

Public Land Management to Support Waterfowl Bioenergetic Needs in the Rainwater Basin Region

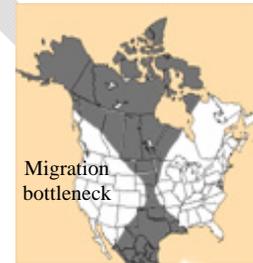
A case study from the Structured Decision Making Workshop

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The Rainwater Basin Wetland Complex (RWB) located in south-central Nebraska is regarded as a key mid-latitude spring staging area for waterfowl. Annually, an estimated 12.4 million waterfowl stop in the RWB to replenish exogenous and sequester endogenous nutrient reserves before continuing their northward migration. The region is used with less intensity in the fall (2.6 million waterfowl) as compared to the spring (9.8 million waterfowl). A recent bio-energetic model estimated waterfowl will consume approximately 24.2 billion kilocalories (*kcal*s) during fall and spring migrations through this region (Bishop and Vrtiska 2008). The model also suggested roughly 9.5 billion *kcal*s (39%) of the total diet should come from wetland-derived seeds. Wetland seeds provide essential amino acids and minerals that cannot be acquired from waste grain (Reid et al. 1989). Therefore, an estimated 1.1 billion *kcal*s derived from hydrophytes would be needed in the fall and 8.4 billion *kcal*s would be needed from hydrophytes during spring migration. To reach the necessary energetic requirements derived from wetland-dependant vegetation, the RWB region will need to provide 37,800 acres of flooded wetland habitat (4,200 acres in the fall, 33,600 acres in the spring) to sustain population targets outlined in the North American Waterfowl Management Plan (NAWMP, 1986).



Historically, fire and grazing by free-roaming bison and elk herds kept wetland vegetation in an early successional stage. Today, natural disturbance has been replaced with sporadic management including fire, grazing, haying, flooding, discing and herbicide application. These actions can directly improve food resources for migratory waterfowl.

The RWB JV is challenged to provide sufficient and available food resources that can support NAWMP population objectives. A model prototype was derived that will

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help land managers make structured decisions on management actions to best optimize *kcal* production and cost benefits. Working group members quickly realized that without including water resources and acquisition that over-all *kcal* goals can not be met in the region.

This prototype model allows wetland managers to use a structured decision framework to evaluate habitat return and cost effectiveness of the management action(s). Thus, the model allows managers to determine management action(s) that optimizes *kcal* production in consideration of financial constraints. Acquisition and restoration in conjunction with management will be required for public lands to produce sufficient energetic resources to meet goal.

Decision Problem

How to optimally manage publicly-owned wetland habitats with limited resources to meet bio-energetic needs of waterfowl during spring migration.

Regional issues:

- Lack of comprehensive management goals
 - site to regional scale
 - state/federal jurisdiction
- Lack of explicit & standardized performance measures
- Impediments (cross-organizational) to implement management in the field
- Region wide, multi-agency coordination

Over the last decade it has become clear that a more formalized decision matrix is necessary to better manage RWB wetlands. A Structured Decision Making (SDM) effort will help conservation partners to understand the optimal allocation of resources for wetland management in the RWB. Additionally, a formal decision matrix will help effectively manage wetland vegetation, understand vegetation community response to management, and develop effective management strategies. These strategies can then be used by the major land managers.

Background

Each spring a significant portion of the waterfowl population (mostly Central Flyway birds) rely on habitat within the RWB. However, compared with historical conditions, the extent, distribution, and quality of remaining wetlands in the RWB has been degraded. Historically > 11,000 individual playa wetlands (>204,000 acres) were scattered across the RWB landscape. Today less than 40,000 wetland acres remain. Despite this large scale wetland conversion millions of migratory waterfowl annually concentrate into remaining wetlands. This creates an intense competition between species and individuals for limited foraging resources. Wetland vegetation and watershed management practices need to be integrated into public land manager's annual responsibilities in order to maximize habitat benefits to migratory waterfowl (Figure 3).

In an attempt to alleviate the stresses associated with limited habitat, managers use a variety of active and passive management treatments to promote optimal foraging

habitat. Management treatments include grazing, haying, chemical application, fire, and mechanical disturbance. Managers focus on management actions that promote early succession vegetation (*Polygonum spp.*, *Echinochloa spp.*, *Amaranthus spp.*) without a clear understanding of the vegetative response resulting from management. Additionally, it is critical that a suite of flooded wetland habitat is available throughout the RWB area in order to meet foraging needs of waterfowl (Gersib et al. 1989, RWBJV 1993, Brennan 2006, Bishop and Vrtiska 2008).

Wetland hydrology for most RWB wetlands has been severely altered. Many water management practices that are utilized support cropping operations but have impacted most of the RWB wetlands. Hydrology losses are typically many in number and become cumulative losses for many wetlands. For example, there are currently 220 concentration pits in wetlands that are either wholly or partially-owned by state & federal agencies. These pits store approximately 1,090 acre feet (acft) of water. Although this is a small amount (6%) of water relative to the potential acft of water the wetlands can hold (16,990 acft), these pits have a negative-cumulative impact to wetland hydrology by ponding water in deeper pools instead of spreading out over a larger area that is shallow.

Irrigation reuse pits in the uplands create an even greater cumulative impact to wetland hydroperiod. There are 877 irrigation reuse pits in the watersheds of public wetlands. These pits can store 3,321 acft or nearly 20% of the total storage capacity of these wetlands. The impact of pits on wetland hydrology is likely greater than simply the storage capacity, pits and other hydrologic modifications slow down runoff headed for the wetland. This slow down directly reduces the wetlands hydroperiod and indirectly affects the next ponding event because the soils are drying at a faster rate than they would have if pits were not intercepting runoff. Soil drying allows the clay particles to decrease in size resulting in downward interstitial flow (Wood 2000).

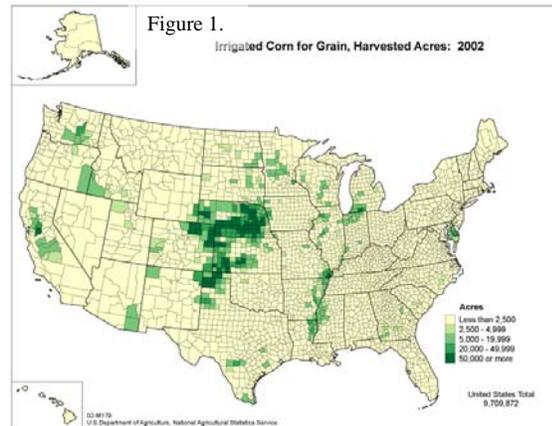
Through hydrologic restoration an additional 4,348 acres (a 127% increase in wetland habitat on Waterfowl Production Areas) of wetland habitat can be restored on FWS managed land. Additional land acquisition of roundouts could also add another 4,205 acres of wetland habitat. Acquisition of these roundouts would not only increase the amount of habitat under protection and management, but also improve function of currently protected wetland acres and improve management of the entire wetland footprint.

Legal, regulatory, and political context,

Management of existing wetlands is critical to ensure sufficient energetic resources are available. Therefore, an important decision facing land managers is the allocation of resources that promote maximum seed production on as many wetland acres as possible. Land management entities in the RWB include: Natural Resource Conservation Service (NRCS), Ducks Unlimited (DU), Nebraska Game and Parks Commission (NGPC), and Fish and Wildlife Service (USFWS). Each cooperating partner has different mandates that influence their objectives in terms of managing RWB wetlands. However, there are currently no legal constants that would limit land management decisions.

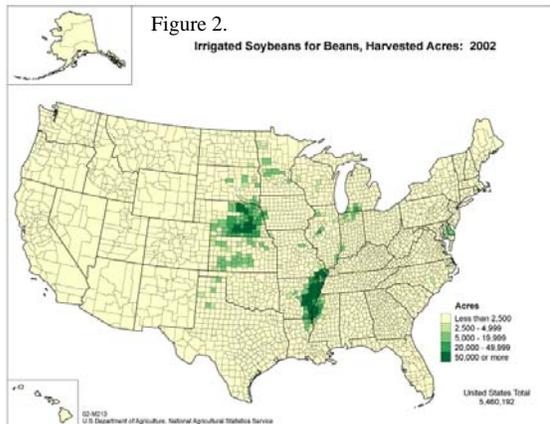
The USFWS recently completed a Comprehensive Conservation Plan (CCP) that outlines the goals and objectives for Waterfowl Production Areas in the RWB. This model does not impede or contradict any goals or objectives specified in the CCP.

There is a relationship between meeting regional habitat goals and acquisition of additional acres. Almost all public areas are limited in the habitat that can be provided due to landownership constraints. In most cases the public entity does not own the entire wetland footprint, thus hampering their ability to effectively manage their property. In these cases, acquisition of key adjacent properties is needed to restore hydrologic function of the basin. Land acquisition could also impose a political constraint in certain instances, but unique strategies like land swaps are being used to acquire these parcels.



Surface Water

Water quantity is directly influenced by flood irrigation within watersheds that contribute to wetlands. Flood irrigating crops can add significant amounts of water to wetlands during the growing season, especially during the dry months. For many wetlands, this directly influences emergent plant communities due to the altered hydroperiod.



Wetland water quality can be heavily impacted by agricultural runoff, particularly when heavy sediment loads, fertilizers, and chemicals are deposited into wetlands. The RWB has 28% (n=54) of the U.S. counties that have >50,000 acres of irrigated corn crop (Figure 1, NASS 2004) within each county (U.S. Department of Agriculture,

2002¹¹). In fact, 15 of the 17 RWB counties are included in these heavily farmed counties. The NASS (2004) also reported 95% and 76% of the corn planted in the RWB receive applications of nitrogen and phosphorus, respectively. Additionally, irrigated acres of soybeans are some of the highest in the country for this region (Figure 2, NASS 2004).

RWB wetlands were found to have higher concentrations of mercury, copper, lead, iron, and zinc than established U.S. Environmental Protection Agency (EPA) standards Gordon et al. (1997). Furthermore, the levels detected were caused by high pesticide and fertilizer use in the area (Gordon et al. 1997). According to NASS, insecticides (organophosphates and pyrethroids) were applied to 93% and 36% of all corn acreages respectively, and some of the highest herbicide use in the U.S. (atrazine for corn

11

http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_2_County_Level/Nebraska/st31_2_010_010.pdf

and glyphosate for soybean acres) occurred in south-central Nebraska (NASS 2004). Atrazine exposure in aquatic systems can adversely affect periphyton (Nelson et al. 1999), invertebrates (Dewey 1986, Dodson et al. 1999), and amphibians (Larson et al. 1998, Hayes et al. 2002). Furthermore, recent studies by Go et al. (1999) and Kim et al. (2004) indicate that certain pyrethroid insecticides, including permethrin, may function as endocrine modulators in both wildlife and humans.

Nutrient-rich runoff can also cause wetland eutrophication. Phosphorus for example, has been linked to eutrophication in many waters of the U.S. (Sharpley et al. 2003). In fact, the EPA (1996) indicated that eutrophication is the main cause of poor surface water quality. The buildup of sediment also reduces native perennial plant survival during the hotter, drier summer period (Reid et al. 1989). Sedimentation of only 0.2 inch (0.5 cm) caused a 92% reduction in hydrophyte seedling emergence and a 99.7% reduction in total invertebrate emergence in northern prairie wetlands (Gleason et al. 2003). Additionally, sedimentation may result in decreased foraging potential for waterfowl (Gaiser and Lang 1998). The implication is that intensively farmed regions can have direct and indirect impact to aquatic systems.

Groundwater

Groundwater is readily available in most areas of the RWB. The depth to groundwater is typically 50 feet to 300 feet or deeper (UNL 2008). There is however, an area just east of the Tri-County canal (including Johnson and Funk WPAs) that does have elevated groundwater levels less than 50 ft deep (UNL 2008). Currently, no explicit policy exists to guide the use of groundwater as a management tool or as a strategy to provide supplemental migratory bird habitat. In addition, there is possible political constraint on this issue of using ground water to supplement or flood wetlands.

Ecological context

The energetic model has identified the need to provide 37,000 acres of desirable wetland vegetation to meet the energetic demands of migratory waterfowl. Simply growing the vegetation however, does not make the food available for consumption by waterfowl. The wetlands must also pond water so the seeds can be consumed by dabbling ducks and geese. The severely altered hydrology of most RWB wetlands hinders the ability of the majority of wetlands to pond water to their full capacity or as frequently as normal. The timing, duration, and level of pool are all affected by alteration of the historical landscape: roads, railroads, land-leveling, hydrologic modifications (pits & drains) all contribute to this overall loss of hydrologic function in RWB wetlands.

Waterfowl Ecology

Historically, RWB wetlands provided resting and feeding habitats for pre-nesting waterfowl, important for survival and overall waterfowl recruitment (Gersib et al. 1989, LaGrange and Dinsmore 1988). Baldassarre and Bolen (2006) stated that the feeding ecology of waterfowl is a complex interaction of nutritional needs, resource availability, habitat quality, and waterfowl behavior. Feeding ecology is further complicated during winter (November–April) when waterfowl are migrating, preparing for production, and facing increased energy demands due to environmental stresses (Kendeigh et al. 1977,

Dubovsky and Kaminski 1994, Ballard et al. 2004). Although Nebraska has an abundance of agricultural fields, waste grains lack many nutrients found in natural foods that occur wetlands (Baldassarre et al. 1983, Loesch and Kaminski 1989, Krapu et al. 2004, Baldassarre and Bolen 2006). Reid et al. (1989) found that native or naturally occurring wetland plant seeds are necessary in a duck's diet to offset the protein and mineral deficiencies in waste grain. Moist soil plants such as smartweed and barnyard grass are typical early successional plants found in the RWB. These plants and other annual early-successional plants respond quickly in disturbed areas, especially when areas are reduced to bare soil (Fredrickson and Taylor 1982).

Ankney and MacInnes (1978), Krapu (1981), and Ankney and Afton (1988) showed a positive relationship between lipid reserves and clutch size for various waterfowl species. Failure to meet the nutritional need of waterfowl during winter and spring migration may result in reduced recruitment. This is called the "lipid limitation hypothesis" (Ankney and Afton 1988) and is supported by Ankney and Alisauskas (1991) as a limiting factor for wintering waterfowl. Lipids are an efficient form of energy storage and are more efficiently catabolized than protein, causing Petrie and Rogers (2004) to suggest that these advantages alone explain why most studies conclude that ducks rely heavily on stored lipids during reproduction. Heitmeyer and Fredrickson (1981) (later confirmed by Kaminski and Gluesing 1987), first suggested a relationship between winter habitat conditions and duck recruitment in the following breeding season. Raveling and Heitmeyer (1989) linked increases in northern pintail populations to winter habitat conditions. LaGrange and Dinsmore (1988) went further to say those stopover areas close to breeding areas were crucial habitats for female mallards to acquire adequate nutrients. Many other authors have suggested the correlation between wintering and spring migration energetics and their implications during nesting (Krapu 1981, Rohwer 1984, Dubovsky and Kaminski 1994). This suggests that RWB wetlands are important for pre-nesting survival and overall waterfowl recruitment (Gersib et al. 1989). It is hypothesized that *kcal* production in the Rainwater Basin Region may be a limiting factor in over-all health of migrating waterfowl.

Wetland Plant Ecology

Food production in early successional wetlands can be very impressive in terms of the number of seeds produced and the varieties. Anderson and Smith (1999) found managed moist soil wetlands had four to five times more ducks than unmanaged wetlands (Anderson and Smith 1998, Haukos and Smith 1993) indicating a potential link with food availability and waterfowl use. Total energy available in wetlands should be the primary focus of land managers in the RWB. For example, metabolized energy (ME) is described as a measure of available energy to waterfowl from their diet (Miller and Reinecke 1984). Kendeigh et al. (1977) describes ME as the total daily energy intake compared to the total food biomass required to supply energy needed for any individual or population. The intent of this process is to summarize management treatments in their ability to provide and meet energy requirements for waterfowl.

Native, undesirable plants such as cattail and river bulrush replace highly productive moist-soil plants if a wetland is rested for a period of years (Reid et al. 1989). Therefore, rest directly results in a decline in seed production. Other negative side effects of rest include woody encroachment and noxious and invasive weed invasion. Nonnative

undesirable vegetation such as reed canarygrass and Canada thistle spread quickly and can dominate or quickly turn a wetland into a monotypic stand of vegetation that is less beneficial and unattractive to waterfowl (Lavergne and Molofsky 2004). Moist-soil plants such as smartweed and barnyard grass are the typical early successional plants that respond quickly to disturbance, especially after a disturbance leaves bare mineral soil (Fredrickson and Taylor 1982).

Grazing and a variety of mechanical treatments are typically used as a vegetation management tool throughout the RWB area. Wetland grazing can reduce perennial vegetation, increase diversity, reduce stand height, and decrease stand density to result in more migratory waterfowl use. During drought and low-water periods, livestock trampling compacts the soil and may increase ponding frequency and duration, and tills the surface to improve seed germination for annuals. Cattle should be removed from wetlands before 30 July (J. Drahota, U.S. Fish and Wildlife Service, pers. obs.) to allow annual plants to produce seed heads (expert opinions) if moist-soil plant communities are desired within the same growing season. Later grazing and multiyear grazing may be needed to reduce the frequency of occurrence of undesirable species before moist-soil plants can grow. Livestock grazing does generate revenue that can offset the costs of fencing and control of invasive plants on public lands. In addition, grazing provides added economic benefits to the local communities. Herbicides and mechanical management are used to change plant compositions from a monotypic un-desirable stand to an early successional in one year. Future goals and wetland conditions will require land managers to use a variety of all techniques.

Both on-site and off-site restoration can provide a long term solution to address altered hydroperiod. Concentration pits and irrigation re-use pits both adversely affect hydroperiod. Although excavated for different purposes, both of these landscape features negatively affect wetland function and ultimately impact overall energy available to waterfowl.

Decision Structure

“Fundamental” Objectives:

- 1) Provide 1/3 of energy (2.8 billion kilocalories) on public lands for spring migrating waterfowl
-8.4 Billion kilocalories required across entire Rainwater Basin Wetland Complex during spring migration
- 2) Provide wet (flooded) habitats for waterfowl hunting opportunities
- 3) Provide sufficient habitat for migrating shorebirds
- 4) Provide roosting habitat for migrating Whooping Cranes in western basins

“Means” Objectives

- 1) Provide & maintain 11,800 flooded acres of waterfowl foraging habitat on public lands.
- 2) Maintain foraging habitat units at 75% of early successional vegetation
- 2) Maintain 2,200 acres of roosting habitat.
- 3) Maintain a spatial distribution/configuration of habitats necessary to mitigate disease, snow goose/duck interactions, and spread out foraging areas

- 4) Restore 90% (4,500 acres) of the 5,000 acres of non-functioning wetland habitat currently under public ownership.
- 5) Acquire and restore 5,000 acres of non-functioning high priority round-outs necessary to restore the 4,500 acres of non-functional wetlands on public lands.
- 6) Acquire and restore an additional 5,000 acres of high priority wetlands to ensure adequate foraging and roosting habitat is available under average precipitation conditions.
- 7) Complete sufficient hydrologic restoration both on and off-site to ensure 50% of habitats under public ownership are flooded under average precipitation conditions.

Figure 4, shows the “nesting affect” of secondary fundamental and mean objectives.

Predictive models

Wetland bioenergetics can be described as the relationship between seed biomass and gross energy available. The more energy a wetland can provide, the more bioenergetically efficient it is to waterfowl. The average energy available to waterfowl in moist-soil seeds found in the RWB is 2.5 kilocalories per gram (*kcal/g*) (Hoffman and Bookout 1985, Sherfy and Kirkpatrick 1998, Checkett et al. 2002).

We used our expert opinion, based on literature and current studies to categorize vegetative states (conditions) and the *kcal* produced per acre (Table 1). The six categories described represent various stages of stand conditions that land managers see as key junctures in the decision process. Kilo-calories produced utilize averages found in the literature and from current research in progress.

Management Actions/Alternative (condition dependent)

The group defined multiple alternative management actions that are currently or have been utilized to influence the vegetative composition. As an example, the change in stand condition for a dominant reed canarygrass community is shown in Figure 5. Probabilities were assigned to each management actions based on the working group’s expert opinion. The probabilities represent the likelihood that the vegetative community will transition to another vegetative state during the following growing season after management.

The caloric potential or energetic loss/gain of the resulting vegetation community was defined for each of the treatments actions. To estimate the caloric potential for multiple with-in year treatments, actions were also multiplied by the combined actions of within-year treatments that are thought to have higher success given the vegetative composition. These actions were compared using the 6 stand conditions (state variables). Alternative actions for a stand of early successional (old) are shown in Table 2.

Decision Analysis

We developed a model prototype to consider management treatments, combinations of management treatments, *kcal*s produced in those communities, pumping influences, decomposition of fall flooded wetlands versus spring pumping or naturally filled wetlands. We used the model to run probability co-efficient of habitat community

types versus management treatments to analyze the best cost/benefit ratio for the desired community composition shift (Table 2).

Our model allowed us to evaluate single or multiple management treatments conducted in a single growing season. The model allowed us to assess probability of reaching an early successional community, and evaluate the transition against the expected management costs. This provides managers with a transparent measure of cost benefit per acre managed. This provides managers with a process and tool set to develop situational solutions based potential management techniques, habitat community, and cost/benefit ratio. To determine if we could achieve *kcal* goals on public lands we optimized vegetative conditions on all acres and assumed 100% flooded conditions (Table 3). This would mean all currently owned public lands would have to provide early successional habitat and be flooded. This assumption is not realistic so we have incorporated state conditions into the prototype that provide a range of conditions.

During the first round of the process we were operating with the assumption that water was a not a limiting factor therefore a variable that could be provided under all conditions. Once water was included and fall and winter depletion was included it was apparent public lands could not meet the original goal of providing sufficient energetic resources on public lands.

The prototype model was also used to evaluate current conditions in the region. We estimated the current regional energetic potential using current vegetative conditions under drought, average, and above average precipitation conditions (Table 4). If the current vegetative state was 100% flooded then the public land acres would still be 8.8% below goal. An average year will fall short by 83.6%, a drought year will be short by 92.7%, and an above average wet year will be short by 73.5%.

This analysis forced the workgroup to develop new objectives, alternatives, and treatments to better address water as a limiting factor. Further modifications of this model will be necessary before complete functionality can be realized. Figure 6 is a visual representation of another model that will need explored to find the most efficient way of acquiring new habitat acres and/or increasing water pumping options in the region.

Uncertainty

As in most initial models we identified multiple uncertainties that will need to be addressed. The key uncertainties center around the model itself, coordination between managers and agencies, and political issues related to wetland and water management.

The probability percentages describing vegetation transitions after management and energetic output or *kcal*s produced per acre are model uncertainties. We are addressing these uncertainties through literature review, monitoring, and directed research. In the future we will need to focus our directed research and monitoring to better address this uncertainty. The RWBJV started a region wide vegetation monitoring protocol in 2003 and repeated in 2007. This data along with a GIS management action data base will be evaluated and results integrated into the current model. This will help validate probabilities of vegetation transition. We will need to develop an annual monitoring protocol to be able to track annual changes that a three-year protocol will not track. The *kcal* production per acre of habitat also contributes to the inherent uncertainty

in the first model. We used previous studies not done in the region to guide our estimates. Current research is on-going and will help solidify the seed production of RWB region wetland habitats.

There are other management uncertainties that need to be addressed as we move forward as well. Some include: grazing density and duration, vegetation stand height, moist soil management, and invasive species control. The duration of individual management actions will also need to be included in the model.

Supplemental water resources were identified as a potential hurdle. We do not fully understand the total need for supplemental water as it relates to the total energy available to waterfowl. However, we do know that hydroperiod and timing can limit the availability of sufficient wetland habitat during migration. Under average precipitation conditions only 20% of the current wetland acres are flooded. In addition there are 5,000 acres of hydric soils under public ownership that are dominated by upland vegetation indicating hydrologic deficiencies. This lack of hydrologic function highlights the importance of supplemental water, on-site and off-site hydrologic restoration, and acquisition of key round-outs that would allow restoration on public lands.

Another key component of wetland bioenergetics is seasonal depletion. There is very little research published that addressed seed loss between fall and spring. Laubhan and Fredrickson (1992) estimated seed deterioration rates for many wetland seeds. However, nothing is known about the differences of seed availability between fall and spring. Future research should be conducted to determine pre-migration seed availability within RWB wetlands.

Other political and agency coordination will need to be addressed as well to ensure inter and cross-agency cooperation to achieve over-all goal success.

Discussion

Land managers in the RWB are faced with decision making uncertainty in the absence of extensive quantitative data. Incorporating expert opinion into science-based conservation does have its drawbacks (Burgman 2005), and has been considered inappropriate by Ruggiero et al. (1999). Therefore, future research should be incorporated into this process as it becomes available.

Value of decision structuring

The structured decision process proved very valuable and at the conclusion of the process provided a new alternative for our over-all goal. Our initial goal was to create a model that predicts vegetation response from management treatments. The structured decision process provided new tools to develop situational treatments based on the best information available. In addition the model will allow managers to integrate a cost/benefit ratio into the decision process. During the process we realized that the problem was more involved and complex than initially thought and that our over-all goal could not be reached without considering additional factors (water and increasing the habitat base).

Further development

As we refine the prototype we will need to include multiple treatments within a year and multi-year treatments. To address our over-all goal the prototype will need to address overall deficiencies through integration of new alternatives such as acquisition and pumping. We will also need to model cost effectiveness of multiple year treatments. As we begin to use the model additional stakeholders will be included and sought for their input and support. Each agency will independently hold meetings to share the SDM process and garner support within their respective agency. To address our multiple partner coordination issues the RWBJV will sponsor a 'public land management' meeting.

To finalize the Prototype there is a considerable amount of work that remains. Current monitoring data and future research results will need to be incorporated into this model. In order to complete this project, we have identified the following avenues: 1) utilize current staff; 2) find graduate student(s); 3) utilize non-profit partnerships; 4) hire additional staff.

Prototyping process

The model framework was developed using our current management actions as well as those documented in the literature. As we worked through the initial iterations of the ProACT cycle we used expert opinion to assign probabilities of success on individual treatments and to define associated costs. Occasionally details associated with individual treatments or the interaction between multiple treatments created excessive uncertainty that stifled progress. As this occurred one team member would seem to realize the issue and bring the group back, if not, the coach would eventually bring the team back to the task at hand. At the end of successfully completing a ProACT cycle we were instructed to re-think and evaluate our initial goals and objectives. We soon realized that our 'problem' was much more complicated and we needed to include other factors in the model. We initiated 'round two' of the ProACT cycle. This proved to be a much harder task than initial thought – but a worthy exercise. During this cycle we had many 'wrong turns' and had to work through them and discuss alternatives to the current philosophy.

By the end of the week we had developed a useful initial prototype that can be used by managers to determine management strategies that optimize energetic return based on the techniques and financial resources available. In addition we recognize that other considerations such as water and acquisition will need to be integrated into the next iteration.

Recommendations

In the past, decisions to manage public wetlands were made on a site basis. These decisions were made independently, without measurable expectations, or in the context of RWB energetic requirements needed to support migratory waterfowl. Structuring habitat decisions using a rapid prototyping process will allow managers to assess conditions, evaluate alternatives, and determine the appropriate action based on financial constraints. This approach allows managers to evaluate actions using an energetic currency and allows the actions to be summarized and evaluated at a regional scale. This approach

also supports regional evaluation to determine acquisition, restoration, and water management goals necessary to meet foraging requirements within the RWB.

Implementation of this structured decision process will require a formal presentation of the process to public lands managers in the USFWS and NGPC. This forum will introduce the rapid prototyping process, facilitate buy-in, and produce commitment to the process and tools. Managers could use these tools to develop property portfolios that would highlight activities to maximize energetic return. Administrators (USFWS and NGPC) will also need to be introduced to the model structured decision process, and outputs. The outputs from these tools would support reallocation of current resources and commitment of additional resources necessary for wetland acquisition, restoration, and management required over time to meet RWB objectives. Applying this process has highlighted model inputs that need to be either evaluated or validated through monitoring and/or directed research. Some key uncertainties include energetic value by state dynamic, response of state dynamic to management action, and strategies to deliver water converting potential habitat to available habitat.

The RWBJV partners are exploring opportunities to contract or cost-share staff time to conduct past analysis of management/monitoring data, as well as conduct and analyze annual monitoring of future management. The partners are weighing several options to conduct the analysis and monitoring including: Cost-share on existing staff to dedicate time to this project, hire a part-time graduate student through a local university, hire independent part-time staff, and allocate responsibilities to current partner staff.

Literature Cited

- Anderson, J.T. and L.M. Smith. 1998. Protein and energy production in playas: implications for migratory bird management. *Wetlands* 18:437-446.
- Anderson, J.T. and L.M. Smith. 1999. Carrying capacity and diel use of managed playa wetlands by nonbreeding waterbirds. *Wildlife Society Bulletin* 27:281-291.
- Ankney, C.D. and A.D. Afton. 1988. Bioenergetics of breeding Northern Shovelers: diet, nutrient reserves, clutch size, and incubation. *Condor* 90: 459-472.
- Ankney, C.D. and R.T. Alisauskas. 1991. Nutrient-reserve dynamics and diet of breeding female Gadwalls. *Condor* 93:799-810.
- Ankney, C.D. and C. C. MacInnes. 1978. Nutrient reserves and reproductive competing hypotheses. *Condor* 93:89-97
- Burgman, M. 2005. Risks and decisions for conservation and environmental management. Cambridge University Press, Cambridge.
- Bishop, A. A, and M. V. Vrtiska. 2008. Effects of the Wetland Reserve Program on Waterfowl Carrying Capacity in the Rainwater Basin Region of South-Central Nebraska. Final report. Conservation Effects Assessment Project. Natural Resources Conservation Service. Washington DC. USA.
- Baldassarre, G.A, R.J. Whyte, E.E. Quinlan and E.G. Bolen. 1983. Dynamics and quality of waste corn available to postbreeding waterfowl in Texas *Wildlife Society Bulletin* 11:25-31.
- Baldassarre, G.A. and E.G. Bolen. 2006. Waterfowl ecology and management, second addition. Florida: Krieger Publishing Company. pp. 567.
- Ballard, B. M., J. E. Thompson, M. J. Petrie, M. Checkett, and D. G. Hewitt. 2004. Diet and nutrition of northern pintails wintering along the southern coast of Texas. *Journal of Wildlife Management* 68:371-382.
- Brennan, E. K. 2006. Local and landscape level variables influencing migratory bird abundance, diversity, behavior, and community structure in Rainwater Basin wetlands. Doctoral dissertation, Texas Tech University. Available electronically from <http://hdl.handle.net/2346/985>.
- Checkett, J.M., Drobney, R.D., Petrie, M.J., and D.A. Graber. 2002. True Metabolizable energy of moist soil seeds. *Wildlife Society Bulletin* 30:1113-1119.
- Dewey S.L. 1986. Effects of the herbicide atrazine on aquatic insect community structure and emergence. *Ecology* 67:148-162.
- Dodson, S.I., C.M. Merritt, J.P. Shannahan, C.M. Shults. 1999. Low exposure concentrations of atrazine increase male production in *Daphnia pulicaria*. *Environmental Toxicology and Chemistry* 18:1568-1573.
- Dubovsky, J.A. and R.M. Kaminski. 1994. Potential Reproductive Consequences of Winter-Diet Restriction in Mallards. *Journal Wildlife Management* 58:780-786.
- [EPA] U.S. Environmental Protection Agency. 1996. Environmental indicators of water quality in the United States. EPA 841-R-96-002. <http://yosemite.epa.gov/water/owrcatalog.nsf/e673c95b11602f2385256ae1007279fe/fcc31256807066e485256b0600723792!OpenDocument>

- Fredrickson, L. H. and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish and Wildlife Service Resource Publication 148, Washington, D.C. 29 pp.
- Gaiser, E.E and K.L. Lang. 1998. Distribution of cladoceran zooplankton among prairie pothole wetlands in northwest Iowa. *Lake and Reservoir Management* 14:37-51.
- Gersib, R.A., B. Elder, K.F. Dinan and T.H. Hupf. 1989. Waterfowl values by wetland type within Rainwater Basin wetlands with special emphasis on activity time budget and census data. Nebraska Game and Parks Commission. Lincoln, Nebr. and U.S. Fish and Wildlife Service. Grand Island, Nebraska. 105 pp.
- Gleason, H. R., N. H. Euliss Jr., D. E. Hubbard and W. G. Duffy. 2003. Effects of sediment load on emergence of aquatic invertebrates and plants from wetland soil egg and seed banks. *Wetlands* 23:26-34.
- Go, V., J. Garey, M.S. Wolff and B.G.T. Pogo. 1999. Estrogenic potential of certain pyrethroid compounds in the MCF-7 human breast carcinoma cell line. *Environmental Health Perspectives* 107:173-177.
- Gordon C.C., L.D. Flake and Higgins K.F. 1997. Trace metals in water and sediments of wetlands in the rainwater basin area of Nebraska. Proceedings of the South Dakota Academy of Sciences 76:253-261.
- Haukos, D.A., and L.M. Smith. 1993. Moist-soil Management of Playa Lakes for Migrating and wintering ducks. *Wildlife Society Bulletin* 21:288-298.
- Hayes T.B., Haston K, Tsui M, Hoang A, Haeffele C, Vonk A. 2002. Atrazine induced hermaphroditism at 0.1 ppb in American leopard frogs (*Rana pipiens*): Laboratory and field evidence. *Environmental Health Perspectives* 111: 568–575.
- Heitmeyer, M.E. and Fredrickson, L.H. 1981. Do wetland conditions in the Mississippi delta hardwoods influence mallard recruitment? In: Transactions, North American Wildlife and Natural Resources [Date and location of conference unknown]. [Place of publication unknown]: [Publisher name unknown]. 46:44-57.
- Hoffman R.D., and T.A. Bookhout. 1985. Metabolizable energy of seeds consumed by ducks in Lake Erie marshes. Transactions of the North American Wildlife and Natural Resources Conference 50:557-565.
- Kaminski, R. M. and E. A. Gluesing. 1987. Density and habitat-related recruitment in Mallards. *Journal of Wildlife Management* 51:141-148.
- Kendeigh, S.C., V.R. Dol'nik and V.M. Gavrilov. 1977. Avian energetics, p. 127-204. In J. Pinowski and S.C. Kendeigh [eds.], Granivorous birds in ecosystems. Cambridge Univ. Press, New York.
- Kim I.Y., J.H. Shin, H.S. Kim, S.J. Lee, I.H. Kang, T.S. Kim, H.J. Moon, K.S. Choi, A. Moon and S.Y. Han. 2004. Assessing estrogenic activity of pyrethroid insecticides using in vitro combination assays. *The Journal of Reproduction and Development* 50:245-55.
- Krapu, G.L. 1981. The role of nutrient reserves in mallard reproduction. *Auk* 98:29-38.
- Krapu, G.L., D.A. Brandt and R.R. Cox, Jr. 2004. Less waste corn, more land in soybeans, and the switch to genetically modified crops: trends with important implications for wildlife management. *Wildlife Society Bulletin* 32:127-136.
- LaGrange, T.G. and J.J. Dinsmore, 1988. Nutrient Reserve Dynamics of Female Mallards during Spring Migration through Central Iowa. *Waterfowl in Winter*. University of Minnesota Press, Minneapolis, 287-297.

- Larson DL, McDonald S, Fivizzani AJ, Newton WE, Hamilton SJ. 1998. Effects of the herbicide atrazine on *Ambystoma tigrinum* metamorphosis: duration, larval growth, and hormonal response. *Physiological Zoology* 71:671-679.
- Laubhan, M.L. and L. H. Fredrickson. 1992. Estimating seed production of common plants in seasonally flooded wetlands. *Journal of Wildlife Management* 56(2):329-337.
- Lavergne, S. and J. Molofsky. 2004. Reed canarygrass (*Phalaris arundinacea*) as a biological model in the study of plant invasions. *Critical Reviews in Plant Sciences* 23:415-429.
- Loesch, C. R. and R. M. Kaminski. 1989. Winter body-weight patterns of female mallards fed agricultural seeds. *Journal of Wildlife Management* 53:1081-1087.
- Miller, M.R. and Reinecke, K.J. 1984. Proper expression of metabolizable energy in avian energetics. *Condor* 86:396-400.
- [NASS] National Agricultural Statistics Service (NASS). 2004. Agricultural chemical usage 2003 field crops summary.
http://www.nass.usda.gov/Statistics_by_Subject/Environmental/index.asp
- [NAWMP] U. S. Fish and Wildlife Service and Canadian Wildlife Service. 1986. North American waterfowl management plan. U. S. Fish and Wildlife Service, Washington D.C., USA.
- Nelson K.J. and B.J. Esmoil. 1999. Background contaminants evaluation of Fort Niobrara and Valentine National Wildlife Refuge. US Fish and Wildlife Service Contaminant Report, Grand Island, NE.
- Petrie, S.A. and Rogers, K.H. 2004. Nutrient-reserve dynamics of white-faced whistling-ducks breeding in a semiarid South Africa. *Canadian Journal of Zoology* 82: 1082-1090.
- [RWB JV] Rainwater Basin Joint Venture. 1993. Water Management Options for Wetland Development in the Rainwater Basin. 16pp.
- Raveling, D.G. and M.E. Heitmeyer. 1989. Relationships of population size and recruitment of Pintails to habitat conditions and harvest. *Journal of Wildlife Management* 53:1088-1103.
- Reid, F. R., J. R. Kelley, Jr., T. S. Taylor and L. H. Fredrickson. 1989. Upper Mississippi Valley wetlands - refuges and moist-soil impoundments. Pages 181-202 In L. M. Smith, R. L. Pederson and R. M. Kaminski, editors. *Habitat management for migrating and wintering waterfowl in North America*. Texas Technological University Press, Lubbock. 560 pp.
- Rohwer, F.C. 1984. Patterns of egg laying in prairie ducks. *Auk* 101:603-605.
- Ruggiero, L. F., K. B. Aubry, S. W. Buskirk, G. M. Koehler, C.J. Krebs, K. S. McKelvey, and J. R. Squires. 1999. Ecology and conservation of lynx in the United States. General Technical Report RMRS-GTR-30WW. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO. www.fs.fed.us/rm/pubs/rmrs_gtr030.html.
- Sharpley, A.N., T. Daniel, T. Sims, J. Lemunyon, R. Stevens, and R. Parry. 2003. Agricultural phosphorus and eutrophication, 2nd ed. U.S. Department of Agriculture. Agricultural Research Service, ARS-149, 44 pp.
<http://www.ars.usda.gov/is/np/Phos&Eutro2/agphoseutro2ed.pdf>
- Sherfy, M. H., and R. L. Kirkpatrick. 1998. Nutritional value and management of waterfowl and shorebird foods in Atlantic Coastal moist-soil impoundments. Masters Thesis.
<http://scholar.lib.vt.edu/theses/available/etd-033199-130907/unrestricted/chapter1.pdf>
- [UNL] University of Nebraska-Lincoln. 2008. Groundwater map—predevelopment to spring 2008 Lincoln, NE: Institute of Agriculture and Natural Resources, School of Natural

Resources, Conservation and Survey Division.

<http://snr.unl.edu/information/GroundwaterMaps.asp>

Wood, W.W. 2000. Ground-water recharge in the southern high plains of Texas and New Mexico. USGS Publication, FS-127-99. 4 pp.

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Figures and Tables

State Conditions	Definition	Utility
Wetland Vegetation	Percent Vegetation Condition	Kilo-Calories per Acre
Reed Canarygrass (dominant)(D)	>75%	20,000
Bulrush-Catail (dominant) (D)	>75%	30,000
Reed Canarygrass (transitional)(T)	25-75%	75,000
Bulrush-Catail (transitional) (T)	25-75%	115,000
Early Successional (new) (N)	>75% Annuals	250,000
Early Successional (old) (O)	>75% Perennials	200,000

Table 1. Classifications (conditions) of wetland units, percent of plant composition to categorize that condition and the *kcal* of energy that condition produces per acre.

Early
Successional
(Old)

Action	RG (D)	BC (D)	RG (T)	BC (T)	ES (N)	ES (O)	E(Kcal)	Cost/acre
Grazing (H)	0	0	0.05	0.05	0.6	0.3	219.5	+ 60
Grazing (L)	0	0	0.2	0.2	0.1	0.5	163	+ 30
Discing	0	0	0	0	1	0	250	-20
Tilling	0	0	0	0	1	0	250	-40
Mowing	0	0	0.05	0.05	0.5	0.4	214.5	-15
Fire (SP)	0	0	0.1	0.05	0.2	0.65	193.25	-25
Fire (FA)	0	0	0.1	0.05	0.05	0.8	185.75	-25
Haying	0	0	0.05	0.05	0.5	0.4	214.5	+15
Herbicide (G)	0	0	NA	NA	NA	NA	0	-25
Herbicide (F)	0	0	NA	NA	NA	NA	0	-30
Water level mgmt.	0	0	0.1	0.05	0.2	0.65	193.25	-14
Rest	0	0	0.3	0.15	0	0.55	149.75	0
scraping	0	0	NA	NA	NA	NA	0	-1250

Table 2. Example of actions that may be taken to manage an early successional (old) plant composition in a wetland unit. Example shows the probability of an early successional (old) plant community following the management action (rows) transitioning into one of the six vegetative conditions (columns). *Kcal* (thousands) is the predicted value of energy (per acre) gained or lost if predicted transitions occur. Estimated cost per acre is cost to perform that management action in dollars.

Public Lands Capacity Preferred Management Strategy and 100% Flooded				
Vegetative Condition	Acres	Kcals (1000's)	Potential Habitat at 100% full (kcal 1,000's)	Average Habitat Conditions (kcal 1,000's)
Reed canary grass (D)	738	20	14760	2656.8
Bulrush-cattail (D)	738	30	22140	3985.2
Reed canary grass (T)	738	75	55350	9963
Bulrush-cattail (T)	738	115	84870	15276.6
early successional (New)	5900	250	1475000	295000
early successional (Old)	5900	200	1180000	212400
Sum	14752		2832120	539281.6
Deficit	939		1.15%	-80.74%

Table 3. Using 75% early successional habitat and 25% late successional habitat in optimal flooded conditions RWB public lands could meet the bioenergetics goals. The Habitat Average Flooded column utilized the 2004 vegetative conditions with 18% flooded habitat which shows current public land acres would fall short by 81.8% on average years.

Current Public Lands Capacity Under Variable Climatic Conditions						
Vegetative Conditions	Acres	Kcals (1,000's)	Energetic Resources 100% flooded (kcal 1,000's)	Energetic Resources Average Conditions (kcal 1,000's)*	Energetic Resources Drought Conditions (kcal 1,000's)**	Energetic Resources Above Average Conditions (kcal 1,000's)**
Reed canary grass (D)	2,791	20	55,820	10,048	4,466	16,188
Bulrush-cattail (D)	1,900	30	57,000	10,260	4,560	16,530
Reed canary grass (T)	800	75	60,000	10,800	4,800	17,400
Bulrush-cattail (T)	400	115	46,000	8,280	3,680	13,340
Eearly successional (New)	7,500	250	1,875,000	337,500	150,000	543,750
Early successional (Old)	2,300	200	460,000	82,800	36,800	133,400
Sum	15,691		2,553,820	459,688	204,306	740,608
Deficit			-8.8%	-83.6%	-92.7%	-73.5%

Table 4. This table attempts to summarize the RWB habitat as it existed in 2004 with 100% flooded, average ponded (18% flooded), drought, and above average conditions. Note that none of these conditions were able to meet the estimated energy requirements.

Annual Management Cycle

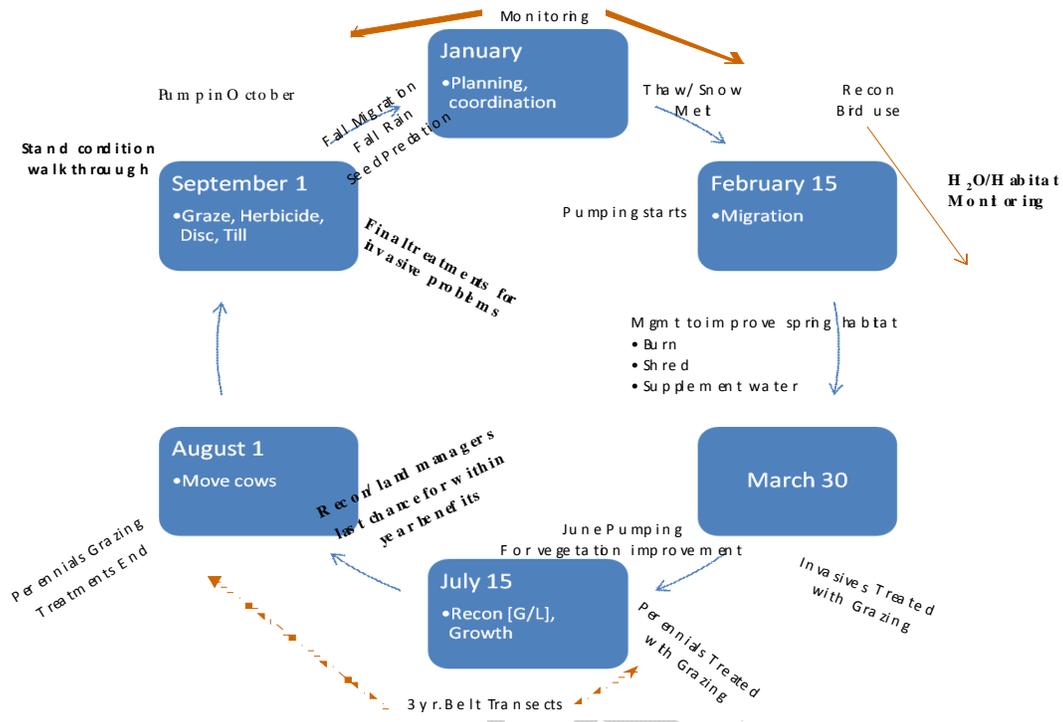


Figure 3. Annual decision cycle that land managers deal with in the RWB.

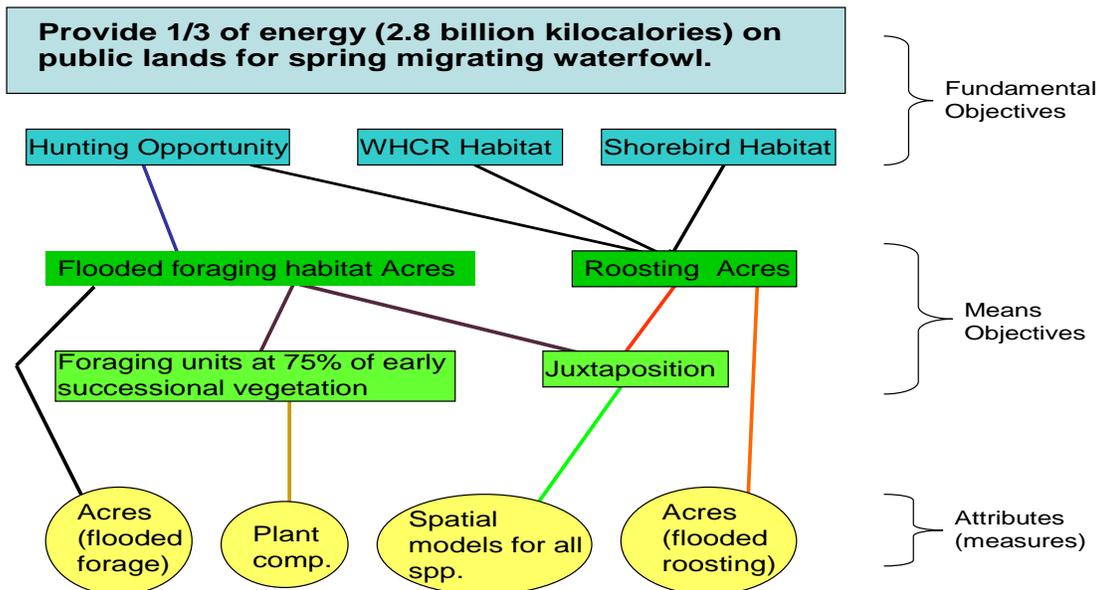
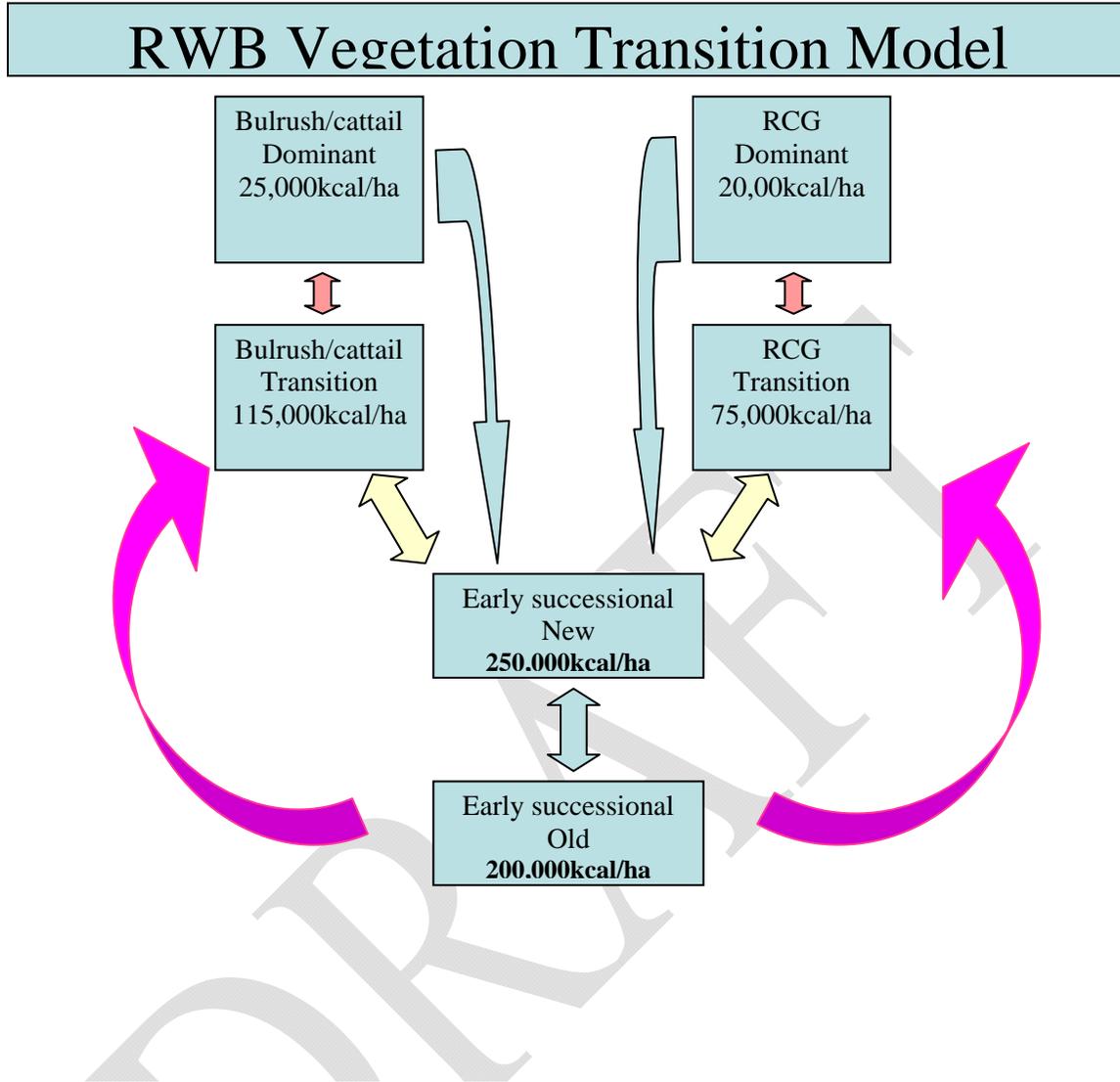


Figure 4. Demonstration of the connectiveness of fundamental and mean objectives and techniques to measure or guide success.

Figure 5. State dynamics for the RWB vegetation transition model.



Fund Allocations

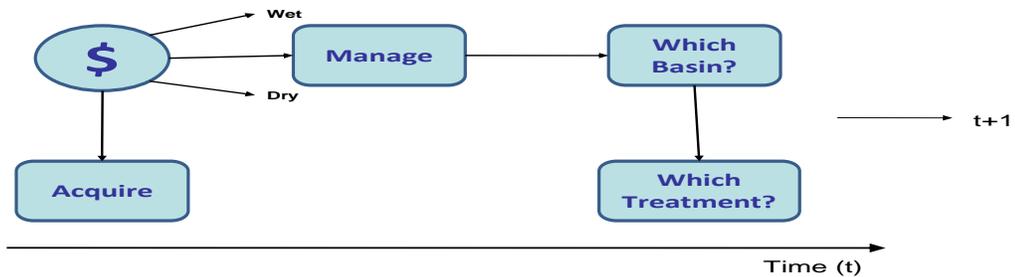


Figure 6. Fund allocation decisions facing the decision makers.