TACTICAL PLANNING IN FISH AND WILDLIFE MANAGEMENT AND RESEARCH

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ABSTRACT

Planning to identify needs and procedures is a prerequisite to rapid progress in fish and wildlife management and research. Logical reasoning applied to a precise problem statement to identify and state clear tactical objectives and testable hypotheses is essential for problem solution. The identification and proper statement of tactical objectives is facilitated by use of a step-down plan. In six steps this plan identifies appropriate activities for scheduling and management control and isolates the needs for experimental design by research.

INTRODUCTION

If we don't clearly define objectives and plan wisely in advance on meeting them, we are not likely to succeed very well. This has always been a problem of Federal and State agencies. It is perhaps most comfortable to stay in a rut, but if progress is to be made, there must be advanced and wise planning. "Without vision the people perish" is as true of fish and game departments as it was of ancient Israel! (Cottam, 1966)

Planning is the selection and prearrangement of events for the predictable attainment of an objective. In driving, when we want to reach a specific destination at a particular time, we use a road map to determine our route and departure time. The development of a travel itinerary is the selection and prearrangement of events for a predictable arrival at a selected destination. Fish and wildlife biologists routinely develop carefully planned travel itineraries.

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All too frequently, however, these same biologists undertake fish and game projects before they have developed a plan that identifies and spans all of the necessary steps from project inception to completion. In practice, unfortunately, the "travel itinerary" of fish and game management and research activities is often intangible and evasive. The consequences of error are not immediately evident for the projects seldom have a definitive objective against which progress or attainment can be measured. Moreover, the biologists, generally beleaguered by workloads, deadlines, and insufficient help, substitute expedience for better judgement and get on with the work thus bypassing the all important thought process--planning.

The same processes that are used in planning a trip itinerary may also be used in planning a "project itinerary." Since no map is available for project planning, one must be developed to specify the destination or objective and to identify and organize the steps necessary to reach the objective.

Step-down planning is one system for developing a tactical plan that is tangible and by which progress can be readily determined. It is a logical system for identifying and displaying all elements needed in problem solving. Its utility is its adaptability for use at any administrative level where a problem arises. It can be as helpful to the director as to the field biologist.

IDENTIFYING THE PROBLEM

> . . . if many innovations must be skillfully fitted together to produce a large net improvement, it is likely that they are not the result of random efforts directed toward diverse and unrelated goals, but are due to a conscious plan . . . It suggests to us that the isolated invention or the random scientific fact is not likely to "fit in" or, therefore, to be utilized. In other words, it tells us once again that recognized need is the key to efficient utilization. (Sherwin & Isenson, 1967)

A fish and game program is a collection of strategies to deal with broad or long-term problems. A strategic plan identifies and focuses attention on these broad problems which may represent the established area of responsibility of a worker or be assigned to him by an administrator.

The resolution of problems identified in the strategic planning process requires tactical planning which is the subject of this paper. Tactical plans give life to the strategic plan. They establish mechanisms for delivering the outputs and accomplishing the strategic objectives in a predictable manner. They permit logical demonstration of need for every element or activity in the plan because every element is generated ultimately by the problem or strategic objective.

There are always more problems than there are time, money, and bodies to solve them. Relative need has not always had a high place in problem selection. "Much past research in the fish and wildlife field was done without a clear idea of who would use the results, how they would be used or if they would be used. We can no longer afford the luxury of doing research without answering those questions before we start" (Solman, 1970).

In like manner, we cannot afford management practices unless they are needed and effective. Unless funded directly by the user, general put-and-take pheasant stocking, maintenance stocking of warmwater fish, as well as wetland acquisition without nesting habitat, winter feeding of game, and carp trapping are popular treatments of questionable financial benefit. Practices "skillfully fitted together to produce a large net improvement" (Sherwin & Isenson, 1967) is management. If these practices are to fit and thereby produce, they must be both needed and effective.

We will consider one problem selected to satisfy a need, phrase the problem properly and then develop a tactical plan to solve it. This section deals with precise problem identification.

When a problem is identified, the circumstances, personalities, conditions and other matters that relate to it must be understood. A statement of the problem must be developed that communicates precisely its identity, nature, and depth. This problem statement is then transposed carefully to an objective without compromise of the identity, nature, and depth of the problem it reflects. This is a crucial step so a special caution is warranted. Unless the problem statement and the basic objective generated by it are on target, the entire plan derived subsequently will not solve the basic problem.

This leads to step number one in step-down planning: (1) From the facts at hand establish one simply stated, single purpose, primary objective that communicates the identity, nature, and depth of the problem.

Consider the example which will be used as the basis for developing the step-down plan displayed in the centerfold. The overall problem is to provide northern pike recruitment in lakes where natural reproduction is inadequate or where it has been reduced by shore development and marsh drainage. An analysis reveals three avenues of solution: Stock hatchery-reared fish, transfer fish obtained through rescue operations from winter-kill lakes, or use production from marshes constructed on or near lakes for pike spawning. In the State fish and game department for which you work the first two of these have been and are being done without precise knowledge of effects or benefits. Nevertheless, both programs have public support and are financed by legislative appropriations.

The fish and game commission favors acquiring data to evaluate all three alternatives, but the climate is not immediately favorable for seeking funds to study the two methods now used. The commission, therefore, voted to initiate a study to evaluate the third alternative. You were chosen by the chief of fisheries to determine the efficacy of artificial spawning marshes. You are to develop a plan which, if adopted and followed, will provide the department and commission with information needed for policy decisions.

These are the facts at hand. In accordance with rule one of step-down planning, what is the primary objective? We have phrased the following primary objective which states the identity, nature, and depth of the problem:

> Determine benefits and costs of northern pike spawning marsh construction and operation for management of lakes where northern pike is a suitable predator and natural recruitment is inadequate.

This is the primary objective of the sample step-down plan displayed in graphic form in the centerfold.

RESOLVE THE PROBLEM INTO DISCRETE ELEMENTS: THINK DEDUCTIVELY

> Confronted with a task too big for our manpower and facilities we have a tendency to dive into the physical part of the work without adequate advanced planning. It is difficult for us to sit back and go through the process of analysis and planning when so much needs to be done. It is easier to get at the job and leave the detailed planning until later. This is where expediency overcomes our better judgement. (Longwood, 1962).

Once a legitimate need has been identified, we proceed through orderly processes of logic to develop a tactical plan to insure that efforts will, in fact, solve the basic problem and that unnecessary effort will be eliminated. After the primary objective has been stated, then reduce the problem into its constituent parts. Within a clear problem statement will be found one or more obstacles to be overcome. Ask why these obstacles exist, why have they not been overcome, and what must be done to overcome them.

Consider the primary objective at the end of the previous section. What obstacles are specified? Benefits and costs of marsh construction and operation are the obstacles that must be overcome. Does any other obstacle exist? We think not, and if these two obstacles are overcome, then the primary objective will have been attained. This illustrates the second step in step-down planning: (2) Derive a second echelon of items that will accomplish the first. In this example there are two second echelon items. The first is:

> Measure the annual increment of capital amortization and document the yearly operation and maintenance costs.

The second is:

> Measure the annual increment of the fishery attributable to marsh production.

When true capital, operation, and maintenance costs are available and when the annual increment of the fishery attributable to marsh production is known, then the primary objective will have been reached.

After the primary objective has been reduced into its constituent parts, test for validity using the conditional sentence,

If and only if __________, then __________.

The first blank of this sentence is the antecedent. The second is the conclusion. The two second echelon objectives above constitute the antecedent and the primary objective is the conclusion. Thus the sentence reads,

If and only if we

Measure the annual increment of capital amortization and document the yearly operation and maintenance costs

and

Measure the annual increment of the fishery attributable to marsh production,

then we will

Determine benefits and costs of northern pike spawning marsh construction and operation for management of lakes where northern pike is a suitable predator and natural recruitment is inadequate.

The two parts of the antecedent are essential to reach the conclusion. Is there any other premise yet missing which would or might preclude reaching the conclusion? In this instance there is not. The antecedent is complete, and therefore, the conclusion (the primary objective) is the consequent of the condition. The reasoning is valid and complete.

The importance of this reasoning cannot be overemphasized. The purpose is still step two of step-down planning, to derive a second echelon of items that will accomplish the first. Two items were stated, but are there more which may have been omitted? Are those that have been identified actually essential to reach the objective? Could one or more be omitted as interesting but non-essential? To develop a valid plan each of these questions must be answered as each new echelon unfolds. Use of the conditional sentence is absolutely essential to derive this second echelon of items. Having done this, assume now that the primary objective and the second echelon objectives of the plan in the centerfold have been derived correctly and completely.

Note on the plan that there are two second echelon objectives and each of these has two third echelon objectives subordinate to it. These are followed on the plan by fourth and fifth echelon objectives. Thus, each component of each echelon of the example has been reduced into its constituent parts and has been tested to see if and only if the antecedent constructs the corresponding conclusion. This introduces the third step in step-down planning: (3) Derive a third, fourth, etc., echelon of items. As each echelon of items is composed, the conditional sentence test must be applied assiduously for the plan to remain on track.

To illustrate this third step, continue with the example above and examine the objective,

> Measure the annual increment of the fishery attributable to marsh production.

This now becomes the conclusion and from it we must derive its antecedents. What obstacle is specified? What must be done to overcome it? The obstacle is statistics of the increment of the fishery attributable to northern pike produced in the artificial marsh. To overcome it we might obtain catch statistics from experimental lakes with the marsh-reared northern pike distinguished by a mark. But knowing the contribution of these marked fish to the creel might not overcome the obstacle to objective attainment, for superimposing the marsh-reared northern pike upon the present fish population could alter the overall fishery significantly. Therefore, it will be necessary to obtain fishery statistics both before and after marsh operation. This has been phrased as two third-echelon objectives in the example on the centerfold.

Next check the validity of this derivation using the conditional sentence. Will the conclusion be reached <u>if and only if</u> these two third-echelon objectives are met? If the answer is yes, proceed to divide other objectives into their constituent parts for further plan development. If the answer is no, stop at this point and determine what is necessary to provide a valid set of antecedents for the conclusion.

The question now arises, how far is successive derivation of echelons continued? This varies with the nature of the problem. Management, development, survey, and inventory-type problem plans will normally terminate when items reached are recognized as actions which can be performed. For example, examine again the two third-echelon elements of the plan which estimate parameters of the fishery. A fourth echelon of items says how this will be accomplished. Artificial marsh-reared fish must be fin clipped for identification, and methods of creel census must be designed. Fin clipping is certainly a terminal item. The creel census design is also, for it is a technique either within the worker's repertoire or available on consultation with a biometrician.

But the spawning marsh example illustrates another type of terminal item. Also in the fourth echelon is the following objective:

> Develop procedures for management of each of the experimental spawning marshes.

By the method already described the solution was resolved into three subordinate fifth-echelon objectives, each dealing with one phase of marsh operation. Down to this level in the plan, and in that area of the plan discussed above dealing with creel census, derivations were based on rational consideration of factually warranted belief. Thus it can be reasoned that one of the fifth-echelon objectives would be the determination of the most productive and least costly method of marsh utilization for spawning.

At this point, however, there are a number of management options for selection to satisfy this fifth-echelon objective. Although some factual considerations may be available to add weight to one or another of the proposed solutions, a further statement of premises is largely based upon opinion. Therefore, the step-down plan developed through deductive inferences must terminate at this point pending refinement from facts derived from literature review, consultations with knowledgeable persons, and field experiments. The fourth step in step-down planning is: (4) Continue the logical derivation of subordinate objectives until terminal items are reached, that is, items recognizable as actions which can be performed, or items whose paths to solution are not immediately evident from existing knowledge or technology. The rational planning of these latter instances will be discussed further under the section on inductive thinking.

This deductive thought process serves well the function of breaking a relatively complex problem successively, step by step, into less and less complex elements. This keeps the primary need in focus at the forefront while identifying steps to its solution and discovering specific unknowns that must be solved or techniques that must be developed. Use of the conditional sentence at each echelon of plan development has been emphasized to insure completeness and focus. While this is necessary at each step, it is also the important fifth step of plan development: (5) Reexamine the plan to determine that the composite attainment of each item, beginning with the terminal items, will build back to accomplish the primary objective.

Everyone is aware of data gathered without need and not used, and of activities undertaken which were later found to be unnecessary. Each item of the plan must address itself upwards through each echelon of objectives to the primary objective. This introduces step-down planning step six: (6) Reexamine the plan to determine that each item is necessary to the accomplishment of the primary objective. Delete all extraneous objectives even though they are interesting and related.

RESOLVE THE PROBLEM INTO DISCRETE ELEMENTS: THINK INDUCTIVELY

> It seems to me that the method of most rapid progress in such complex areas, the most effective way of using our brains, is going to be to set down explicitly at each step just what the question is, and what all the alternatives are, and then to set up crucial experiments to try and disprove some. (Platt, 1964)

The step-down process develops a plan in conformity with fact or with propositions considered to be true. The plan conceived is for predictable attainment of a needed end point. It is really an action plan, a fish or game "travel itinerary." This plan identifies essential elements to attain objectives, reducing the chances of error and omission in problem solving. In this process actions will be identified whose paths to solution are not immediately evident from existing knowledge or technology. These unknowns are candidate research problem areas, areas of need.

Further deduction may serve to an extent in these research areas, but a point will come where the method of inference must change. Rather than continuing blindly with activities and data gathering because these are accepted standard procedures, the scientist must stop and ask "just what the question is, and what all the alternatives are" (Platt, 1964). And what's new about this? Nothing, for the concept extends back to Francis Bacon, and he, in fact, confesses borrowing it from Plato. We were taught in college to use our imaginations, devise multiple alternative hypotheses, design experiments to try and disprove them, and carry out the experiments with precise techniques. But today we seem to have lost sight of the techniques. Platt (1964) pointed out a major pitfall in biological research and suggested a way to avoid it when he stated that, "biology with its vast informational detail and complexity, is a 'high-information' field, where years and decades can easily be wasted on the usual type of 'low-information' observations or experiments if one does not think carefully in advance about what the most important and conclusive experiments would be." This advice is highly relevant to research in fish and wildlife and, if heeded, could eliminate the all too common practice in research of groping our way through broad and multiple relationships toward generalized conclusions.

The northern pike spawning marsh example illustrates the place of inductive inference by footnotes 1/, 2/, 3/, 4/. These need further imaginative development. First, the options must be examined critically for omissions. Second, each must be ranked in the light of knowledge, experience, and intuition for its timeliness, impact on the basic problem, and adaptability to experimentation so that the most important and potentially conclusive experiments may be done first. Third, alternative hypotheses must be devised and sharply focused at a crucial option. Fourth, experiments must be designed and carried out for possible alternative outcomes, aimed at excluding hypotheses. With a large number of options and variables, experiments designed for multiple exclusion are expedient, but more important are decisive results.

PLANNING CONSIDERATIONS

> Aren't we really only trying anything that comes to mind? Put enough money into it and it will work. (Regier, 1968)

This paper illustrates two forms of the spawning marsh plan. The centerfold display is graphic while that in the Appendix is typed. The typed form is sufficient and convenient for short plans of uncomplicated problems, and it may serve as a convenient record for filing. The graphic form is the more convenient for involved plans, and initial construction of step-down plans is facilitated by the graphic form using cork board or a wall area.

The importance of planning for problem solving has been emphasized. There are four other uses and advantages of the graphic form of the step-down plan. First, planning should be a team effort. This form is convenient for review and comment by associates and other competent professionals. Second, it is convenient and understandable for administrative review. Frequently administrators assign problems without realizing what is involved. From plans they can see this. If the solution is beyond economic means, the problem may be narrowed. If the problem must be solved with less effort or in a shorter time period, steps to be eliminated can be studied, and the administrator will be fully aware of the risks involved by the omissions. Third, step-down plans have served as persuasive graphics in budget hearings where decision makers can see clearly what is involved. Fourth, there is a trend toward cooperative efforts within the disciplines and agencies at solving complicated problems. The graphic step-down plan facilitates delineation of responsibilities.

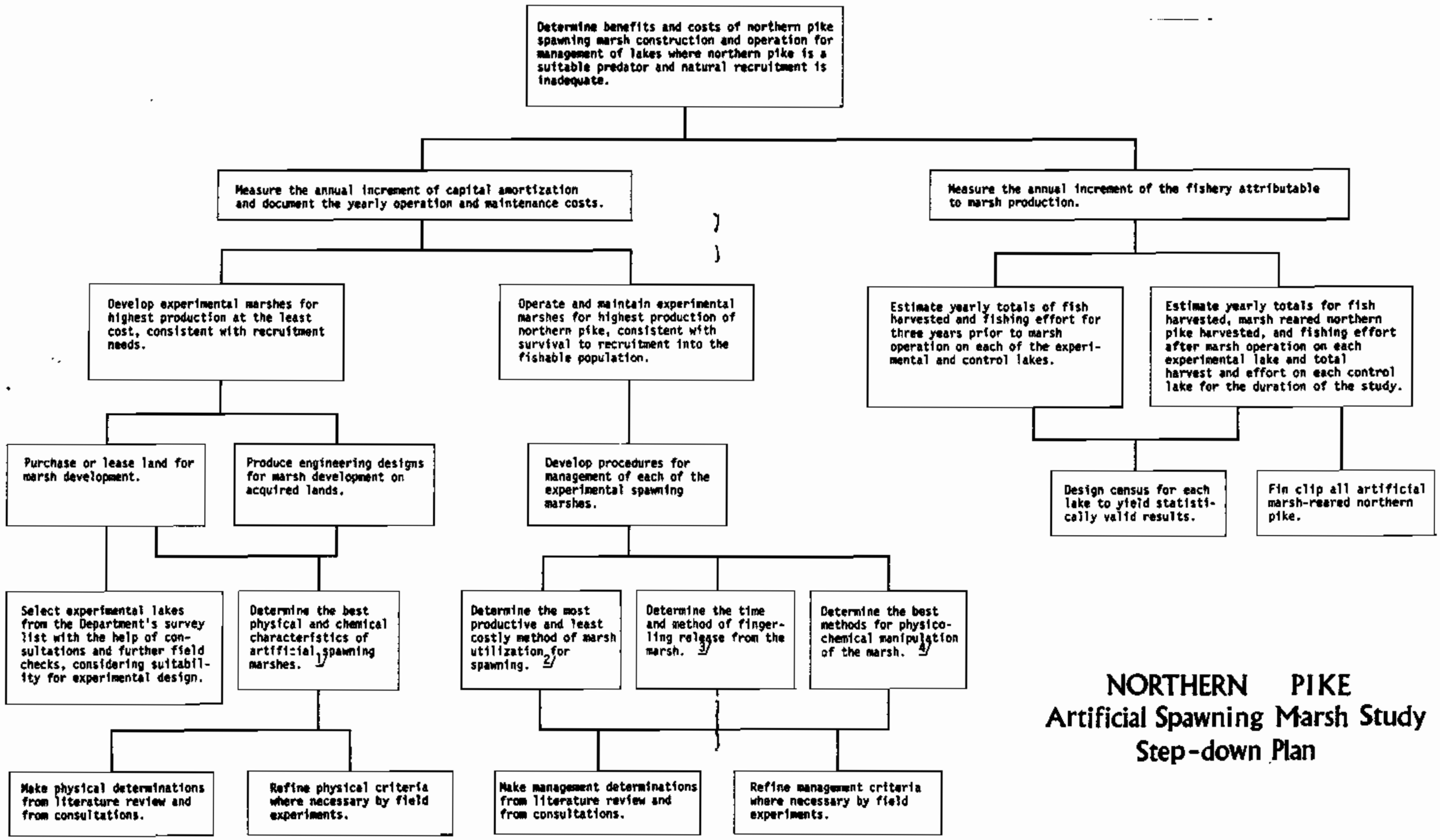
We have laid out a logical system for choosing paths of endeavor for profitable expenditure of our professional energies. Some will say that this system is their present mental process for resolving a problem, and it may well be. This is a way of thinking and no more. From our own experience, and from others we observe, a common error emerges. The primary and immediate lower echelon objectives may be phrased properly, but at some point the worker invariably sets aside his mental discipline of identifying obstacles and specifying solutions. Instead he reverts to his old pattern of thinking by inserting those techniques he knows, by including the tools of problem solving he was taught or has developed. His thinking becomes method oriented instead of problem oriented, and the plan is not valid. If each objective is clearly on target and if the conditional sentence is used to test each echelon of objectives, this trap will be evaded. The plan will outline needs and not contain simply "anything that comes to mind" (Regier, 1968).

STATEMENT OF ACTION OBJECTIVES

> . . . if you're not sure where you're going, you're liable to end up someplace else - and not even know it. (Mager, 1962)

In the same sense that the travel itinerary prearranges progress from a known location for a timely arrival at a selected destination, the tactical plan arranges for predictable stepwise progression from the present status of knowledge of the problem to attainment of the objective. An objective, if derived correctly, is the principal control point in management operations or research. An objective is an end point, an accomplishment destination. Its utility is in communicating this intended destination to the boss, to co-workers and most important of all, to the worker himself.

In practice, the research and management objective often fits another definition: A statement of intended pursuit wherein the worker may exercise imagination and ingenuity without restriction in direction or scope. We have heard the spirit of this definition vigorously defended by a number of fish and wildlife workers, a defense we believe is groundless. Proposed management and research accomplishments can be phrased specifically to support planning for predictable attainment. More rapid and productive progress will be made toward meeting needs of the resource when we learn to state where we are going and when we intend to get there.



NORTHERN PIKE
Artificial Spawning Marsh Study
Step-down Plan

1/

1. Area relative to lake area and number of marshes per lake.
2. Depth--marsh morphometry.
3. Proximity to receiving lake.
4. Degree of shelter necessary including axis of marsh relative to prevailing wind.
5. Water supply source--diverted stream, direct runoff, pumped from lake or stream.
6. Water quality--pollutants.
7. Marsh watershed--potential for excessive siltation.
8. Drainable or not, and if drainable, should bottom be dry or swampy.
9. Low iron content.
10. Suitability for structural control of water levels, immigration and emigration of adults and trapping of fingerlings.
11. Stability of water level to avoid exposure of eggs and crowding of fry and fingerlings.

3/

1. Should young of the year be allowed to emigrate to the lake at will?
2. Considering cannibalism, marsh food supply, fingerling size, physico-chemical conditions in the marsh and conditions in the receiving lake system, when is the best time for fingerling harvest if controlled?
3. Should marsh be drained and young of the year flushed to the lake without handling?
4. Should young of the year be trapped and distributed in receiving lake?

2/

1. Should adult spawners be used?
   a. Should free access by spawners be allowed?
   b. Should selected numbers, sizes, and sex ratios of spawners be stocked?
   c. Should adults be removed after spawning?
   d. What should be the source of the spawners?
2. Should marshes be used for rearing only?
   a. Should fertilized eggs or fry be stocked?
   b. If fry, what age should be stocked?
   c. If eggs or fry, what should be the stocking density?
   d. If eggs or fry, what should be the manner of introduction?

4/

1. Should water be left in the marsh year around?
2. Should the marsh be left drained after fingerling removal?
   a. If drained, when should it be flooded for spawning or rearing use?
   b. Should the dry marsh bottom be fallowed?
   c. Should the dry marsh bottom be plowed, disked and seeded?
3. Should marshes be fertilized?
4. What type of vegetation is most desirable?
   a. If marsh is left flooded, should vegetation control be instituted?
   b. If marshes are drained, what type vegetation will provide the best spawning substrate?
5. Considering potential for problems from NH_3, CO_2, H_2S, CH_4, and low O_2, how should fresh water supply and organic budget be manipulated?

To be meaningful and useful, an objective must (1) state fully what the worker intends to accomplish; (2) exclude fully what is not the intent; and (3) specify a recognizable end point so progress or attainment can be determined. Consider the following objective for example:

> To study the relationship between black bullheads and channel catfish.

This objective fits none of the three guidelines. The intent of the researcher was narrower than this, and the following wording is much improved:

> To measure the influence of black bullheads on:
> (1) reproduction,
> (2) fry survival, and
> (3) growth of 0-, 1-, and 2-year-old
> channel catfish in 1/2-acre experimental ponds.

This objective includes much, and yet it also excludes a great deal. First, it restricts the direction of the investigation to one where only the effects of bullheads on catfish are to be examined. There is further exclusion by noting the location of the work, and the use of experimental ponds implies controlled conditions. Perhaps the time-frame is not so evident, and yet careful experimental design should allow specified measurements to be made within a relatively short period of time, three to five years or less.

It is helpful if an objective can be worded in performance terms; that is, in terms where an act, behavior, or measured accomplishment demonstrates attainment of an objective. Consider this example:

> To produce a manual of techniques for use in aspen management by commercial cutting which will, at no cost to the department of natural resources, provide an average annual harvest potential of four ruffed grouse per square mile and winter 20 white-tailed deer per square mile.

This objective has an end point of immediate significance in performance terms: production of the manual. The effectiveness of the manual at a later terminal end point is also measurable in performance terms. This end point is a harvest of four ruffed grouse per square mile and a wintering population of 20 white-tailed deer per square mile.

If some area, species, or situation is important enough for expenditure of time and money in management or research, then it is important enough for the worker to think, plan, and set forth attainable objectives complete and discrete in content. In research studies these objectives are subject to experimental design. In management endeavors these objectives are the basis of scheduled field operations. The tactical plan is not complete until these action objectives are stated clearly. Many workers neglect proper attention to this critical step, probably because they underestimate its importance.

For those further interested in developing their skill in preparing useful objectives, we recommend Mager's (1962) helpful book on preparation of instructional objectives in education. It is cleverly written, easily read, and most thought-provoking.

SUMMARY

Improved planning will enhance progress in the fish and wildlife field. Step-down planning through deductive thinking is offered as a tool in tactical planning to identify all necessary elements to solve a problem. There are six steps in plan development.

The first step is to identify precisely a problem whose solution is needed to produce benefits.

1. From the facts at hand, establish one simply stated, single purpose, base item, or primary objective that communicates the identity, nature, and depth of the problem.

The question is then asked, to attain this objective, what obstacle(s) must be overcome? In answer to this question,

2. Derive a second echelon of items that will accomplish the first.

The question is repeated for each second and succeeding echelon objective to

3. Derive a third, fourth, etc., echelon of items.

As each echelon is derived, its validity is tested with the conditional sentence

If and only if __________, then __________.

This will determine with certainty that each antecedent (the lower of two echelons in the plan) leads to and completes or accomplishes the conclusion (the superior of two echelons).

4. Continue the logical derivation of subordinate objectives until terminal items are reached, that is, items recognizable as actions which can be performed, or items whose paths to solution are not immediately evident from existing knowledge or technology.

This deductive thought process breaks a relatively complex problem into more items, each being less and less complex. It assures focus of attention on the primary objective and specifies all actions necessary, and only those actions which are necessary to attain that objective.

After the plan is developed use the conditional sentence to

> 5. Reexamine the plan to determine that the composite attainment of each item, beginning with the terminal items, will build back to accomplish the primary objective.

Step 5 insures that no necessary element has been omitted from the plan. By the same method determine that no elements are included which are not necessary to attainment of superior objectives and, therefore, the primary objective:

> 6. Reexamine the plan to determine that each item is necessary to the accomplishment of the primary objective.

Terminal items whose paths to solution are not immediately evident from existing knowledge or technology are candidates for solution by research through literature review, consultations, and experimentation. The inductive thought process is recommended whereby the question is explicitly stated at each step, all of the alternatives are listed, alternative hypotheses are devised, and crucial experiments are conducted to try and disprove some. Graphic and typed formats for step-down planning are given. The former is recommended for most plan development and display.

Deductive logic is a method of thinking that requires discipline to maintain in plan development. Our experience indicates that special caution must be exercised to prevent the pattern of thought from shifting prematurely from a problem orientation to processes and methods orientation. If this occurs before terminal items are reached, the plan will not be valid.

Since management activities and much research are aimed at attaining tactical objectives, rules are given whereby such objectives may be phrased. To be meaningful and useful, an objective must (1) state fully what the worker intends to accomplish; (2) exclude fully what is not the intent; and (3) specify a recognizable end point so progress or attainment can be determined. It is helpful if an objective can be worded in performance terms.

Use of the step-down method of action plan development will aim efforts at precise problem solution. It will speed attainment of management goals and allow research workers to concentrate on those areas of basic and applied research which are needed. Plan development is from the top down, from the complex to the less complex. Execution of the plan is from the bottom up, from terminal items to the primary objective.

ACKNOWLEDGEMENTS

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APPENDIX

NORTHERN PIKE
ARTIFICIAL SPAWNING MARSH STUDY
STEP-DOWN PLAN

1. Determine benefits and costs of northern pike spawning marsh construction and operation for management of lakes where northern pike is a suitable predator and natural recruitment is inadequate.

  2. Measure the annual increment of capital amortization and document the yearly operation and maintenance costs.

    3. Develop experimental marshes for highest production at the least cost, consistent with recruitment needs.

      4. Purchase or lease land for marsh development.

        5. Select experimental lakes from the Department's survey list with the help of consultations and further field checks, considering suitability for experimental design.

        5. Determine the best physical and chemical characteristics of artificial spawning marshes. 1/

          6. Make physical determinations from literature review and from consultations.

          6. Refine physical criteria where necessary by field experiments.

      4. Produce engineering designs for marsh development on acquired lands.

        5. Determine the best physical and chemical characteristics of artificial spawning marshes. 1/

          6. Make physical determinations from literature review and from consultations.

          6. Refine physical criteria where necessary by field experiments.

1/ 1. Area relative to lake area and number of marshes per lake.
2. Depth-marsh morphometry.
3. Proximity to receiving lake.
4. Degree of shelter necessary including axis of marsh relative to prevailing wind.
5. Water supply source--diverted stream, direct runoff, pumped from lake or stream.
6. Water quality--pollutants.
7. Marsh watershed--potential for excessive siltation.
8. Drainable or not, and if drainable, should bottom be dry or swampy.
9. Low iron content.
10. Suitability for structural control of water levels, immigration and emigration of adults and trapping of fingerlings.
11. Stability of water level to avoid exposure of eggs and crowding of fry and fingerlings.

3. Operate and maintain experimental marshes for highest production of northern pike, consistent with survival to recruitment into the fishable population.

4. Develop procedures for management of each of the experimental spawning marshes.

5. Determine the most productive and least costly method of marsh utilization for spawning. 2/

6. Make management determinations from literature review and from consultations.

6. Refine management criteria where necessary by field experiments.

5. Determine the time and method of fingerling release from the marsh. 3/

6. Make management determinations from literature review and from consultations.

6. Refine management criteria where necessary by field experiments.

2/ 1. Should adult spawners be used?
- a. Should free access by spawners be allowed?
- b. Should selected numbers, sizes, and sex ratios of spawners be stocked?
- c. Should adults be removed after spawning?
- d. What should be the source of the spawners?

2. Should marshes be used for rearing only?
- a. Should fertilized eggs or fry be stocked?
- b. If fry, what age should be stocked?
- c. If eggs or fry, what should be the stocking density?
- d. If eggs or fry what should be the manner of introduction?

3/ 1. Should young of the year be allowed to emigrate to the lake at will?

2. Considering cannibalism, marsh food supply, fingerling size, physico-chemical conditions in the marsh and conditions in receiving lake system, when is the best time for fingerling harvest if controlled?

3. Should marsh be drained and young of the year flushed to the lake without handling?

4. Should young of the year be trapped and distributed in receiving lake?

5. Determine the best methods for physico-chemical manipulation of the marsh. 4/
    6. Make management determinations from literature review and from consultations.
    6. Refine management criteria where necessary by field experiments.

2. Measure the annual increment of the fishery attributable to marsh production.
    3. Estimate yearly totals of fish harvested and fishing effort for three years prior to marsh operation on each of the experimental and control lakes.
        4. Design census for each lake to yield statistically valid results.
    3. Estimate yearly totals for fish harvested, marsh-reared northern pike harvested, and fishing effort after marsh operation on each experimental lake and total harvest and effort on each control lake for the duration of the study.
        4. Design census for each lake to yield statistically valid results.
        4. Fin clip all artificial marsh-reared northern pike.

4/ 1. Should water be left in the marsh year around?
2. Should the marsh be left drained after fingerling removal?
    a. If drained, when should it be flooded for spawning or rearing use?
    b. Should the dry marsh bottom be fallowed?
    c. Should the dry marsh bottom be plowed, disked and seeded?
3. Should marshes be fertilized?
4. What type vegetation is most desirable?
    a. If marsh is left flooded, should vegetation control be instituted?
    b. If marshes are drained, what type vegetation will provide the best spawning substrate?
5. Considering potential for problems from NH_3, CO_2, H_2S, CH_2, and low O_2, how should fresh water supply and organic budget be manipulated?

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