giant herbs" but no one has ever called a palm of form 8 a herb of any kind. Since the underground trunks of acaulescent palms have a sufficient proportion of lignified cells to be considered "woody", they also are geoxylic plants, but are a persistent-leaved rather than a recurrent-leaved form of this type.

2.3. HISTOLOGICAL ASPECTS

EAMES and MACDANIELS (1947, p. 297-300) go into histological detail in defining a dicotyledonous herb. Their definition includes the woody forms 2 to 6 as herbs, because they say, "The herbaceous stem is one in which cambial growth is limited to one season or part of one season, or is lacking". Thus, they allow a certain amount of secondary wood to be present in the stem of a "herb". Although they do not say so specifically, this implies that the woody stem of a "herb" is alive for only one growing season and so is not persistent, for so far I know, there do not exist aerial stems which have secondary wood production in their first year and then continue to live over more years without producing new secondary wood. EAMES and MACDANIELS' definition of a herb can also include perennial, aerial, purely herbaceous stems like *Heliconia*. Since this definition does not state that the stem to which they are referring is aerial, it would exclude from herbs form 7, in which the subterranean stems (rhizomes) do produce secondary wood each growing season. I am not able to find in the literature whether the rhizomes of *Musa* and the underground trunks of acaulescent palms have cambial growth each year; if they do not, *Musa* and these palms (form 8) would be herbs by this definition.
Producing a closed cylinder of secondary wood is not the only way a stem can have a woody consistency. Even a dictyostele or an eustele, which in dicots shows a ring of separate vascular bundles in a cross section, can have a woody consistency. This will occur when the separated vascular bundles have

one or more of the following characteristics: 1) be large in radial extent, 2) be close together in the ring, i.e. have only thin strips of interfascicular parenchyma separating the bundles, 3) have secondary xylem production within the bundles, 4) have each a thick strand or sheath of fibers. But in this case it will have to be decided arbitrarily whether the fact that the ample xylem does not form a *closed* cylinder should exclude that stem from being considered "woody". This is a subtle point that I have not come to a firm decision about.

As a quick, rough determination of the woodiness of an aerial stem at a particular level from its base, one may scratch the stem with one's fingernail with such force that all tissues outside the vascular ring are removed. If the vascular tissue is in small, well-separated bundles without large fiber sheaths or strands (a herbaceous consistency of the stem at that level) one may not see any evidence of their existence with the naked eye for all the stem material will be scratched away. If they are larger they can be seen to be present and can be separated by teasing them apart. If there is a continuous cylinder of secondary xylem, whether of one or of several years' formation, the cylinder will remain intact, although if the wall of the cylinder is very thin it may flatten under the pressure.

Once the presence of the structure of the xylem is indicated by this test, one must draw the line somewhere as to what is a sufficient amount to call the stem "woody" at that level. A good indication is the presence of bark at the level tested. Bark only occurs where, at the same level, there is a closed cylinder of secondary xylem, but the stem can be definitely woody even without bark.

Then one must determine whether the plant as a whole is a herb, a semishrub or a true shrub (or a herbaceous, semiwoody or woody vine), and if the definition is to be applied to dicotyledonous plants of any region of the world, the problematic growth forms mentioned above must be taken into consideration. Personally, my choice is the following. I prefer to call a dicotyledonous plant a herb only if there is no woodiness at any level of the aerial stem by the fingernail test, that is, to be called a herb, the plant must be a pure herb. (A possible exception would be still to allow a plant to be a herb if a small amount of woodiness occurs [with or without bark] at the very base of the stem at the end of the growing season, and the whole stem including the woody base dies to the ground later on). Thus, there are herbs with annual stems (annual, biennial, and perennial herbs) and herbs in the moist Tropics with perennial stems.

If the basal part of the aerial stem is woody from the beginning of its matura-

tion (when it has stopped elongating), with or without bark, and this part remains alive over the unfavourable season and new shoots grow from it, but the distal part of the stem is herbaceous and dies during or at the end of the growing season or part way into the unfavourable season, the plant would be regarded as the first or classical type of semishrub (or if a vine, semiwoody). This is a persistent semishrub or vine since part of the aerial stem is persistent.

With the same division of basal woody and distal herbaceous as in the previous case but the whole stem dies annually, the plant would be regarded as a second type of semishrub or vine, a "recurrent semishrub" or "recurrent semiwoody vine".

If the stem is woody to the tip but without bark, or bark only at the base, and the whole stem dies annually, the plant is a third type of semishrub or semiwoody vine, also recurrent.

If the stem is woody to the tip but without bark or bark only basally, and the whole stem remains alive over the unfavourable season, like *Vaccinium myrtillus*, the plant is a fourth type of semishrub, a persistent semishrub. (This species is usually considered to be a dwarf shrub but I prefer to restrict the concept of shrub, in the case of dicots, only to plants with aerial stems, these woody to the tip and with bark to the tip).

If the stem is woody at the base or to the tip and with no bark or bark only basally, and the plant as a whole is annual, dying completely and reproducing only from seed, the plant is the fifth type of semishrub, neither persistent nor recurrent, but an "annual semishrub".

If the stem is both woody to the tip and with bark to the tip, I regard it as a complete woody plant. So far as I know this never occurs in an annual plant but only in plants that have an underground part (root, rhizome, corm, lignotuber, xylopodium, etc.) that lives several to many years. There are several types: 1) with the whole aerial part of the stems annual (die completely to the ground each year); 2) with the whole aerial part of the stems breviperennial, dying back completely to the ground in two to few years and replaced by other similar stems, 3) like 1) but the annual woody stems arising not from the underground part of the plant but (at least some) from a persistent short *aerial* stem; 4) like 2) but the breviperennial stems arising from a *more* persistent short aerial stem; the short aerial stem in 3) and 4) may eventually die and be replaced by another from the underground part of the same plant; 5) with the aerial stems living as long as the plant itself lives, although of course some twigs, branches, and boughs may die and fall off. In all cases here the

removal of stems is by self-pruning, not because of burning, cutting by man, or being bitten off by animals.
Annual woody stems are necessarily thin (in the cerrado always less than 2.0 cm diameter at the base, usually only a few millimeters) and never become tall (in the cerrado always less than 2.0 m, usually less than 1 m). Type 1 is a "recurrent shrub", the rest are "persistent shrubs", or if taller, in type 5, are trees, or if climbing, are lianas. Thus, my definition of herb, semishrub, and shrub takes only consistency of the aerial vegetative stem (when this exists) into consideration, not its seasonal behaviour. Behaviour, whether annual, recurrent, or persistent, is a qualification given by an adjective.
With these definitions, very few dicotyledonous species in the humid temperate zone, that are usually considered to be herbs, would be called herbs. Almost all the perennial cauline "herbs" would be thin-stemmed recurrent semishrubs of the third type, without bark. A few cauline species would be true herbs. (For acaulescent species, see below. Scapes, as in *Taraxacum* and acaulescent *Viola*, are part of the inflorescence and do not count in this discussion, which is restricted to vegetative stems).

3. EXAMPLES FROM DICOTYLEDONS

3.1. HUMID TEMPERATE ZONE IN POLAND

The following is a list of species of dicotyledonous plants in Poland usually considered to be "herbs", in which the living specimens I examined in July 1989, had woody stems, plus five true herbs. Hundreds of other species undoubtedly are also woody. There may possibly be variation in woodiness among different individuals of the same species or at different parts of the growing season in the same plant.

1. Perennial plant with complete cylinder of secondary xylem in the base of the aerial stem (woody condition) and separate thin vascular bundles in the distal portion (herbaceous condition), no bark, dies completely to the ground at the approach of winter. Recurrent semishrub, type 2.
   Aconitum moldavicum, Euphorbia cyparissias, Geum urbanum.
2. Perennial plant with complete cylinder of secondary xylem from the base of the aerial stem to the tip, no bark, dies completely to the ground at the approach of winter. Recurrent semishrub, type 3.
   Agrimonia eupatoria, Anthyllis vulneraria ssp. *polyphylla, Betonica offi-*

cinalis, Centaurea austriaca, C. jacea, C. rhenana, C. scabiosa, Galium verum, Gypsophila fastigiata, Linum hirsutum, Lotus corniculatus, L. uliginosus, Rumex crispus, R. obtusifolius, Saponaria officinalis, Scabiosa ochroleuca, Selinum carvifolia, Silene inflata.

3. Annual plant with complete cylinder of secondary xylem in the basal part of the aerial stem, separate small spaced vascular bundles in distal portion, no bark, whole plant dies at the approach of winter. Annual semishrub, type 5.
   Melampyrum pratense, Melandrium noctiflorum.
4. Annual plant with complete cylinder of secondary xylem from the base of the aerial stem to the tip, no bark, dies completely to the ground at the approach of winter. Annual semishrubs, type 6.
   Adonis aestivalis, Agrostemma githago, Centaurea cyanus, Euphorbia exigua, Matricaria inodora, Melampyrum arvense
5. Stem completely herbaceous, no xylem cylinder, no bark, dies at the approach of winter. Herb.
   Galium aparine (scandent), *Myosotis palustris* sp., *Ranunculus acer, Rumex arifolius, Stellaria nemorum.*

3.2. TROPICAL SAVANNAS

In the tropical "savannas", some of the many forms of what I have termed "recurrent semishrubs" look like herbs because the aerial stems are thin and completely without bark although they are slightly to quite hard. Other species look like woody plants because the stems, although thin, are woody, usually to the tips, and have bark in the basal half or two thirds. The "recurrent shrubs" (with secondary wood to the tips of the aerial stems and also bark to the tips) all look exactly like woody plants and belong to genera whose other species are all persistent-stemmed regular trees and shrubs.

If we restrict ourselves to the humid temperate zone, there is sense in the conventional definition of a herb as plants with stems with no secondary wood *or* with secondary wood produced within a single year, and therefore as a plant with no persistent woody stem, all the stems dying back to the ground each year. This is because in one year's season of not more than about seven or eight months, there is no time for a stem to become very thick by secondary wood deposition (although some species can have large-diameter herbaceous stems, like *Heracleum* and *Angelophyllum*), nor for much if any bark to form, except sometimes a slight amount at the very base of the stem late in

the season. For these reasons the stem and the plant as a whole look like those pure herbs that have no secondary wood formation in the aerial stems and behave like them in dying completely to the ground within the year. But when you go into the dry parts of the temperate zone and into the Tropics, especially into the summer-rain "savannas", the conventional definition of a herb breaks down, as the problematic growth forms mentioned above show.
If we are going to be consistent and procure definitions of growth forms that are valid for the whole world, the question resolves itself into the choice of changing the conventional definition of a herb (which I doubt will be done by temperate-zone botanists), or keeping the conventional definition and thereby having to include as "herbs" woody plants with aerial stems sometimes up to 2.0 cm diameter and almost all of this thickness secondary wood, and that have bark to the tips of the stems, such as *Zeyheria digitalis* in the Brazilian cerrado. Plants such as these look as much like shrubs as any true shrubs in the temperate and boreal zones do, and that would be called shrubs by anyone not knowing that their stems die completely to the ground each year.

3.3. ACAULESCENT PLANTS

If the plant has no above-ground vegetative stem at all, i.e. it is "acaulescent", as can occur in some species of annual, biennial, and perennial "herbs", and in the problematic forms 7 and 8, the plant cannot be truly said to be either herb, semishrub, or shrub, just as it cannot be said to be a self-supporting plant or a vine. One cannot determine this by the woodiness of the underground part, for there exist delicate, truly herbaceous aerial stems, whether self-supporting or as ground or climbing vines, that arise from definitely woody, often massive, underground parts. One can perhaps call acaulescent plants herb, semishrub, or shrub depending on what their related species with aerial stems are, in the same genus, tribe or family, as is usually done. But this is not really a satisfactory solution, for often both herbaceous and woody species (with aerial stems) occur in the same genus (*Cornus*) or other supraspecific taxonomic group. Also, a growth form should be determined by what that plant is, not by what its related species are.
Sometimes in an acaulescent species, an occasional plant can be found in which the aerial stem is elongated somewhat and the consistency of this stem can be used to define the stem consistency of the species. Some acaulescent plants have a basal rosette of leaves arising from a very short length of above-ground stem and the consistency of this perhaps can be used, but such a stem

is a close sequence of nodes whose consistency can be quite different from the internodal part of the extended stem. The only subdivision that can always be made is whether the acaulescent plant is annual, biennial or perennial, and this may vary in a species if it grows in different climates.

4. EXAMPLES FROM MONOCOTYLEDONS

Monocotyledons are another problem. These have scattered vascular bundles that weave their way through the parenchymatous ground tissue towards the center and towards the rim of the stem and interconnect in various patterns as well as give off leaf and branch traces. In some species the pith is solidly present and in others there is a lacuna between the nodes. The bundle may have many xylem vessels or few, much fiber or little or none. The woodiness of a monocotyledonous stem then depends on the density of the bundles (at least in the outer part of the stem), their width, and the proportion of their cells with lignified walls. Therefore, there exists a continuous gradation between 1) herbaceous stems (most temperate-zone monocots and many in the Tropics), 2) half-woody stems, either thick as in *Alpinia officinarum* whose aerial stems are partially woody at the base or thin, hard, flexible, "wiry" stems (almost all *Cyperaceae* in the South African Cape scrub and in Australian "heaths"), and 3) woody stems (bamboo and some non-bambusoid grasses like *Arundo donax*). The hollow woody stems also show a gradation in the thickness of the culm wall from very thin (less than 1 mm) to several centimeters thick. One may choose not to regard the very thin hard culm walls as "woody".

Some arborescent *Liliaceae* and the *Velloziaceae* also have an anomalous form of secondary growth that forms more ground tissue with scattered vascular bundles, so it does not change the basic histology, but the bundles are close enough so that the stem appears to be woody.

Like palms, the primary stele in the trunk of tree-ferns is sufficiently hard and with a sufficient proportion of cells with lignified walls that we may consider the trunk to be "woody". The aerial trunk of cycads is mostly parenchymatic, pith and cortex, with a narrow intermediate cylinder of secondary wood, but the persistent petiole bases that cover the trunk as a tunic are hard and woody, so the trunk can be considered to be "woody" also. In these non-dicot and non-coniferophyte plants, bark is not normally present and is not necessary for the plant to be a tree or a shrub. Some large monocots have bark, such as *Philodendron arboreum* and *Cordyline*.

There is a category of growth form called "hemixyle" (half woody). This is simply a Greek term for semishrub and has the same problems in its intergradation to true herbs at one end and to completely woody plants at the other end.

WHITE (1976) terms "suffrutices" plants whose stems "are woody at the base and persistent for several years, giving rise to less persistent shoots, which die back after a relatively short time, sometimes each year, sometimes after a longer interval". The African suffrutices dealt with in WHITE's paper all die back to the base if even lightly singed by fire. If protected from fire, "in some species there is a considerable die-back every year almost to the base. In other species there is a limited amount of upward growth which may continue for a few years. In obligate suffrutices, however, upward growth is severely restricted and ultimately the subaerial parts [low aerial stems] become moribund". Thus, WHITE's suffrutices include, by his definition, some but not all of the forms we are calling semishrubs, plus some but not all of the forms we are calling shrubs. The suffrutices with relatively thick underground parts but having aerial stems WHITE calls "geoxylic suffrutices", but I think "geoxylic" should be restricted to plants that have *all* of their vegetative stems totally underground and that the underground parts be woody; there should be no aerial vegetative stems at all, as in our form 7, or the acaulescent palms in form 8. WHITE's "geoxylic suffrutices" include, besides persistent shrubs with breviperennial aerial stems, also our forms 2, 3, and 4, that is, only perennial forms that have woody or partially woody recurrent aerial stems. There are fewer than 150 species of these in Africa, so it is not true as he states that there are fewer species of this form in South America than in tropical Africa; there are several times as many only in the cerrado as in all of Africa.

In the list of problematic forms given at the beginning of this paper, only eight forms were mentioned so as to keep the discussion less complicated. In the constantly humid tropics and in the tropics with a dry season but in ground kept continually moist by shade or by a high water table so that plants can grow all year round, it is possible to have other problematic forms. Among these are three perennial forms that look like herbs.

Continuing the numbering of the previous list, these are the following:

9) Perennial plant with perennial aerial stems which are woody or partially woody at the base (without bark or bark only basally) and herbaceous distally (certain Scitaminales such as *Alpinia officinarum*). This is a persistent semishrub. It differs from form 1 of the previous list in that the aerial stems are semiwoody instead of completely herbaceous, and differs from

form 2 in that the aerial stems are perennial instead of annual.

10) Perennial plant which always has live, purely herbaceous aerial stems present during the whole year and over the years, but each of these stems lives one year or less (certain Scitaminales). This differs from form 1 in having the aerial stems annual instead of perennial. Since aerial stems are always present this growth form may be called a "pseudo-persistent herb".
11) Plant behaving as form 10 but the aerial stems, although annual, are not completely herbaceous but are woody or partially woody at the base (without bark or bark only basally). and herbaceous distally (pseudo-persistent semishrub"). This differs from form 2 in having some live aerial stems always present instead of the whole above-ground part of the plant disappearing for part of the year.

Forms 9, 10, and 11 are also not taken into consideration in the above mentioned definitions of herb, and therefore their inclusion or not as herbs in these definitions are as irregular as in the forms 1 to 8.

It should be noted that in the Tropics, where growth is possible the whole year when there is enough water in the soil, certain perennial plants have purely herbaceous aerial stems *all* of which die at a certain time of the year so that the above-ground part of the plant disappears for a while. Examples are *Impatiens, Canna indica, Zingiber officinale*, etc. Thus, in consistency and behaviour of the aerial stems, these plants are equal to pure herbs growing in a region where an unfavourable cold or dry season causes the above-ground part of the plant to disappear for a time. They are not a problematic form.

5. CLASSIFICATION OF ELEMENTARY GROWTH FORMS

The growth forms treated in this paper are based on particular combinations of classes of expression of each of the following criteria:

I. Applied to the germinated and growing plant as a whole

1) Duration
   a) annual (summer annual and winter annual; seeds may not germinate in deserts in dry years)
   b) biennial, i.e., living more than one year, either through two growing seasons, or as two separate appearances in a non-seasonal climate, not flowering in the first year but flowering and fruiting in the second year and then dying
   c) perennial, with the subclasses 1) flowering every year including the first, 2) flow-

ering every year (or alternate years) after two or more years without flowering, 3) flowering only once after two or more years without flowering and then dying (hapaxanthic).

II. Applied to aerial stems

2) Presence: a) present, b) absent.

III. Applied to perennial acaulescent plants

3) a) Leaves arising separately from the ground along a rhizome or in clumps or rosettes but the base of the petioles not forming a pseudostem.
   b) many overlapping petioles together forming a pseudostem.

IV. Applied to aerial stems when present

4) Consistency
   a) the mature stem woody from the base to the tip
   b) Only the basal part woody, distal part herbaceous
   c) stem completely herbaceous.

5) Presence of bark where the stem is woody
   a) absent
   b) present only in the basal portion of woody part of the stem
   c) present over the whole woody part of stem.

6) Degree of self-support of aerial stem
   a) self-supporting stems erect or ascending
   b) scandent (leaning against other plants but not twining around them nor provided with special organs for support)
   c) climbing over other plants and either supported by special organs (hooks, adhesive pads, twining special leafless branches or leaf rachises, etc.) or the whole main stem twining around other plants (vine)
   d) ground vine, i.e., like a climbing vine in form and lack of self-support but lying on the ground and not climbing over plants.

   There are intermediate cases like plants, both herbaceous and woody, whose main stem is erect and self-supporting but its distal portion or its branches or both twine around other plants

7) Seasonal behaviour of each aerial stem
   a) whole stem perennial, i.e., persistent, distal part not *regularly* dying each year (includes breviperennial and longiperennial)
   b) distal part of aerial stem, whatever its consistency, dying regularly each year and eventually falling off, basal part, whatever its consistency, continues alive and persistent
   c) annual, i.e., whole stem dies each year, whatever its consistency.

8) Size, when the aerial stem and its branches are self-supporting, wholly woody, and perennial
   a) shrub
   b) tree.

9) Prolificness of the persistent aerial stems
   a) produces new branches in each year or some years
   b) never produces new branches.

   In both, new aerial stems may also occasionally or regularly be produced from underground parts.

10) a) Some live aerial annual stems present at all times of the year, whether there is an unfavourable season or not
    b) all live aerial annual stems absent for part of the year even when no unfavourable

season occurs, but leaves are present above ground all the time, from the aerial stems during the part of the year when these are present, and from underground organs when the aerial stems are not present.

c) all the aerial part of the plant, stem, leaves and inflorescences absent for part of each year, whether there is an unfavourable season or not.

Using only these criteria and the small number of classes defined for each, 556 combinations are possible, i.e. elementary growth forms. Note that certain criteria further subdivide only certain classes of previous criteria. Some of the types of growth form mentioned in this paper (the four classical forms and eleven problematic forms) include only one of these elementary forms while others include several. Only those growth forms were mentioned for which I am aware that examples exist. For instance, does there exist a perennial plant with completely woody aerial annual stems, with bark to the tips, and in which some live aerial stems are always present over the whole year? Does there exist a perennial plant with completely herbaceous aerial stems in which the distal part dies during the year of its production and the basal part continues alive for several years (and perhaps even produces new shoots in these further years)? There do exist perennial dicotyledonous plants with mature aerial stems and branches which are woody from the base to the tip but have bark only at the base of the plant or no bark at all, the barkless stems covered with epidermis and cortex (in some, perhaps later lignified), such as *Vaccinium myrtillus*. But do such plants of a size large enough to be called trees exist?

Many other criteria, not considered here, are also part of growth form:

1) the branching pattern of the shoot (its "architecture")
2) the branching pattern and degree of massiveness of the subterranean organs
3) consistency of leaves (membraneous, mesomorphic, scleromorphic, coriaceous, succulent, woody) and their size
4) succulence of stems
   a) non-succulent
   b) succulent thin stems as in *Impatiens*
   c) cactoids
5) Presence of leaves
   a) regular leaves present
   b) absent or as tiny, often caducous, scales, the stems taking over the whole phosynthetic function, switch plants, etc.
6) Presence of pneumatophores, etc.

Also, one can distinguish:

a) acaulescent plants which have leaves, flowers and fruits above ground
b) parasitic and saprophytic forms whose above-ground shoot constists only of a

single flower (i.e., *Rafflesia* and *Thismia americana*)

c) wholly underground forms in which even the flowers and fruits are subterranean (certain orchids in Australia)

Considering all these possible criteria would cause the number of possible elementary forms to be in the tens of thousands and the task would then be to see which of these really occur.

SUMMARY

The usual definition of "herb", as given in floras and botany textbooks, always states that it is a plant which does not have a woody stem or does not have a persistent woody stem. "Persistent" means here living through more than one growing season. However, almost all species of dicotyledonous cauline vascular plants called herbs, in the boreal, temperate, and tropical zones, have a closed cylinder of secondary wood from a cambium which extends from the base to the tip of the aerial stems and a few have secondary wood at the base only. Even though these stems have no bark and are not persistent but die within or at the end of the growing season, one cannot say that they are "herbaceous" and or a "herb". The growth forms of the plants are classified according to the woodiness and duration of their aerial stems (plants without aerial stems included). Most of these growth forms are not taken into consideration by the authors of definitions of "herb". It is suggested that "herb" should be applied only to plants whose aerial stems are not woody at any level. The other plants called herbs should be called "recurrent semishrubs" if the plants are perennial and "annual semishrubs" if the plants are annual.

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