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Nature-based forest management—Where are we going? Elaborating forest development types in and with practice

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Abstract

The decision to transform ‘‘classical’’ age-class forests (plantation forestry) into more nature-based forest stand structures implied a paradigmatic shift in the Danish state owned forests and their management. In order to facilitate this process of change, scientists were employed by the Danish Forest and Nature Agency which enabled interactions with the professionals in the forest over a nearly 2-year period. Very soon it became evident that the main questions were not so much related to the process of shifting from age-class forests to nature-based management, but more to the evident lack of settled long-term goals in terms of stand structure and dynamics of the ‘‘future’’ forests. Realizing this constraint, forest development types (FDT) and their illustration by means of profile diagrams were elaborated in an adaptive, participatory process involving people both inside and outside the organisation. FDT describes long-term goals for forest development on a given locality (climate and soil conditions) in order to accomplish specific long-term aims of functionality. It is based upon an analysis of the silvicultural possibilities in combination with the aspirations of future forest functions. It will serve as a guide for future silvicultural activities in order to ‘‘channel’’ the actual forest stand in the desired direction.

Looking through the lens of ‘‘social learning’’ this paper reflects on and discusses the participatory, bottom-up process in which the knowledge of professionals and scientists was mixed in the development of long-term goals for stand structures and dynamics in nature-based forest management. Specifically, the use of FDT scenarios and their illustration by means of profile diagrams as tools to organise and ease communication in this learning process is addressed and presented as an integrative, flexible and easily comprehensible concept for communicating long-term goals for stand development in nature-based forest management.

Keywords: Forest development type (FDT); Nature-based forest management; Profile diagrams; Social learning

1. Introduction

Across Europe declining health and lack of stability in age-class forests as well as growing concern about the environmental sustainability of the related management systems have led to an increasing interest in more ‘nature-oriented’ forest stand structures and dynamics. Nature-oriented forest management is based on continuous forest cover, mixed stands, uneven-aged stand structures, selective harvest, and excessive use of natural regeneration. In the Danish context this implies further not only to focus upon the ‘‘native’’ species but also to continue using a number of ‘‘exotic’’ species. It is expected that moving in this direction more resilient forests and a more sustainable forestry sector can be achieved (Larsen, 1995; Koch and Skovsgaard, 1999; Franklin et al., 2002; Gamborg and Larsen, 2003; Franklin, 2004).

For the Danish Forest and Nature Agency, this development implies a replacement of 250 years of tradition and related knowledge of plantation forestry in favour of more nature-based management principles in all state owned forests (Danish Forest and Nature Agency, 2002). The forests are spread all over the country covering approximately 110 000 ha equal to 24% of the total forest area in Denmark, with a central office formulating the management strategies and planning, while 20 local districts are implementing these in the day-to-day management.

Facing the paradigm shift it became imperative to incorporate knowledge from scientists with experiences and ideas from the professionals; ranging from forest supervisors, forest officers, and forest rangers to field staff with vocational level education and staff doing semi-skilled labour. Further, the size of the organisation and share of competence between the

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central and local units demanded a shared understanding of framework and long-term goals. In order to meet these ‘‘demands’’, scientists were employed by the Danish Forest and Nature Agency over a 2-year period, which enabled them to interact with people from all levels of the agency thereby facilitating a bottom-up participatory learning process.

Confronted with this huge conversion task one could expect that the first question asked by the professionals would be: ‘‘How do we get there?’’ However, this was not the case. The professionals went one step further back asking ‘‘Where are we going?’’ It turned out that their main hesitation adopting nature-based management principles came from a pronounced uncertainty in terms of long-term goals for stand structures and dynamics. Due to a long tradition of managing uniform, even-aged monoculture stands, the professionals were short of experience with natural and semi-natural forest structures and dynamics in the temperate nemoral zone, in which Denmark is situated. Here regeneration develops in gaps resulting in a fine- to medium-grained shifting steady-state mosaic of mainly broadleaved species (e.g. Emborg et al., 2000).

This experience pinpointed that a common understanding of the nature-based management principles and long-term goals for stand development had to be created before any changes in the forest management towards more nature-based principles could be initiated successfully. This task necessarily implied the development of concepts for organising, describing and communicating these whole new management principles and desirable stand structures and dynamics to the professionals and other stakeholders.

Looking through the lens of ‘‘social learning’’ this paper reflects on the participatory, bottom-up process in which the knowledge of professionals and scientists was mixed in the development of long-term goals for stand structures and dynamics in nature-based forest management. Specifically, the use of FDT scenarios and their illustration by means of profile diagrams as tools to organise and ease communication in this learning process is addressed and presented as an integrative, flexible and easily comprehensible concept for communicating long-term goals for stand development in nature-based forest management.

2. Materials and methods

Forests, like most renewable natural resources, are complex in both their nature and their management arrangements. Hence, it is not possible to tell with certainty how the system works, or even to be able to predict precisely what the outcome of management actions might be. This basic uncertainty is increased further when moving from one management paradigm to another, as in the present case. In this context, the classical top-down management of forests is too general to account for local complexities and the uncertainties they create.

Taking the pronounced uncertainty of long-term goals for stand structures and dynamics in nature-based forest management, scientists and professionals were for nearly 2 years united in a demand-led, participatory process with a social learning focus that takes inspiration from adaptive management as described by, e.g. de Boo and Wiersum (2002). Adaptive management is management and capacity building which accepts uncertainties related to not having all information one would like, or not being sure what the future should be (de Boo and Wiersum, 2002). Here, concepts of relevance to practice are developed with an active focus on advancing knowledge in a social learning process; i.e. the process of framing issues through analysing and debating alternatives in the context of inclusive social deliberation (Reich, 1988). The active focus on learning and feedback provides all parties with better opportunities to understand the situation and to draw upon the different parties' experiences and knowledge (Daniels and Walker, 2001). Thus, it is not only a way to achieve objectives in ecological–technical aspects. It is also a people-oriented process involving professionals from all levels of the agency, as in this case, in an experimental and reflective learning process of exploring problems and their solutions and uncertainties and their answers. This approach is in line with the joint recommendations from IUFRO, FAO and CIFOR which emphasises that forestry research should not be conducted in a vacuum but bridge the gaps between the traditional and modern pools of knowledge and experiences (Burley et al., 2001).

Recognising the interdependence among science and local knowledge in developing ideas about long-term goals for stand development in nature-based forestry, self-interest was used as a motivating factor for incorporating knowledge and views from professionals at all levels of the classical forestry ‘hierarchy’ (Ruitenbeek and Cartier, 2001).

We entered the agency as participants and scientists with the dual purpose of advancing knowledge and facilitating practical transformation. Through numerous iterations where professionals and scientists were joined in various configurations (Fig. 1), the task was to facilitate continuous dialogue and debate in order to encourage the encounter between the professionals' experience-based, contextual knowledge and skills and the scientists context-free knowledge to be synthesised and adjusted in interaction with the situation (Tydén, 1993; Stringer, 1999; Huxham and Vangen, 2003). Focus was on framing the issues, advancing and locally adapting knowledge, analysing alternatives, and debating choices in inclusive deliberation. As scientists, we gave advice embracing not only what we knew beforehand, but also what we had learned in the process.

2.1. Vision scenarios—FDT

The complex nature of near-natural forest structures and dynamics and their management arrangements requires integrative and flexible management frameworks. Creating scenarios of what such structures and dynamics might be are useful when complexity and uncertainty are high, as they introduce hypothetical possibilities that spur imagination and encourage interaction and debate. Thus, whether expressed visually or verbally, scenarios can be tangible ways of exchanging knowledge among people because of their inherent

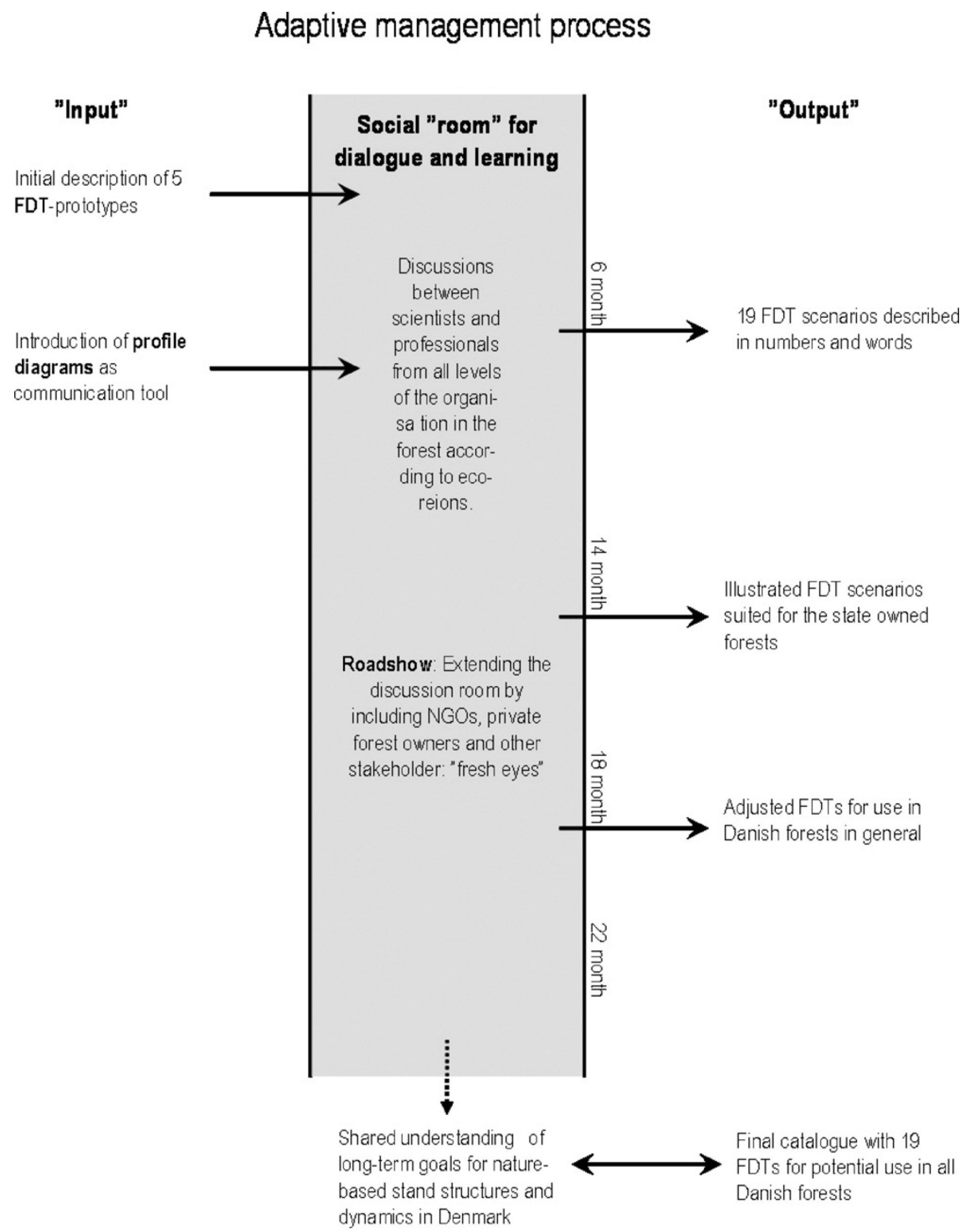


Fig. 1. Diagram illustration the sequence of events in the adaptive management process of developing long-term goals for stand structures and dynamics in nature-based forest management in Denmark.

nature as means of expression and communication (Wollenberg et al., 2000a,b; de Boo and Wiersum, 2002). Correspondingly, scenarios can be useful to stimulate new ways of thinking about uncertain and complex future stand structures and dynamics, as in this case. In the following we use the term scenario to reefer to the possible realisation of a long-term goal for stand structures and dynamics to be achieved by the forest management and not to the sequence of silvicultural treatments leading to that goal.

FDT scenarios provide one such adequate framework for advancing and describing ideas about long-term goals for structures and dynamics in stands subjected to nature-based forest management (Perpeet, 2000). A major object of FDT scenarios is to describe the practical impact of the general policies for nature-based silviculture on the stand level. The concept comprises a broader understanding of natural disturbance regimes and successional processes than hitherto used. As such it has great similarities with the forest cycle models that have successfully been used to describe the temporal and spatial dynamics and cyclic preoccupation of a specific forest type in natural forest reserves (see, e.g. Leibundgut, 1959; Zukrigl et al., 1963; Meyer and Neumann, 1981; Mueller-Dombois, 1987; Jenssen and Hofmann, 1996; Emborg et al., 2000; Grassi et al., 2003).

An FDT describes the long-term goal for forest development on a given locality (climate and soil conditions) in order to accomplish specific long-term aims of functionality: ecological-protective functions which embrace both protections of the ecosystem itself and neighbouring (eco) systems; economical-productive, and social/cultural functions). It is based upon an analysis of the silvicultural possibilities on a given site in combination with the aspirations of future forest functions. The FDT will serve as a guide for future silvicultural activities in order to "channel" the actual forest stand in the desired direction.

In an early stage, five FDT scenarios, describing in words and numbers the potential long-term goals for stand structures, regeneration dynamics, species distribution as well as management objectives were initially drafted to facilitate platforms for and stimulate debate. The idea was to provide a framework that tapped the field foresters' imagination and enabled them to articulate their ideas, to build awareness about these and to empower them to think it is possible to achieve those.

In the following stage professionals were gathered according to four eco-regions for regional discussions around these preliminary FDT scenarios in the real world, i.e. in the forest. This process had several iterations conducted over a 6-month period. The periodic confrontations with exchanges of knowledge and feedback allowed the original 5 FDT scenarios to be refined and modified and for an additional 14 FDTs to be developed (Fig. 1).

This process, however, left several questions unresolved and only partly rectified the feeling of uneasiness about the long-term goals, especially among the professionals with little or no formal education. They simply were not able to translate all the words and numbers into visions. Even professionals with long education and many practical experiences came up with statements like "this will not work in reality". As the professionals were short of experiences with the complex structures of vegetation in near-natural stands, we realised that describing the FDT scenarios in numbers and words did not provide a sufficiently common platform for discussion. The professionals simply generated different meanings and mental images from interpreting the written descriptions. This mismatch limited the discussions of the FDT scenarios to an abstract and theoretical level and impeded the creation of a shared understanding and ownership of nature-based forest management.

2.2. *Lifting barriers to communication—profile diagrams*

Visualising scenarios provides one way to overcome such communicative gaps, simply because every one can understand what is being shown (Taket and White, 2000; Emmelin, 1996). Further, the integration of visual with verbal and numerical information has proven to be a useful triangulation that helps to initiate dialogue and augment discussions in which a shared understanding of the information can be generated across knowledge cultures and among members of a group (Innes, 1998).

Hand drawn profile diagrams are useful tools for illustrating forest stand structures. As the name indicates, a profile diagram is a depiction of a cross-section through a forest stand. During the last century profile diagrams have gained interest in studies of natural forests and where mixed-forest management has been practiced (Leibundgut, 1959; Gustavsson, 1986; Koop, 1989), and many textbooks in silviculture have applied profile diagrams as means to communicate silvicultural systems and their related stand structures (e.g. Mayer, 1980; Oldeman, 1990; Oliver and Larson, 1990; Otto, 1994; Röhrig et al., 2006), which all indicate the potential of integrative visual tools for communication of near-natural stand structures (Nielsen and Nielsen, 2005). This might be best illustrated by drawing a parallel to architects' use of plan and cross section; architects might choose a nice photo-realistic illustration to communicate or "sell" their ideas for a new house to laypersons, while plans and cross-sections are the modes of illustration used to communicate the ideas to the craftsmen who should construct the house. Correspondingly, illustrating the FDT scenarios by means of profile diagrams were used pro-actively as a way to bridge the communicative gap: i.e. creating a shared platform for discussions about how the future forests could be "constructed" and enhance the professionals' (the craftsmen) capacity to make sense of and link the scenarios to their explicit reality.

For the illustration of each FDT scenario, a small group of local professionals (2–5 persons) were requested to identify a specific stand in the forests they managed where site conditions and forest functionalities matched the FDT scenario. Stands approximately half of the rotation-age were chosen because the same stands are planned to be monitored in the coming process of conversion for uniform to irregular stand structures; demonstration plots. However for the FDT 11 (see Table 1) we purposefully chose a beech stand where natural regeneration was well established under an irregular shelter because this structure and dynamic is similar to the vision for that specific FDT.

The stands were used as an 'arena' for discussing and visualising the FDT scenario by means of profile diagrams. The

Table 1
The 19 Danish forest development types

Broadleaved dominated
11 Beech
12 Beech with ash and sycamore
13 Beech with Douglas fir and larch
14 Beech with spruce
21 Oak with ash and hornbeam
22 Oak with lime and beech
23 Oak with Scots pine and larch
31 Ash with alder
41 Birch with Scots pine and spruce
Conifer dominated
51 Spruce with beech and sycamore
52 Sitka spruce with pine and broadleaves
61 Douglas fir, Norway spruce and beech
71 Silver fir and beech
81 Scots pine with birch and Norway spruce
82 Mountain pine
"Historic" forest types
91 Coppice forest
92 Forest pasture
93 Forest meadow
94 Unmanaged forest

(a)

(b)

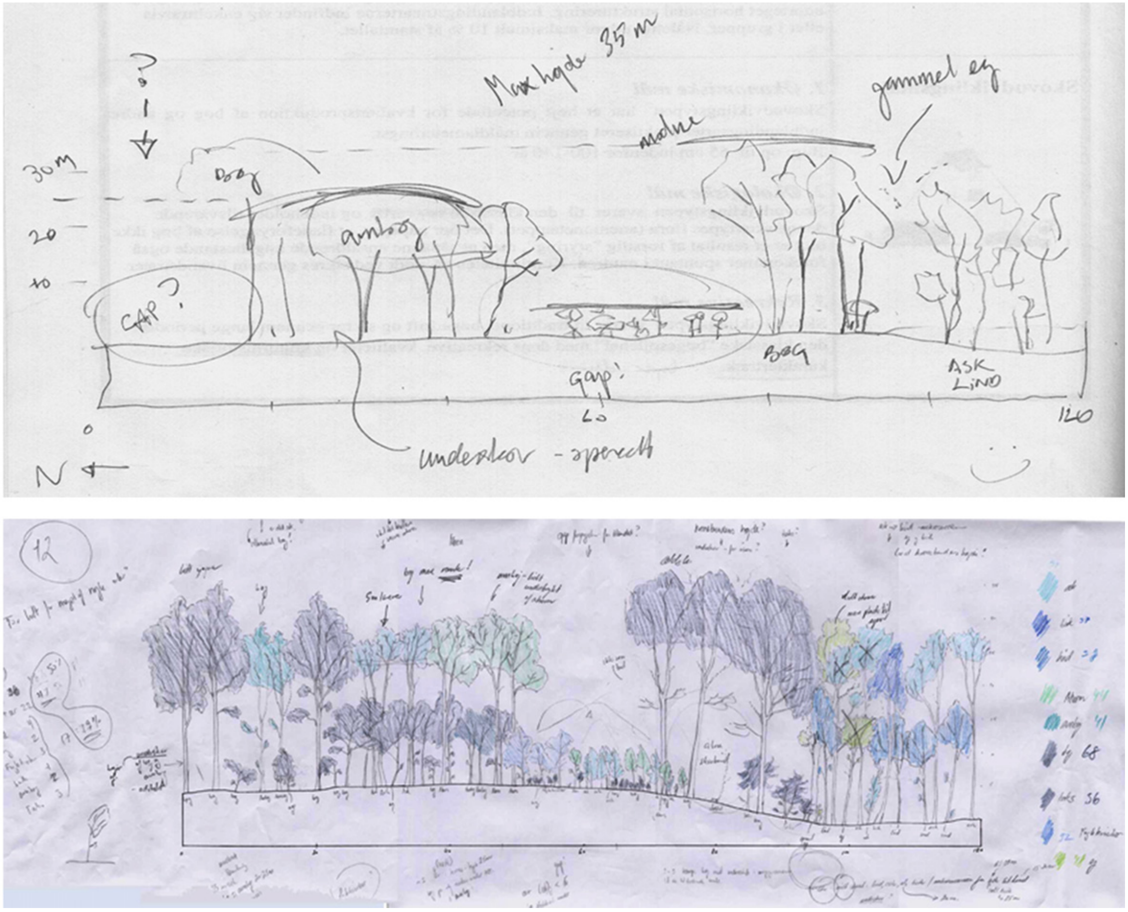


Fig. 2. (a and b) Drafts illustrating the process of developing the final profile diagram of FDT 12: beech with ash and sycamore, which is described in Fig. 3.

present stand condition was depicted in profile diagrams. This served two purposes. First, the purpose of depicting a stand known very well by the professionals and which they could easily envision in their mind was to make them familiar with the way in which profile diagrams represent reality. Second, as ‘thinking calls for images’ (Taket and White, 2000) the idea was to support and guide their ‘thinking in pictures’. Thus recent research has shown that the way in which practitioners contextualize, i.e. put information into context, is largely a flow of mental images (Nielsen and Nielsen, 2005; Jönsson and Gustavsson, 2002).

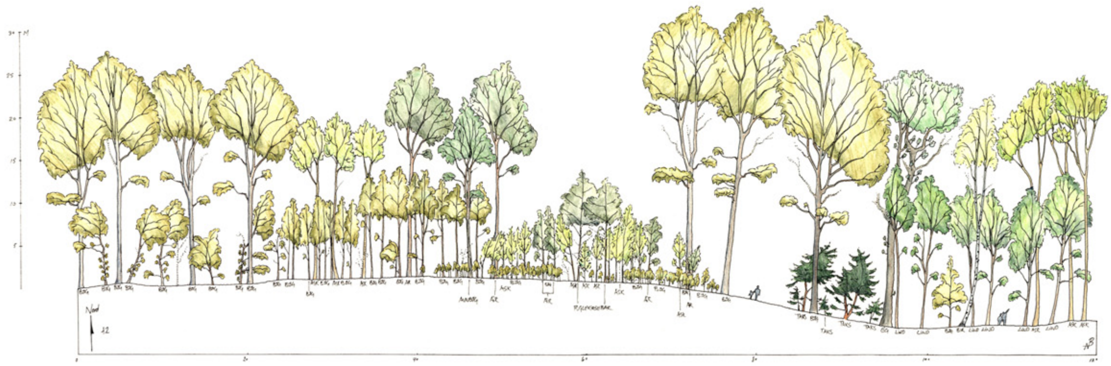
In addition, a preliminary ‘‘draft’’ profile diagram, of how the FDT scenario could be translated into a profile diagram was prepared. As evident from Fig. 2a, this draft was by intention made very roughly, so that it clearly indicated that further elaboration and improvement was needed.

The profile diagram documenting the present stand condition and the preliminary draft of the profile diagram visualising the FDT scenario were used to provide a link between the future FDT scenarios and the present reality in discussions with the group of professionals: ‘This is how the stand you know today would look when translated into a profile diagram. How will you translate the FDT scenario into a similar profile diagram?’ This question initiated detailed analysis and discussions of the scenario. The discussion was summed up in an improved draft (Fig. 2b), which was presented and discussed at a second meeting. Again discussing and developing the profile diagram added levels of detail to the understanding of the FDT scenario through which agreement on the scenario and its visualisation was achieved and the final visualisation and FDT scenario was prepared (Fig. 3). Over a period of 8 months, this sketching process was successively undertaken for each of the 19 FDT scenarios. However, each time the illustration of a FDT scenario was completed it was taken up in meetings, workshops and working documents to enable communication and learning among all people in the agency.

2.3. Extending the dialogue

In order to extend the participatory process beyond the Forest and Nature Agency and especially to incorporate the private forest sector and other user groups including NGOs we went on a ‘‘road show’’ with the FDT scenarios. Three meetings were arranged in the different eco-regions through Pro Silva Denmark where the FDT-concept and the preliminary drafts were presented and debated. The outcome of this was substantial improvement of the FDT scenarios and in addition shared knowledge and improved ownership beyond the public sector.

Forest Development Type 12: Beech with ash and sycamore



Structure: Species rich, well structured forest with beech as dominating element mixed with ash and cherry and in south-eastern Denmark additionally with hornbeam and lime. The in-mixed species occur mainly in groups. The horizontal structures arise between groups of varying size and age. Where the light demanding species such as ash, sycamore and cherry dominate, vertical structures occur periodically with shade trees (beech, hornbeam, elm, and others) in sub-canopy strata.

Species: Beech. 40 – 60 %, ash and sycamore: 30 – 50 %,
cherry, hornbeam, oak, lime, and others up to 20 %

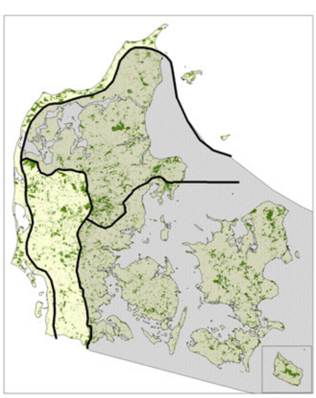
Dynamics: Beech regenerates mainly in groups and smaller stands. Ash and sycamore as gap specialists regenerate in openings later followed by beech. Hornbeam belongs to the sub-canopy stratum and regenerates under shade, whereas the pioneer species (cherry and oak) only regenerate after lager openings and/or in relation to forest edges.

Functions: Productive: The forest development type has a high potential for production of hardwood in larger dimensions and of good quality.

Protective: In most parts of the country the beech dominated forest represents the potential natural vegetation; consequently, many indigenous species are connected to this forest development type. It has a great potential for conserving biodiversity connected to the NATURA 2000 habitat type 9139 and 9150.

Recreational: Through ist mixture of (indigenous) species in combination with pronounced variation in size the forest development type gives a multitude of recreational experiences and intimacy.

Occurrence: The forest development type belongs on protected sties in the eastern and northern parts of Denmark on rich, well drained soils with good water supply as illustrated below.



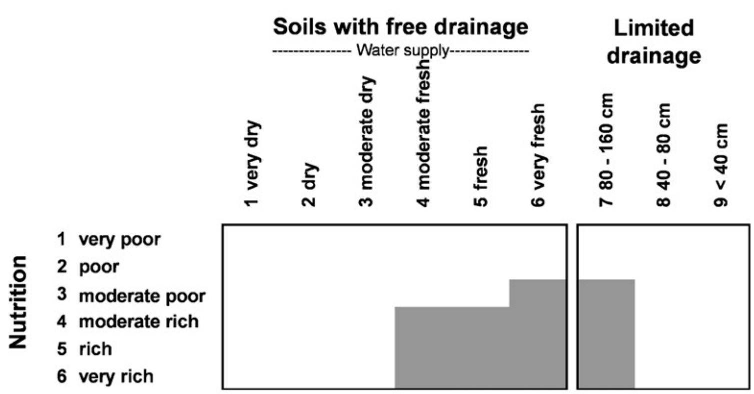


Fig. 3. Description and illustration of forest development type 12: beech with ash and sycamore.

3. Results

3.1. Nineteen illustrated FDT scenarios

The nearly 2-year participatory process, outlined above, resulted in a catalogue with FDTs covering the range of variation in Danish growing conditions and anticipated forest functions. The catalogue as published (Larsen and Danish Forest and Nature Agency, 2005; Larsen et al., 2005) describes 19 different FDTs which can be grouped into broadleaved dominated (9), conifer dominated (6), and an additional 4 ''historic'' (Table 1 and Fig. 4). Whereas all 15 ''nature-based''

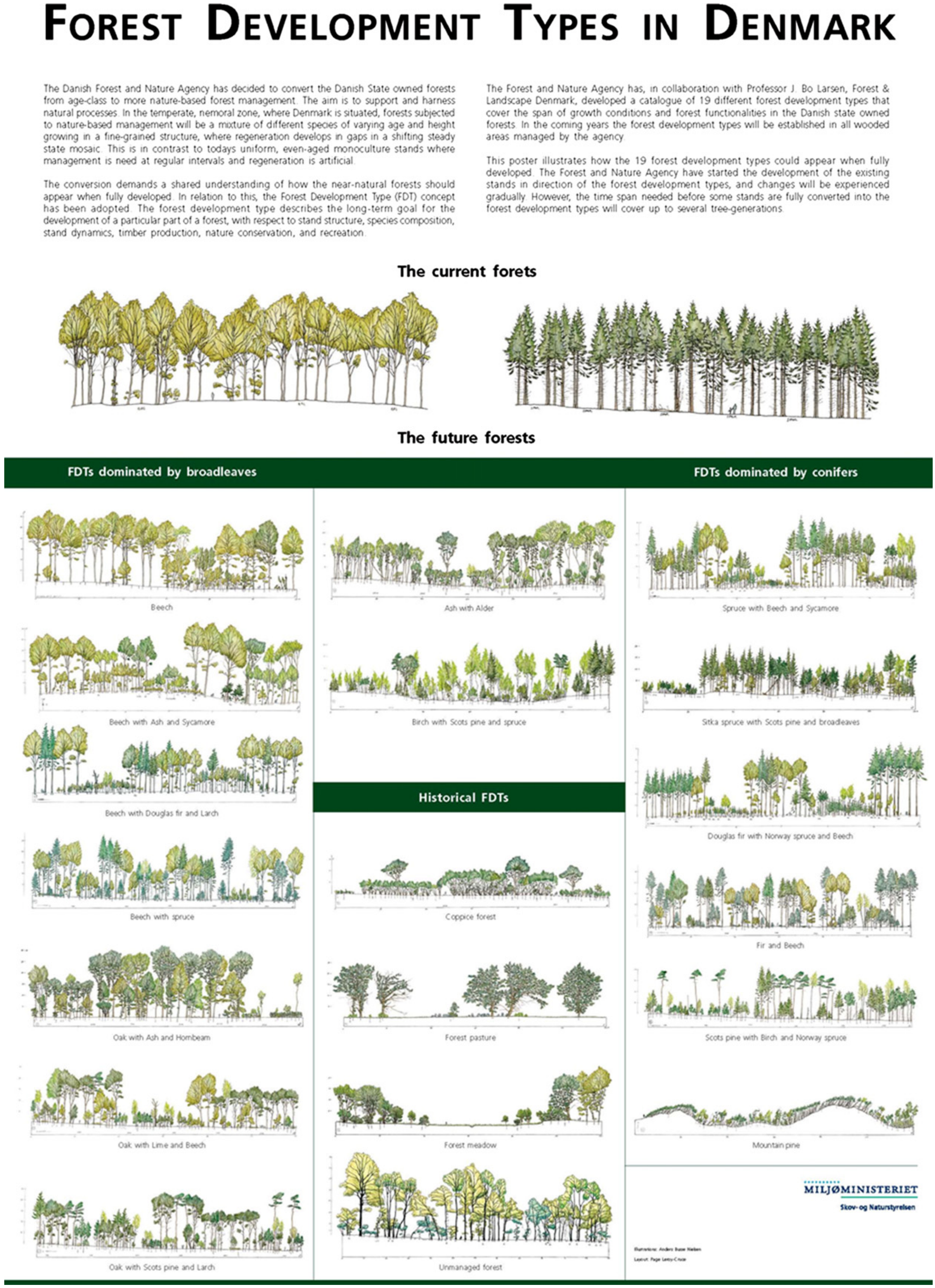


Fig. 4. Poster depicting the present and the future 19 FDTs in Denmark. The two upper profiles diagrams show typical forest stands at present (even-aged monocultures of beech, respectively Norway spruce). Below the 19 FDTs are grouped in broadleaved dominated (9), conifer dominated (6), and ''historic'' (4).

FDTs encompass a balance between productive, protective and recreational/social functions, the ‘‘historical’’ types (no. 91–94) mainly serve protective and cultural functions.

As shown in Fig. 3, each FDT is described as follows:

Name. The name encompasses the dominating and co-dominating species. The first digit in the FDT-number indicates the main species (1 = beech, 2 = oak, 3 = ash, 4 = birch, 5 = spruce, 6 = Douglas fir, 7 = true fir, 8 = pine, and 9 indicating a ‘‘historic’’ FDT).
Structure. A description of how the forest structure could appear when fully developed. This description is supplied with a profile diagram depicting a 120 m transect of the anticipated forest structure at ‘‘maturity’’.
Species distribution. The long-term distribution of species and their relative importance.
Dynamics. The regeneration dynamics described in relation to the expected succession and spatial patterns (species, size).
Functionality. Indication of the forest functionality (economic-production, ecologic-protection, and social/cultural functions).
Occurrence. Suggested application in relation to climate and soil. For this purpose the country is divided into four sub-regions with each their typical climatic characteristics. Further, the application of the specific FDT in terms of soil conditions is stated in relation to nutrient and water supply.

In order to communicate the Danish FDTs to a broader circle including interest groups and the public in general, all 19 FDTs are depicted in profile diagrams in a poster (Fig. 4).

To fine-tune the FDTs to the EU-NATURA 2000 project each of the 10 Danish tree dominated NATURA 2000 habitat types was designated a specific Forest development Type. NATURA 2000 Habitat type 2180 corresponds accordingly to FDT 23, habitat type 9110 and 9120 to FDT 11, habitat type 9130 and 9150 to FDT 12, habitat type 9160 and 9170 to FDT 21, habitat type 9190 to FDT 22, habitat type 91D0 to FDT 41, and finally habitat type 91E0 to FDT 31.

4. Discussion

The process of developing a national catalogue of FDTs started with an outcry from professionals in the field. In the plantation forestry paradigm, the professionals possessed an inherent understanding of goals and means. However, when nature-based management was introduced, they were called on to design, plan and manage ‘new’ types of forest stands for which they had neither mental nor real models. Suddenly, the well-known management practices supported by years of empirical research and the governing variables behind those were questioned, which is characteristic of ‘‘double loop learning’’, as defined by Argyris and Schön (1974).

Taking the pronounced uncertainty of long-term goals for stand structures and dynamics in the future forests subjected to nature-based forest management, scientists and professionals were united in a demand-led process, where professionals defined the problem, which in turn helped to keep focus throughout the process and to secure commitment and an adequate and timely output. In retrospective, this process constitutes a successful example of social learning among professionals and scientists in a process that holds similarities with the concept of adaptive management (see, e.g. de Boo and Wiersum, 2002) as well as with the family of research methodologies called ‘action research’ (Stringer, 1999; Lee, 1999; Huxham and Vangen, 2003). However, when compared to the standard adaptive management cycle of planning-acting-monitoring, the adaptation of the FDT scenarios has in this case developed from a process of qualitative information exchange and feedback rather than from controlled monitoring of changes in the forest management and forest conditions. The latter type of evaluation of the described planning process remains for the future, when the practitioners begin to change their management and the forest conditions changes accordingly.

Despite the lack of exact measurement, observations throughout the process have pinpointed a number of, what we believe are, preconditions and characteristics for successful social learning in natural resource management. From the observations, it is clear that social learning requires sharing of power, which on the one hand must be accepted throughout the whole organisation and on the other hand requires organisational flexibility. This was the case in the present study. Additionally, it requires special abilities from the scientists involved; namely the ability to listen, to pose key questions, to observe, and the will to suppress their inborn tendency to talk scholastically. Correspondingly, we worked as facilitators, whose prime task was to stimulate debate about key questions by bringing professionals at all levels of the agency hierarchy together in various configurations, co-ordinate the process, demarcate it, reflect upon it, and act according to the new insight gained. In short, we facilitated the process and led the professionals become the researchers—exploring their collective experience-based wisdom.

4.1. Collective responsibility—collective ownership

Standing in the forest in front of a problem, the professionals automatically enquired the scholar. Partly due to lack of good answers, we reciprocated: ‘‘But together you have been here more than 200 years, you must have some ideas!’’ And suddenly a dialogue between the professionals started, leaving the scientist in the role of facilitator and reporter. This change in roles developed the professionals’ perception of the information and surfaced the ways this was incorporated into the FDT scenarios. In turn, this enhanced individual and shared understanding of the situation and engagement in the development of the FDT scenarios as well as the professionals trust in the final outcome.

4.2. The importance of a dialogue

The process facilitated dialogue among the professionals in various groups and configurations, utilizing knowledge and information contributed by the professionals themselves, which in turn empowered them to understand and learn about the principles of nature-based forest management and possible goals for stand development. From this perspective, the dialogue-based process activated many kinds of information which shaped perceptions that became part of the base-line assumptions. Judith Innes has highlighted this aspect of dialogue, which unfortunately is often forgotten or neglected in decision-making process: "Dialogue and other forms of communication in themselves change people and situations" (Innes, 1998).

4.3. Voicing many kinds of information and knowing

The dialogues and collaboration between scientists and professionals demonstrated the importance of paying more attention to multiple kinds of information in decision-making processes regarding natural resources. Scientific knowledge had its place in the development of the FDTs, but it was not privileged. Unless the scientific information was related to practical examples or to the context and specific realities of the professionals from the different eco-zones – i.e. until it became practically useful – they tended to reject it.

Further, scientifically validated information was only a small part of the information used in advancing and locally adapting long-term goals for stand development. Throughout the nearly 2-year period, much local information and insight into possibilities, functions, and desires surfaced. For example, local professionals managing *Pinus mugo* plantations established some 100 years ago to control the sand drifting along the west cost of Denmark opposed vehemently the scientists' rejection of a mountain pine FDT. And the professionals succeeded since they were able to demonstrate the species stability and regeneration ability under these climatically harsh conditions and to pinpoint its cultural and recreational values. Another working example was the "creation" of forest development type 11—beech in horizontal structured and almost pure stands. Although this FDT is only in part nature-based, it was developed as a response to different user groups' advocacy for their beloved "beech cathedral" or "pillar hall", which they feared was threatened through "too much nature".

An additional type of information evolved through the stories told by the different parties as typified in the following "story": Professionals from the most western parts of Jutland along the North-Sea were somewhat reluctant in adopting the general concept of a small scale disturbance regime leading to a fine scaled mosaic forest structure. During the process a major forest fire occurred in the area, and suddenly the stories of forest fires came into "play", resulting in the acceptance of a more coarse-grained structural dynamic and in part accepting smaller clear-cut for conifer dominated FDTs in this specific region.

Indeed, all these kinds of information, outlined above, affected the perception of the possibilities and limitations of nature-based forest management and thereby influenced the decision-making process. The value of these kinds of information in management of natural resources has also been recognised in studies of communicative planning (e.g. Innes, 1998) as well as adaptive management activities (for reviews see, e.g. de Boo and Wiersum, 2002) and action research studies (Stringer, 1999; Huxham and Vangen, 2003). These observations pinpoint the dynamic nature of collaborative decision-making.

4.4. The importance of developing appropriate sharing mechanisms/tools

The process of developing long-term goals for stand structure and dynamic in nature-based forest management also showed that the many kinds of information and knowing cannot be activated for social learning until comprehensible tools (platforms) to organise and enable discussions of the issues faced have been developed. Here, FDT scenarios and profile diagrams turned out to be decisive "new" tools, each in their own way.

FDT scenarios worked as a framework for organising hypothetical possibilities which encouraged interaction and debate. As such, they helped us to stimulate and organise new ways of thinking about the uncertain and complex future stand structures and dynamics (Wollenberg et al., 2000a,b). In a complementary manner, the illustrations of the FDT scenarios by means of profile diagrams forced the professionals to consider the principles of nature-based management and its impact on stand structures and dynamics in a way they were unable to by means of only the verbal FDT tool. As such, the illustrations of stand structure augmented the discussion of the FDTs and were instrumental for information to be internalised and interpreted (Schön, 1983). It was evident that even experienced professionals were decisively inspired by the profile diagrams enabling them in bridging the communicative gap between experiences and visions. Some forest officers who were highly sceptical in the beginning changed their view and joined the discussions after being exposed to the profile diagrams. One stated enthusiastically: "This language of drawing is universal, you can even discuss these visions of forest development with a Chinese!"

Over time, the FDT scenarios and their illustrations developed a status of their own. Not only did they provide a framework and a platform for discussion, in fact they also functioned as an "eye opener" for the whole agency in terms of internalizing and initiating the shift into nature-based forest management. Thus a following-up questionnaire amongst DFNA employees has shown that employees across all levels of the hierarchy assess the illustrated FDTs favourably as a way to describe long-term goals for stand structures and dynamics in stands subjected to nature-based forest management and as an aid for their work in order to realize these goals. Both managers and workers have already used and have clear ideas of a wide range of future uses for the FDTs. The areas of use and expectations range from management planning and silvicultural decisions to communication with various stakeholder groups (Nielsen, 2006).

The extent to which the practitioners' general acceptance of the FDTs and their wide application of the tool is attributed to the "tool" itself or to their engagement in the process of developing the FDTs, however, call for further research.

5. Concluding remarks

Hitherto, the dominant forest research agenda has concentrated on providing generalized and objective facts as guidance for professionals involved in management planning (Jönsson and Gustavsson, 2002), and most research does not legitimate the scientists to reflect on how their findings can become powerful agents in creating the desired changes (Innes, 1998).

Addressing the challenges and uncertainty experienced by the professionals when urged to move from plantation forestry towards nature-based forest management, and the parallel development in forest management where more and more decisions are made by professionals in the field, the research approach taken also needs to accept and adapt to this new agenda where uncertainty, adaptability, communication and learning are keywords.

In this context, the case presented in this paper indicates possible gains related to scientists and professionals being joined in a social learning process that allows both parties to reflect and learn from the many kinds of information and empower all interest groups in the organisation – the forest workers and forest contractors, the forest rangers, the regional foresters as well as the forest planers in the central agency – as well as the private forest sector and different NGOs to have a stake in the process through which information becomes embedded in new management goals and practices. Further, the case underpins the importance of proper tools to organise and ease communication in such social learning processes. In relation to this our observations and the post survey reported by Nielsen (2006) suggest FDT scenarios in combination with their illustration by means of profile diagrams as an integrative, flexible and easily comprehensible concept for communicating long-term goals for nature-based stand development. The validity of these observations and more exact measures of the success or failure of the presented process of FDT development and the need for further adaptation of the FDTs, however call for further research when the practitioners begin to change their management and the forest conditions changes accordingly.

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