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FORUM

Long-term studies on vegetation dynamics: some notes on concepts, fundamentals and conditions

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Objectives of long-term studies

Many concepts were developed and much experience was accumulated in 65 years of studying permanent plots in forest and non-forest communities of the temperate zone, specifically in the Białowieża Primaeval Forest of northeast Poland (Faliński 1967, 1977, 1986, 1999, 2001b, 2002, Falińska 1991, 2002, Matuszkiewicz 1977, Włoczewski 1972 and continuation in Bernadzki et al. 1998). Details regarding the methodological aspects are described in two special methodological guides to long-term and plant population biology studies (Faliński 2001a, 2002, Falińska 2002). The topic of dynamic studies of vegetation is treated by Braun-Blanquet (1928), Knapp ed. (1974), Miles (1979), Miles et al. (1989), and Faliński (1978) in some detail, and in relation to governing principles by Orlóci (1993, 2000, 2001), He and Orlóci (1999), Anand and Orlóci (1997), and Orlóci, Pillar and Anand (2002), Orlóci, Anand and Pillar (2002) who also provide relevant references to the world literature.

The present contribution discusses ideas and concepts regarding long-term ecological studies, on the basis of the following assumptions:

1. Where duration and complexity are concerned, most ecological and biological processes in nature take time to manifest themselves clearly, thereby necessitating long-term studies based on well founded research procedures.

2. Long-term studies trace processes and associated phenomena through phases of development.

3. Disruptions of a study are to be avoided because they undermine the credibility of the results when the effects responsible for the unfolding of the process and the associated phenomena are accounted for.

Long-term studies are undertaken with six main objectives in mind:

1. Gaining familiarity with the nature of processes;

2. Recognition of regularities over space and time;

3. The accumulation of information as to the functioning of an entire physiographic object, and especially its functioning as an integrated ecological system;

4. The development of a scientific basis for active protection, as well as the maintenance and reconstruction of ecosystems;

5. Facilitation of the sustainable management of natural resources;

6. Monitoring of overall changes at regional and national levels.

Study objects and the duration of long-term studies

The length of the intended studies should depend on the nature of the processes to be studied, and the properties of the given ecological systems. Recent reports covering periods of just several to 10-20 years are often characterized as "long-term" (see Likens 1987, Burrows 1990; exceptional examples are Schreiber 1997 and Wildi

Table 1. The shortest study time indispensable for description of some ecological phenomena and processes by way of accompanying long-term studies (after Faliński 1997, 1999, 2001a, modified).

To 1/2 year:
- seasonal change in the domination of geophytes/hemi-cryptophytes in herb layer
- effect of freezing
- tree stand foliage; leaf fall

To 1 year:
- course of single seasonal cycle in forest communities and plant populations
- actual biomass of populations, layers, communities

During 1...10 years:
- primary production
- neophytism: observations and experiments on the penetration of plant communities by alien species
- population structure of perennial and woody plants
- permanent relations in plant community

During 10...15 years:
- secondary production, consumption, decomposition
- seasonality of forest communities
- fluctuation in non-forest communities
- initial phases of succession
- features of herbaceous plant populations; life history
- course of flowering initiation in the populations of pioneer woody plants (*Populus, Juniperus, Salix* sp. sp.)
- changes in sex, size and age structure in populations of woody pioneer species
- balance of uprooted trees in forest
- game preferences to forest environments
- neophytism - process of establishment and fitness of alien species in plant communities

During 15...25 years:
- fluctuation in forest communities
- degeneration of forest communities
- stability of community structure; repeability of seasonal rhythms
- regression in non-forest communities
- co-evolution between plants and animals (confirmation of phenomenon only)
- secondary succession - parts of series

During 25...80 years:
- regeneration of forest communities after long zoogenic or anthropogenic pressure
- regression of forest communities

Over 80 years:
- forest primary and secondary succession

2002). Since there is a strong need for clear terminology to avoid misinterpretations (Table 1), I would suggest the following categorization:

- short-term studies (3-10 years);
- medium-term studies (11-25 years);
- long-term studies (26-80 years);
- studies of indefinite duration (80 years).

General study concepts

The concept and programme for research should assume the stepwise resolution of problems, not unlike Poorean successive approximation (Faliński 1967, 1972, 1977, 1998b, 1999, 2001b, 2002, Orlóci 2001). In such a case, the processing of data and publication of results may have to take place in a similar manner. The stepwise approach recycles past experience and data, favours research interests to stay the line, allows synergism in the definition of problem and approach, and promotes co-operation. It needs to be assumed in advance that the tasks may involve successive generations of researchers who commit themselves to continuing the work of their predecessors.

Choice of environments, if not otherwise dictated in long-term ecological studies, should consider national parks, nature reserves and agricultural land removed from utilisation for the foreseeable future. These are sites of a kind that assure continuity of study under controlled conditions, and - not least in importance – they attract international and interdisciplinary co-operation via working groups formed to service major programs in long-term research (e.g., the “International Working Group on Succession Research on permanent Plots”; “International

Long Term Ecological Research ILTER"; "Networking of Long-Term Integrated Monitoring NoLIMITS", etc.).

Conditions for long-term studies

Long-term studies are complex by their nature, because they deal with complex, dynamic objects. These studies have to meet at least seven conditions:

1. clearly-defined aims, hypotheses and study objects, and a detailed plan and timetable for the work to be done (Figs. 1 and 4);
2. an appropriately selected, prepared and secured site;
3. a system of permanent research plots;
4. long-term, systematic observations;
5. a complete research procedure (see Fig. 4);

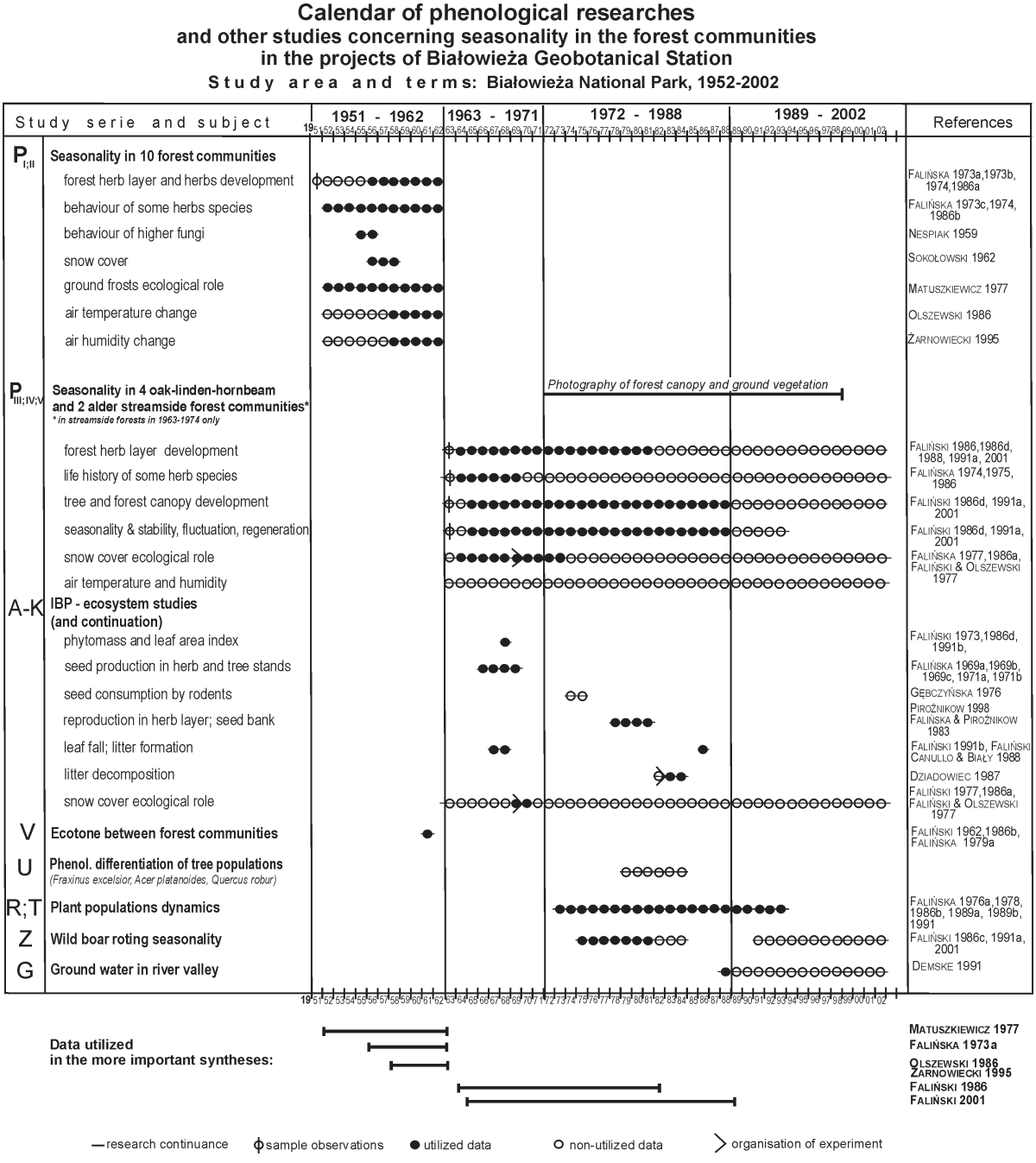

Figure 1. Calendar of phenological research and other studies concerning seasonality in the forest communities in the projects of Białowieża Geobotanical Station, Białowieża National Park, 1952-2002. All references in Faliński 2001b (after Faliński 2001b, supplemented).

6. a system for archiving and processing data;

7. a team of qualified researchers, effective team management and adequate financial and technical resources.

The conceptualisation of a study must be such that it allows consideration to be given to all phenomena that bear on the nature of the process to be understood, ensures the collection of data that bear directly on the hypotheses posed, and also allows for the ongoing optimisation of resources and economy of effort. With respect to permanent plot locations, potential biases that can be introduced are discussed by Palmer (1993).

Model study objects

It is not merely continuity that is a fundamental requirement in long-term studies, since it is equally important that the same frame of reference be retained. This im-

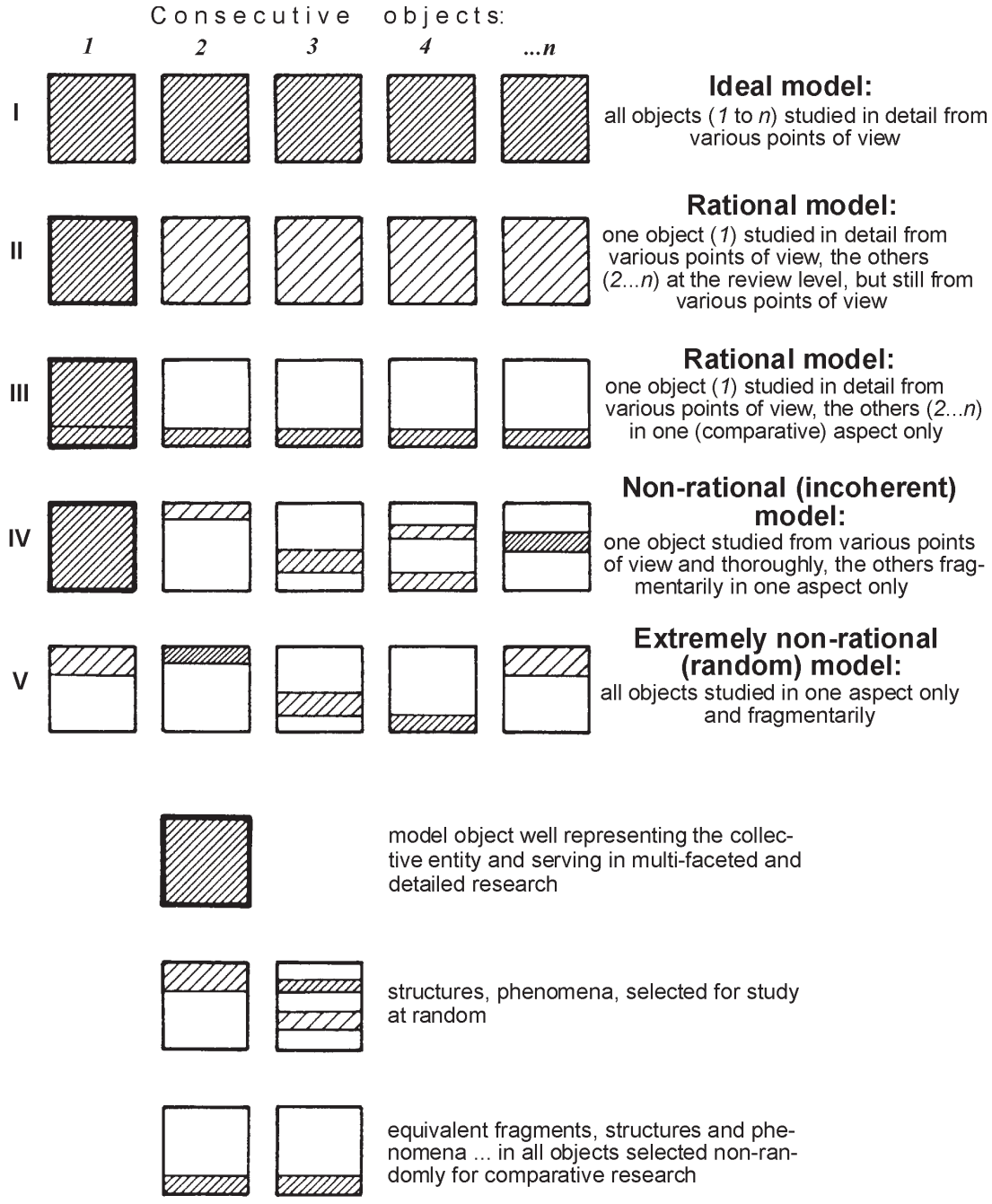

Figure 2. Optimization in geobotanical studies through the selection of research objects and the establishment of their degree of detail. In the Białowieża studies, the rational model (III) is used (on the objects studied from various points of view and details, the others from one point of view, supplementary and comparatively) (after Faliński 1989, 2001b).

plies a system of experimental plots of appropriate size, shape and stratification, as well as a system of fixed reference points (Fig. 2) skilfully selected to serve the aims.

Long-term observation models

An example of the long-term observational model is shown in Fig. 3: *A*, *B*, *C*, depicting the real course of events in successive series of phenomena. As time passes, there is more of a possibility to synthesise data obtained simultaneously, which can then be generalised in the form of a large-scale ecological map. Proving itself best in practice is a combination of the rational model (Model II) with model III (Fig. 3: II, III). The latter assumes the simultaneous undertaking of observations on several research objects, within which the process under study is occurring at different stages (*C* – the initial phase, *B* – the transitional phase, and *A* – the final phase). This model supplies data that allow for preliminary synthesis over a period several times longer than the research has lasted in reality. In the literature, this is referred to as space-for-time substitution (Faliński 1989, 2001b, Pickett 1989). In Wildi and Schütz (2000), an example is found for a time series derived by this method spanning almost 600 years (cf. Wildi 2002). The unsuitability of models IV, V and VI has to be accepted, while model VII is unreliable when

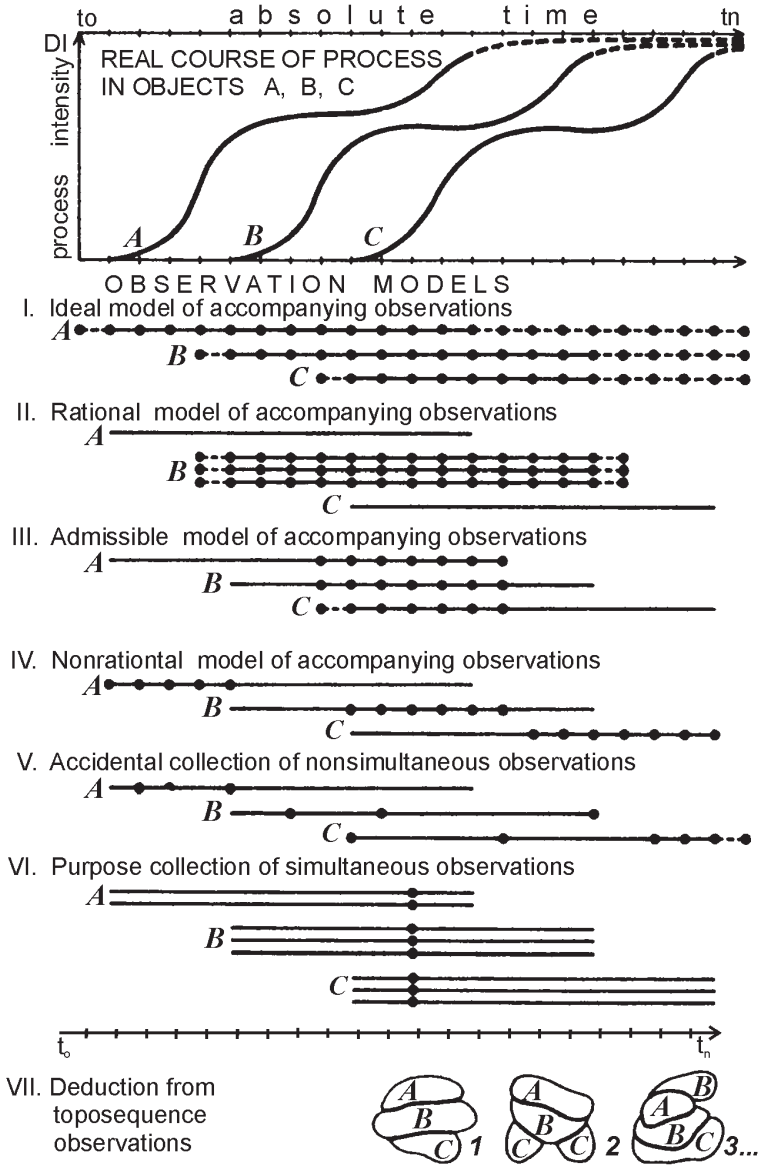

Figure 3. Optimization in long-term studies on vegetation dynamics. In the Białowieża studies, model (II) in used. A, B, C: study objects; –•–•–•–•–: observations terms (after Faliński 1998a, 2001b).

it comes to the drawing of conclusions regarding the dynamic links between ecological systems on the basis of their proximity to one another in the field (Fig. 3: VII).

Research procedure

With reference to the concept of "research procedure", I have in mind the way tasks are approached under the given frame of reference. Thus, the procedure comprises methods for the collection of data (observational and experimental) and their mutual relations, the means by which the data are obtained and the data sources can be verified, and the manner in which conclusions are drawn. The research procedure is thus something more than the collection of methods described in detail in every scientific work (Fig. 4). Considering the fundamental element in studies of the dynamics of ecological systems, it is recommended that all auxiliary sources of information are used, most typically those from dendrochronological analysis in forests under temperate climates (Faliński 1998a, 1998 b, 1998c, 2001a, Koop 1989).

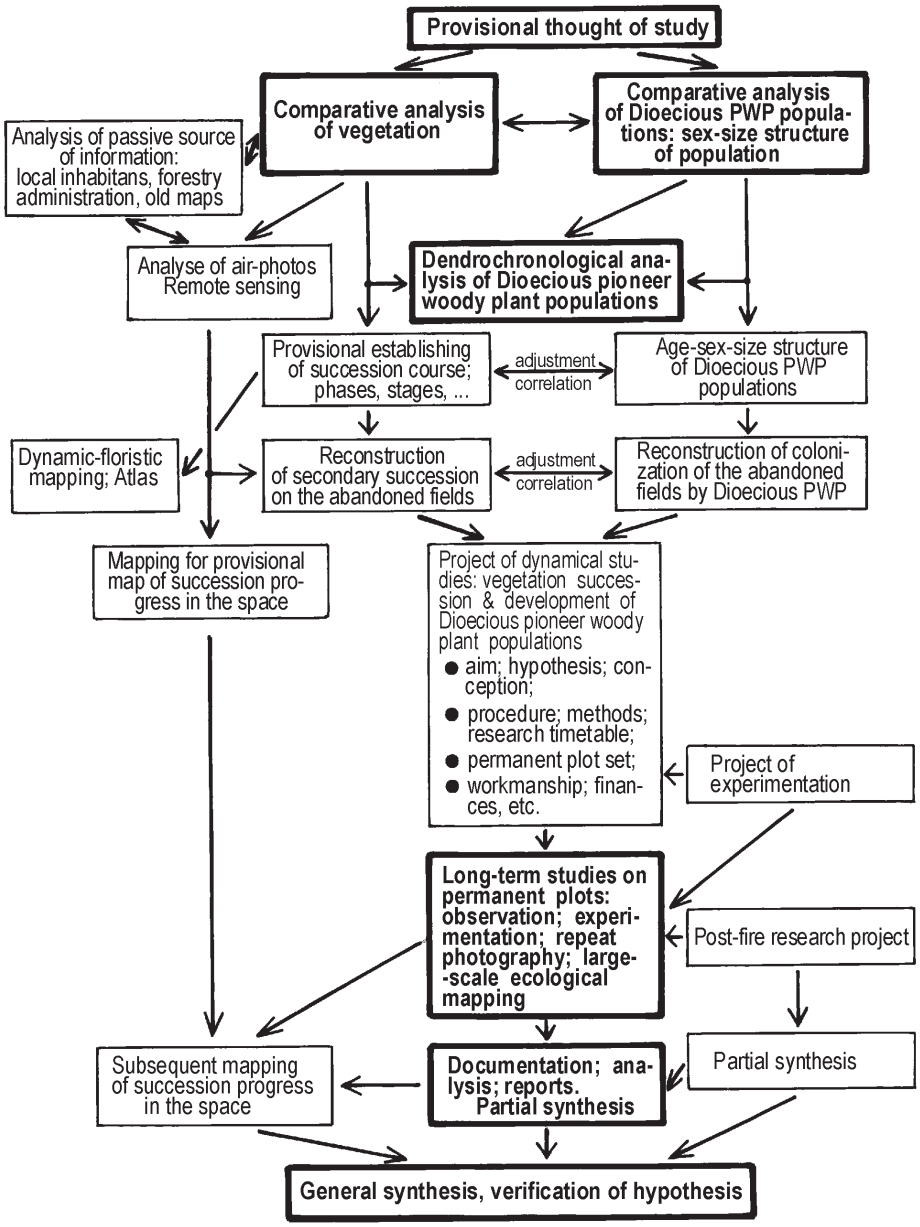

Figure 4. Research procedure: the course and the significance of long-term observations and dendrochronological reconstruction in the study on secondary succession and on the development of populations of pioneer woody species (PWP) during the process (after Faliński 1998a).

Closing remarks

If success is to be achieved with the application of direct observation and auxiliary study, then there has to be methodological uniformity throughout the whole observational process. This has to hold true for measurements, scales, instrumentation, means of recording and regularity, and indeed for the whole range of activities making up the research procedure (Figs. 1 and 4). The procedure is only successful if planned properly and pursued effectively to the benefit of both theoretical and practical ecology.

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