


Agriboard

Agriboard, lumber substitutes made from plant fibers, are revolutionizing how plant wastes are used and has potential for far ranging impact on agriculture, forestry and conservation. Typing agriboard into a search engine brings up nearly 100 web pages. Three of these pages have been reviewed and are offered here for your examination.

The first is an in-depth report from Environmental Building News, Vol. 4 (No. 3) and offers an excellent, balanced overview on the use of wheat straw lumber in homebuilding.

The second article reviewed by *EBL*, Environmental Building News, Vol. 4 (No. 6), is a brief commentary on this topic including reaction to use of this material by an architect.

Third is an excerpt written by David Morris, from the book, 'Non-woody Fibers and the Future of Rural Economics," edited by J. Janick., discussing general use of plant fibers for building materials. This last entry is of particular interest as it discusses cellulose for construction, from non-timber sources, in a broad sense.

That opens the door to using native prairie grasses and other native plant resources to provide income from restored land . This is especially important for land which would otherwise be converted to cash crops and for areas which have lain fallow for several years but recently lost set aside status. It has also been pointed out that most areas loosing set aside status are eligible for organic certification. Production of agriboard fiber has potential to stand alone or easily dovetail with organic agriculture to aid conservation.

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Ethnobotanical Leaflets

Inclusive Herbaria

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TEXT ONLY (from Indian Journal of Genetics & Plant Breeding 11(1): 1-3)

IN the earliest days of Systematics more attention was paid to cultivated plants and weeds than to wild species. The great herbals of the sixteenth century were largely given over to field and garden crops and everyday weeds. Until well after the time of Linnaeus, taxonomists included both cultivated plants and wild species in their botanical gardens, in their herbaria and in their writings. Only by slow degrees was there general recognition that the methods which are so effective for the bulk of the world's flora do not yield results of comparable efficiency when applied to cultivated plants and weeds. This perception came into being so gradually, that taxonomy as a whole drifted into its present position without any one taxonomist being aware of the drift and with only a few lone workers (Oakes Ames, L. H. Bailey, O. Stapf, D. Chatterjee) attempting to fight against the current. We now find ourselves in an anomalous position. Ninety-nine per cent of taxonomic effort is devoted to the plants least interesting and least important to man. Surely matters are out of balance when in many of the world's great herbaria there is not a single taxonomist who is devoting himself to the classification of cultivated plants and when the taxonomy of many of the world's most important genera (Phaseolus, Coffea, Brassica, Cinchona, Hevea, etc.) is so imperfect as to be of little practical use.

The gradual decision of orthodox taxonomists to avoid the classification of cultivated plants wherever possible was originally sound. Wild species could efficiently be understood by their methods; cultigens could not. Since the development of the so-called "New Systematics" such avoidance is no longer necessary. The special methods of this modern development in taxonomy are as useful in working out the complicated interrelationships of cultivated plants as they are in determining the course of evolution in natural populations. While it is usually assumed that the New Systematics derived its newness from the introduction of such techniques as cytology and pedigree culture from the experimental sciences, it would be more accurate to ascribe the change to new attitudes. The old taxonomy was satisfied if it discriminated between species; the new, desired to illuminate them as well. It wanted to know not only to which pigeonhole each entity belonged, but what kind of an entity it was. Was it diploid or polyploid, or did it include both diploid and polyploid races? Was it partially or wholly apomictic? Did it include

many highly differentiated local races of no nomenclatorial significance but of great biological interest? The New Systematics in other words interested itself in forces as much as in forms and in populations as well as in individuals.

The development of these techniques and attitudes makes it possible for us now to approach the classification of cultivated plants with some prospect of success. Relatively simple modifications and additions to previous herbarium techniques can produce an herbarium record which is efficient even with our most difficult cultivated plants. The resulting specimens resemble orthodox herbarium specimens in that they are mounted on the same size sheets and are stored in the same kind of steel or wooden cases. In other ways they are more like a loose leaf note book than herbarium specimen. They are different enough in purpose and in appearance that it may be well to christen them with a name of their own, and designate a collection of such specimens as AN INCLUSIVE HERBARIUM.

The inclusive herbarium has a more difficult job to perform than the ordinary herbanum. Therefore a more complete record of the plant is required. Knowing exactly what to include for the most efficient record of any particular cultigen is in itself something of a research problem; only by considerable experience with a crop plant or a weed can one determine exactly which features are most useful in working out its taxonomic relationships. One may summarize the necessary information under two heads (1) As complete a record of the plant as can be obtained, using pressed fragments, notes (morphological, ethnological, cytological), charts, and photographs to scale. (2) Information not only about the individual but of the population from which it came and the population to which it gives rise. This is essential either for cross-pollinated crops or for heterogenous native varieties of self-pollinated crops.

Two guiding principles need to be stressed. (1) Compactness is essential. A record of a single plant should not occupy more than one herbarium sheet if possible. Combinations of photographs and fragments will do a better job and take less space than a complete herbarium specimen. With Zea Mays, for instance, it has been found that while a pressed specimen of the entire male infloresence is useful, that a photograph, to scale, of such an inflorescence plus the pressed central spike and lowest secondary branch plus a simple diagram of the numbers and positions of branches at each node takes less space and is more useful. (2) Accuracy is more important than appearance. Provided field notes are legible it is better to mount the original notes directly on the sheet than to run the risk of having them altered during the copying process. For the same reason the name and number of each plant or plant portion which is photographed is taken directly on the photograph so that there need be no chance of mixing negatives or prints. If the material to be photographed is of any size, a permanent background is efficient. It should be set up in a well-lighted place but out of direct sunlight since strong shadows destroy the accuracy of the pictures. A set of deheaded nails down the middle of the board are useful in holding plants in position while the photograph is being taken. The background is painted flat white with black lines (horizontal or vertical or both) at regular intervals. Though it has to be renewed at frequent inter vals, adhesive lantern slide tape is convenient in making the black lines on the white background. Numerals giving the year are affixed to one side of the board and removable stencilled letters (heavy black on white cards) give the name and number of each culture which is photographed.

The exact record to be made will vary with every crop and with the extent to which its most salient variables have been determined by previous study. After ten years' work with maize the following optimum record (see Plate I) may be recommended. (1) A photograph of an entire plant taken against a scaled background and a similar but more enlarged photograph of the tassel (male inflorescence). (2) An internode diagram showing the lengths of successive internodes and the number of developed and undeveloped ears (Anderson and Schregardus 1944). (3) The sheath and lower blade of the leaf below the ear, slit in half longitudinally and pressed. (4) The central spike and the lowest secondary branch from the main tassel. (5) A sample of the kernels from which the plant was raised. (6) Notes as to silk and anther colour and plant colour. (7) Notes as to the numbers and positions of the knobs on the pachytene chromosomes. (8) Notes and statistics as to the variation of sibling plants. (9) Diagram of the tassel node by node, showing the number of secondary branches at each node and their relative positions. For making a record of field samples of a mature crop of maize see, Anderson, 1947.

For Phaseolus, the following schedule has been worked out. (1) Pressed specimens of an average leaf, an inflorescence, and a mature seed pod. (2) Samples of the mature seeds. (3) Notes describing flower colour in the keel, wings and standard of the flower. (4) Notes and measurements as to the extent the cotyledons remain above or below ground after germination. (5) A photograph of an entire mature plant showing its branching habit.

An inclusive herbarium, carefully assembled, is of wide usefulness. Since it makes an accurate record of the plants most closely associated with man, the results obtained from studying the collection may be of significance for the study of man as well for the study of his economic plants. Frequently they will be found to yield precise data for such diverse disciplines as plant breeding, ethnology, prehistory, anthropology, ethnobotany or archaeology.

References

Anderson, E. and Schregardus, D. (1944). A method for recording and analysing variations of internode pattern. Ann. Mo. bot. Gdn., 34: 241-47.

Anderson, E. (1947). Field studies of Guatemalan maize. Ann. Mo. bot Gdn., 34: 433-67.

EXPLANATION OF PLATE [see original article]

Photograph showing a typical sheet from an inclusive maize herbarium. Upper left, male inflorescence photographed against a scaled background, below it the ear from which this plant and its siblings were grown. Upper centre, entire plant photographed against a scaled background. (All three of these photographs have the name, number and dates of the culture photographed on the negatives but it has been trimmed off in mounting). Upper right, diagram showing arrangement, node by node of the secondary branches of the male inflorescence. Center of sheet, lowermost secondary branch and central spike of male inflorescence mounted on the sheet. Lower left, notes and measurements on the 14 siblings from which the photographed plant was selected. These are stapled to the sheet (staples shown

as two lines at the base). Behind these notes can be seen the upper portion of an internode diagram of the above plant. Center below, notes as to pachytene knobs, etc. and B chromosomes, written directly on the sheet.

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Ethnobotanical Leaflets

The Species Problem

Selected Definitions
(Presented in Chronological Order)

Compiled by Donald Ugent
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John Ray. 1704. "*Nulla certior occurit quam distincta propagations ex semine*." (Nothing is more certain to distinguish species than the criterion that true species faithfully reproduce their kind by seed.) "Plants which derive their origin from the same seed, and again propagate themselves in sowing, we may consider as belonging to a single species...Thus as to plants of specific conformity: there is certainty that they came from the seed of the same plant, whether as species or individual. For those which differ as species preserve their species in perpetuity, and one does not arise from the seed of the other, or vice versa." (*Historia Plantarum*. Chapt XXI).

Linnaeus, C. 1731. "All species number their origin first from the hand of the Omnipotent Creator: for species having been created, the Author of Nature has imposed the eternal law of generation and multiplication within the species itself...there is never a metamorphosis from one species into another." (*Critica Botanica* Sect. 271). "There are as many species as there were originally created diverse forms." (*Classes Plantarum* 1738). "That species of plants were created by God at the beginning of the world and do not change into other species, and are therefore natural, and that they remain unchanged to the present day no sane person will doubt; the confusion which would arise from the change of one species into another, to the detriment of mankind, would not be allowed by the most provident Maker." (Ortega's 1792 edition of Linneaus, *Philosophia Botanica*. 410).

John Lindley. 1832. "A species is an assemblage of individuals agreeing with each other in all essential characters of vegetation and fructification, capable of reproducing perfect seed from which progeny can be reared." In J. Heslop-Harrison, 1960. *New Concepts in Flowering Plant Taxonomy*, Harvard Univ. Press. p. 4).

Charles Darwin. 1859. "Nor shall I here discuss the various definitions which have been given of the

term species. No one definition has satisfied all naturalistists; yet every naturalist knows vaguely what he means when he speaks of a species." Also, "In determining whether a form should be ranked as a species or as a variety, the opinion of naturalists having sound judgment and wide experience seems the only guide to follow." (*Origin of Species*, London).

George Bentham. 1874. "It would seem, therefore, that at this stage of our progress .....the systematic botanist could already look towards that summit, upon reaching which his labours in aid of the general advance of the science might come to a close. But there was a rock ahead which had been looming in the distance, and which on a nearer approach posed a formidable obstacle, to most minds apparently insurmountable. What is a species? and what is the meaning of those natural affinities according to which species are to be classed? were questions which in 1859 it was generally thought vain to discuss.... We were taught, and some may still believe, that every species...was an original creation, perpetuated through every generation within fixed limits which never have been and never will be transgressed." (On the Recent Progress and Present State of Systematic Botany. *Report of the British A.A.Sc.*).

Asa Gray. 1887. "Each individual owes its existence to a parent, and produces similar individuals in its turn. So each individual is a link of a chain; and to this chain the natural-historian applies the name of Species. All the descendants from the same stock therefore compose one species. And it was from our observing that the several sorts of plants or animals steadily reproduce themselves, or, in other words, keep up a succession of similar individuals, that the idea of species originated. There are few species, however, in which man has actually observed the succession for many generations. It could seldom be proved that all the white pine trees or white oaks of any forest came from the same stock. But observation having familiarized us with the general fact that individuals proceeding from the same stock are essentially alike, we infer from their close resemblance that these similar individuals belong to the same species. That is, we infer it when the individuals are as much like each other as those are which we know, or confidently suppose, to have sprung from the same stock." Again, "Species are the units in classification. Varieties, although of utmost importance in cultivation and of considerable consequence in the flora of any country, are of less botanical significance. For they are apt to be indefinite and to shade off one form into another. But species, the botanist expects to be distinct. Indeed, the practical difference to the botanist between species and varieties is the definite limitation of the one and the indefiniteness of the other. The botanist's determination is partly a matter of observation, partly of judgment." (*The Elements of Botany*, Am. Book Co., NY).

R.V. Wettstein. 1901, "One may call species the totality of individuals which agree among each other and with their progeny in all characters which seem essential to the observer." (*Handbuch der Systematischen Botanik*, Wien. p. 13).

J.P. Lotsy. 1916. "A species consists of the total of individuals of identical constitution unable to form more than one kind of gametes." (*Evolution by Means of Hybridization*, The Hague. p. 23).

Alexis Jordan. (*ex* Lotsy, 1916). "The Linnean species is no species."

G.E. Du Rietz. 1930. "Species are the smallest natural populations permanently separated from each other by a distinct discontinuity in the series of biotypes". (The fundamental units of biological taxonomy, *Svensk. Bot. Tiolskr. 24:333-428*).

N.I. Vavilov. 1935. "The study of several hundered cultivated crops conducted by a large body of scientific workers has led us to a conception of the Linnaean species including the cultivated plants, as a definite *heterogeneous system*. As we interpret it, *the species represents a more or less distinct heterogeneous and variable morpho-physiological system, the origin of which is associated with a particular environment and area*." (The Origin, Variation, Immunity and Breeding of Cultivated Plants, Page 17, Translated by K. Starr Chester, In *Chronica Botanica 13(1): 1-366. 1951*.

Webster's Collegiate Dictionary. 1940. "*Biol.* A category of classifcation lower than a genus or subgenus and above a subspecies or variety, a group of animals or plants which possess in common one or more distinctive characters, and do or may interbreed and reproduce their characters in their offspring; a distinct kind or sort of animal or plant."

W.B. Turrill. 1940. "No single absolute test for a species is yet known, and it is debatable if such is ever likely to be found, but as a working hypothesis the following criteria should be considered: a species is morphologically definable in that it has a sum-total of characters, and every individual within it has constant resemblances with every other individual within it, and constant differences from every individual of other species, even when the individuals are grown under diverse conditions; species are isolated one from another, sometimes geographically, sometimes by habitat preferences, sometimes by having different flowering periods, usually by not crossing naturally to produce completely fertile offspring; species may show chromosomal differences. A species is an isolated group of individuals whose sum of characters tends to keep constant by natural inbreeding." (*Experimental and synthetic plant taxonomy*. In Huxley, J. ed. *The New Systematics*, Oxford Univ. Press. p. 62).

N.W. Timofeeff-Ressovsky. 1940. "A species is a group of individuals that are morphologically and physiologically similar (although comprising a number of groups of the lowest taxonomic category), which has reached an almost complete biological isolation from similar neighboring groups of individuals inhabiting the same or adjacent territories. Under biological isolation we understand the impossiblilty or non-occurrence of normal hybridization under natural conditions." (*Mutations and geographical variation*. In Huxley, J. ed. *The New Systematics*, Oxford University Press. pp. 91-92).

Mayr, E. 1942. "A species consists of a group of populations which replace each other geographically or ecologically, and of which the neighboring ones intergrade or interbreed wherever they are in contact or which are potentially capable of doing so (with one or more of the populations) in those cases where contact is prevented by geographical or ecological barriers." "Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups." (*Systematics and the origin of species*, Columbia Univ. Press).

W.H. Camp and C.L. Gilly. 1943. "There are even some among us who have advocated that we discard

the concept of a species altogether. Therefore, the question which the systematist should seek first to answer is not: Upon what criteria should the concept of a species-unit be based? Rather, he must enquire: Does the species-unit deserve to be a fundamental philosophical concept? This, perhaps fortunately for his own peace of mind, has long ago been decided for him. The concept of species or kind, as a unit, has become so firmly entrenched in the mind of man--so much a part of his awareness, so necessary to his basic philosophy--that it remains only for the systematist to interpret this unit . . ." (The structure and origin of species, *Brittonia 4: 325-385*).

Alfred Emerson. l947. "A species is an evolved or evolving, genetically distinctive, reproductively isolated, natural population. All of these attributes are necessary, and no others would seem to be essential." (*Encycl. Brit.*).

M.L. Fernald. 1950. "The species is conceived as a series of individuals (usually numberless) occupying, until disturbed by man's activity, a natural geographic area and having essentially identical morphological characters of flower, fruit, or reproductive structure, somewhat exemplifying the biblical definition 'It is by their fruits ye shall know them', for most critical taxonomic study starts, when possible, with flower, fruit, seed or spore." (*Gray's Manual ed. 8*, p. vii).

G.L. Stebbins. 1950. "Species are separated from each other by gaps of genetic discontinuity in morphological and physiological characteristics which are maintained by the absence or rarity of gene interchange between members of different species." (p. 190). "In order... to make valid inferences as to the specific status of allopatric, as well as sympatric, population systems, one must determine not only whether they can cross and produce fertile hybrids under the optimum conditions of a cultivated garden plot but, in addition, whether they could coexist in the same territory and hybridize under natural conditions." Also, "The wisest course would seem to avoid defining species too precisely and to be tolerant of somewhat different species concepts held by other workers. The one principle which is unavoidable is that species are based on discontinuities in the genetic basis of the variation pattern rather than on the amount of difference in their external appearance between extreme or even 'typical' individual variants." Again, "If we accept this latitude in our species definitions, then we can recognize the existence as species-isolating mechanisms of purely spatial isolation, strictly ecological isolation of sympatric forms, or various combinations of these two isolating factors. And the latter are by far the most common in nature." (p. 204). (*Variation and Evolution in Plants*, Columbia University Press. Chapter IV: 189-250).

Henry A. Gleason. 1952. "A genus is a taxon of higher rank than a species. It ordinarily includes several or many species which resemble each other in important features of structure and which differ from other genera in equally important characters." (*Illustrated Flora of the Northeastern United States and Adjacent Canada*).

Andrewartha and Birch. 1954. "The species is the most inclusive Mendelian population; its chief characteristic is that its members do not (no matter how good may be the opportunity) interbreed with members of other Mendelian populations. Populations whose members do not interbreed because they

are kept apart by geographic barriers may not be classed as species on this evidence alone; for example, a number of Mendelian populations living on several widely separated oceanic islands may all belong to one species, even though there is virtually no chance of interbreeding in nature because of the distances separating the islands. On the other hand, if it were found, when they still did not interbreed, then they would be correctly classed as separate species."

Verne Grant. 1957. "...a community of cross fertilizing individuals linked together by bonds of mating and isolated reproductively from other species by barriers to mating." (*The plant species in theory and practice*. In E. Mayr (ed.), *The species problem: 39-80,* Amer. Assoc. Adv. Sci., Washington, D.C.).

D.H. Valentine and Askell Love. 1958. "The species of the biosystematist, for which it is convenient to use the term ecospecies, is defined in terms of gene- exchange. If two populations are capable of exchanging genes freely under either natural or artificial conditions, they belong to the same ecospecies; but if internal barriers to gene-exchange exist (e.g. in the form of incompatibility or hybrid infertility), then the populations are ecospecifically distinct. This definition is apparently simple, and it provides an objective criterion of a species, something which can be determined by experiment; and it also has a biological meaning in that it marks a certain stage in the process of evolutionary divergence." (Taxonomic and Biosystematic Categories. *Brittonia 10 (4): 153-166*).

Clausen and Hiesey. 1958. "Species are composed of genetically distinguishable ecological races and morphological subspecies, each of which is adjusted to its own kind of environment and controlled by interacting systems of genes loosely held together through genetic coherence." (*Carnegie Inst. of Washington Publ. Experimental Studies on the Nature of Species IV*).

V.H. Heywood. 1959. "It needs to be stressed that a fundamental tenet of taxonomy is that rules cannot be made about delimiting species: the most that can be done is to lay down general guiding principles. There must always be an element of judgment (involving experience and perhaps intuition) in any taxonomic decision. Non-taxonomists may deplore this, but it is unavoidable. For this reason no precise definition of the species is possible." (in *Fedde Repert. 63: 180*).

George Gaylord Simpson. 1961. "An evolutionary species is a lineage (an ancestral-descendant sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies." (*Principles of Animal Taxonomy*, p. 153).

S.T. Cowan. 1962. ". . . just as no two observers see the same rainbow, so no two biologists conceive exactly the same species." (In G.C. Ainsworth & P.H.A. Sneath, ed., *Microbial Classification*, pp. 433-455).

Lyman Benson. 1962. "Definition of the term species is an ellusive goal only if an attempt to limit the category is included. Leaving out criteria for distinguishing species from each other, the problem narrows down to the question of what kind of entity is being classified. A working definition must take into account the following elements: 1) The species discussed in this book are composed of living

organisms. 2) A species is able to reproduce itself. 3) A species is ordinarily a natural population or system of populations, rarely an individual. 4) The individuals composing a species are genetically closely related." Also, "A living natural species is a reproducing population or system of populations of genetically closely related individuals." (*Plant Taxonomy.*, The Ronald Press Company, N.Y. pp. 289-290).

P.H. Davis and V.H. Heywood. 1963. "Many evolutionary taxonomists believe that species are formed as a result of the evolutionary processes. It is an act of faith for both Linnaean and evolutionary taxonomists that their task is to go out into nature and find these creations. The *concepts* covering these and other groups called species are, however, constructions of the human mind and cannot be defined. (P.89). And, on another page "...we may regard species as morphologically definable units, made up of groups of individuals (populations), which it is assumed are usually interbreeding, the containers and expression of one or more gene pools." (P. 98). (*Principles of Angiosperm Taxonomy*, D. Van Nostrand Company, Inc. N.Y.).

Carl L. Wilson and Walter E. Loomis. 1967. "Many difficulties are involved in the study of species and of their origin. Some species are sharply defined. but others grade into related species through intermediate forms. Some of these intermediate forms may represent incipient species, for species are arising today as in the past. Most evolutionary changes take place so slowly, however, that they do not become evident within any easily recorded period of time and so the problem is attacked indirectly. By growing plants in experimental gardens, by studying their mutations and their chromosomes, by collecting them and studying their distribution, it is frequently possible to make reasonable inferences concerning their evolutionary history. Although there is no general agreement on the definition of a species, it may be defined ideally as a group of individuals that are morphologically distinguishable from related kinds, and that will not cross or that cross with difficulty with related species. All existing species have come from pre-existing species, but so complex are environmental factors and living organisms that species are believed to have arisen in different ways; there is no one solution to the problem of their origin. The chief principles involved in the formation of new plant species may, according to modern views, be grouped under two main heads: (1) reproductive isolation and (2) species hybridization." (*Botany, 4th Ed.*, Holt, Rinehart and Winston, NY).

Arthur Cronquist. 1968. "An exact definition of the species is impossible, and the more precise one attempts to be, the larger number of species which do not fit the definition. Still, the basic concept is simple enough. A species is the smallest population which is permanently (in terms of human time) distinct and distinguishable from all others. It is the smallest unit which simply cannot be ignored in the scheme of classification. It is the primary taxonomic unit, and it may also be thought of as the basic evolutionary unit." And, "The line between strong varieties and weak species is necessarily an arbitrary one, involving subjective taxonomic judgment. The weak species of one taxonomist may be the strong varieties (or subspecies) of another." (*The Evolution and Classification of Flowering Plants*," Houghton Mifflin Co., Boston. P. 29).

George H.M. Lawrence. 1970. "The species (i.e., the ecospecies), as conceived by the biosystematist, is a group of interbreeding or potentially interbreeding individuals reproductively isolated from other

groups of individiuals. It is a unit delimited primarily by genetical criteria and secondarily by criteria derived from ecological and morphological evidence." (*Taxonomy of Vascular Plants*, the MacMillan Co., NY. p. 182).

Oswald Tippo and William L. Stern. 1977. "1. A species is a kind of plant (or animal). White oak (*Quercus alba*, Figure 3.11), red maple (*Acer rubrum*, Figure 3.15), white pine (*Pinus strobus*, Figures 16.9 and 16.10), coconut palm *Cocos nucifera*, Figure 11.12), tobacco (*Nicotiana tabacum*), are species or kinds of plants. 2. Each individual of a species is related to other individuals of the same species because they have common ancestors; they have evolved from the same sources. 3. Individuals of the same species are similar in structure, more so to each other than to other kinds of plants. 4. Species maintain themselves in nature; they do not change appreciably from generation to generation over short periods of time. 5. Individuals of a species interbreed and produce fertile offspring." (*Humanistic Botany*, W.W. Norton & Co., NY).

Clive A. Stace. 1980. "There have been many attempts to define a species, none totally successful. This difficulty has led to the cynical definition of a species as a group of individuals sufficiently distinct from other groups to be considered by taxonomists to merit specific rank. The crux of the question does of course, lie in the term 'sufficiently distinct', since, from what has been said above, there is no magic formula to decide the issue. Most taxonomists use one or more of four main criteria. 1. The individuals should bear a close resemblance to one another such that they are always readily recognizable as members of that group. 2. There are gaps between the spectra of variation exhibited by related species; if there are no such gaps then there is a case for amalgamating the taxa as a single species. 3. Each species occupies a definable geographical area (wide or narrow) and is demonstrably suited to the environmental conditions which it encounters. 4. In sexual taxa, the individuals should be capable of interbreeding with little or no loss of fertility and there should be some reduction in the level or success (measured in terms of hybrid fertility) of crossing with other species. As discussed elsewhere in this book. none of these criteria is absolute and frequently it is left to the taxonomist to apply his judgement. Often he does this by attempting to recognize as species units that are of comparable significance in whatever terms are being applied." (*Plant Taxonomy and Biosystematics*, Edward Arnold, London).

Webster's New World Dictionary (2nd Concise Edition). 1982. Species (-shez, -sez) *n., pl.* -cies [L., appearance, shape, kind, etc.] 1. a distinctive kind; sort; variety; class 2. *Biol.* a group of highly similar plants or animals that is part of a genus and that can reproduce fertile offspring only among themselves 3. *Logic* a class of things with distinctive attributes, grouped with similar classes in a genus.

Warren H. Wagner, Jr. 1984. ". . . a convenient taxonomic category that defines a unit of organismic diversity in a given time frame and composed of individual organisms that resemble one another in all or most of their structural and functional characters, that reproduce true by any means, sexual or asexual, and constitute a distinct phylogenetic line that differs consistently and persistently from populations of other species in gaps in character state combinations including geographical, ecological, physiological, morphological, anatomical, cytological, chemical, and genetic, the character states of a number and kind ordinarily used for species discrimination in the same and related genera, and if partially or wholly

sympatric and coexistent with related species in the same habitats, unable to cross or, if able to cross, able to maintain the special distinction." (A Comparison of Taxonomic Methods in Biosystematics, In *Plant Biosystematics*, ed. W.F. Grant, pp. 643-54, Academic Press, Canada).

H. Crum. 1985. "A species cannot be fully defined, nor can it be intuitively sensed. Although subjectivity is involved in decision making, a species is only as good as the knowledge and insights used in its delimitation. Certain methodologies help. So do good sense and good judgement based on meaningful experiences, and the more the better." (Traditional make-do taxonomy, *Bryologist* 88: 221).

Peter H. Raven and George B. Johnson. 1986. "In Chapter 21 we reviewed the nature of species and saw that there are no absolute criteria that can be applied to the definition of this category. Individuals that belong to a given species, for example, dogs (Figure 22-5), may look very unlike one another. Nevertheless, they are generally capable of hybridizing with one another, and the different forms can appear in the progeny of a single mated pair. On the other hand, the members of a given species often cannot hybridize with those of a second species. For example, dogs are not capable of interbreeding with foxes, which, although they are generally similar to dogs, are members of another, completely distinct, group of mammals. In contrast, dogs can and do form fully or partly fertile hybrids with related species such as wolves and coyotes, which are also members of the genus *Canis*. The transfer of characteristics between these species has, in some areas, changed the characteristics of both of the interbreeding units. About the only points that can be made about species generally are that they differ from one another in at least one characteristic and that they generally do not interbreed freely where their ranges overlap in nature. In some groups of organisms, including bacteria and many eukaryotes, asexual reproduction predominates and classification systems clearly do not have a genetic basis. Biologists agree, in general, on the kinds of units that they classify as species, but these units share no biological characteristics uniformly. Species differ from one another in at least one characteristic and generally do not interbreed freely with one another where their ranges overlap in nature." (*Biology*, Times Mirror/Mosby College Publishing, St. Louis).

Author and date unknown: "A species is what a good taxonomist calls a species."

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