LOWER MISSISSIPPI VALLEY JOINT VENTURE

MAV WATERFOWL STEPDOWN STATE SUMMARIES

Lower Mississippi Valley
JOINT VENTURE
www.lmvjv.org

LOWER MISSISSIPPI VALLEY JOINT VENTURE

WATERFOWL WORKING GROUP

DECEMBER 2015

Acknowledgments

Many partners and individuals have contributed time and energy to the planning and implementation of waterfowl habitat objectives for the Mississippi Alluvial Valley in the Lower Mississippi Valley Joint Venture. We thank those partners for their dedication in creating a collaborative vision for waterfowl conservation.

"IN PLANNING FOR THE FUTURE OF WATERFOWL, WE MUST REFLECT UPON THE PAST, CONSIDER THE PRESENT, AND RECOGNIZE AND APPRECIATE THE TREMENDOUS EFFORTS THAT HAVE BEEN MADE SINCE THE TURN OF THE CENTURY ON BEHALF OF DUCKS, GEESE AND SWANS BY THOUSANDS OF INDIVIDUALS, NUMEROUS PRIVATE CONSERVATION ORGANIZATIONS, AND THE STATE, PROVINCIAL, TERRITORIAL AND FEDERAL GOVERNMENTS OF CANADA, THE UNITED STATES AND MEXICO." – NAWMP 1986

Suggested Citation:

Lower Mississippi Valley Joint Venture. 2015. MAV Waterfowl Stepdown State Summaries. LMVJV Waterfowl Working Group c/o Lower Mississippi Valley Joint Venture, Vicksburg, MS.

LMVJV Vision for Waterfowl Populations and Habitat

The vision of the Lower Mississippi Valley Joint Venture partnership is a landscape supporting healthy native bird populations and other wildlife across the LMVJV (LMVJV 2013). Waterfowl are supported on the LMVJV landscape through forested wetland and managed waterfowl-habitat complexes, which include naturally flooded habitats and managed habitats on publically and privately owned lands (Fredrickson and Heitmeyer 1988; Reinecke et al. 1989). Habitat types include flooded bottomland hardwood forest, moist-soil wetland impoundments, green-tree reservoirs, and flooded agricultural crops. Each habitat and ownership type is important to supporting the needs of wintering waterfowl in the LMVJV (Reinecke et al. 1989).

"Past habitat protection efforts in the MAV can be characterized as an attempt to offset losses of habitat on unmanaged private lands through acquisition and development of public lands.

Habitats in the land ownership categories are not completely interchangeable, however. Managers of public lands can increase food production, but cannot meet demands for waterfowl hunting or maintain historic patterns of waterfowl distribution.

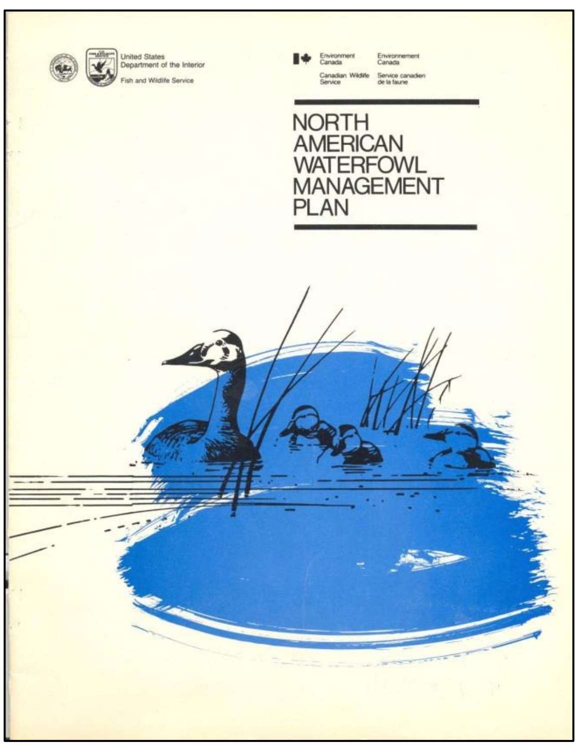
Thus, complexes of public and private habitat are important on a regional scale. We recommend maintaining traditional efforts to acquire and manage public lands, and initiating innovative programs to protect habitat on private lands."

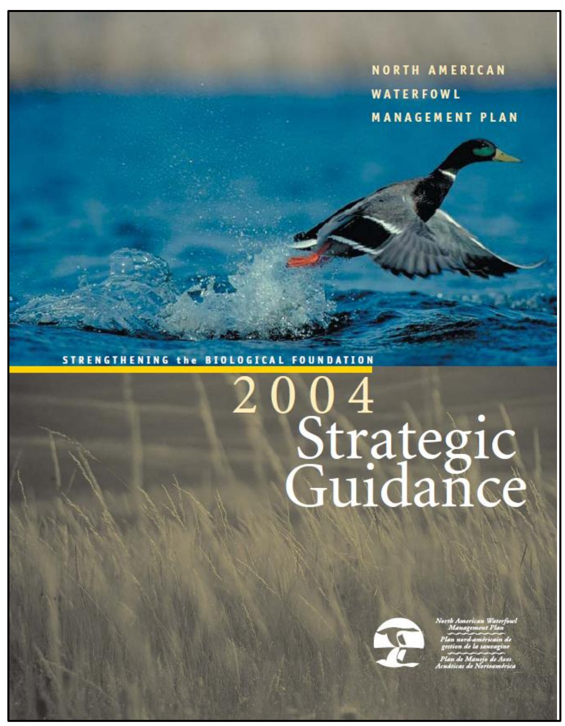
-- Reinecke et al. (1989)

Plan Scope and Purpose

Scope. Planning in this document is for the Mississippi Alluvial Valley (MAV) geography (BCR 26), which includes portions of the states of Arkansas, Louisiana, Kentucky, Mississippi, Missouri, and Tennessee. In this document, we consider both public lands and private lands. Public lands include a network of state Wildlife Management Areas, managed by their respective state agencies, and federal National Wildlife Refuges, managed by the U.S. Fish & Wildlife Service (USFWS). Private lands include land managed for waterfowl through a conservation program (e.g., Conservation Reserve Program, Wetland Reserve Program, Environmental Quality Incentives Program through Migratory Bird Habitat Initiative) and land managed for waterfowl that is not enrolled in a conservation program (e.g., private duck clubs).

Purpose. This document summarizes the North American Waterfowl Management Plan (NAWMP) allocation process and biological planning for waterfowl (dabblers and Wood Ducks) in the MAV as outlined in Edwards et al. (2012). The intent of this document is to provide guidance for managers on decisions regarding maintenance and/or improvement of management practices to meet objectives across the landscape. Ultimately, this plan helps accomplish the implementation of original NAWMP goals at the LMVJV regional scale to: "maintain populations of ducks of various species and their habitats at levels acceptable to people who use and enjoy them" and "to maintain and manage an appropriate distribution and diversity of high quality waterfowl habitat in North America that will (1) maintain current distributions of waterfowl, and (2) under average environmental conditions, sustain an abundance of waterfowl" (NAWMP 1986).





Executive Summary

Planning in this document is for the Mississippi Alluvial Valley (MAV) geography (BCR 26), which includes portions of the states of Arkansas, Louisiana, Kentucky, Mississippi, Missouri, and Tennessee. This document summarizes the North American Waterfowl Management Plan (NAWMP) allocation process and biological planning for waterfowl (dabblers and Wood Ducks) in the MAV as outlined in Edwards et al. (2012). The primary intent of this document is to provide guidance on decisions regarding acquisition, maintenance and/or improvement of management practices to meet objectives across the landscape.

The MAV supports a diverse and ecologically rich forested wetland ecosystem – one of the most productive in North America. Nearly 40% of the Mississippi Flyway's waterfowl and 60% of all U.S. bird species migrate through or winter in the MAV. However, changes in land use practices have resulted in degradation of natural habitats and alteration of historic flooding regimes.

As a result of concerns over habitat loss on the wintering grounds, the Lower Mississippi Valley Joint Venture (LMVJV) partnership was formed in 1987. The LMVJV continues to improve waterfowl habitat conditions in this heavily altered landscape to support the mission of the NAWMP. The NAWMP established continental population objectives to be implemented through Joint Ventures. The LMVJV, as a predominantly non-breeding habitat Joint Venture, stepped-down those continental objectives into regional population objectives based on historic bird distributions from mid-winter surveys and county-level harvest statistics.

The LMVJV uses an energy-based model to translate regional population goals into habitat-based goals as Duck Energy Days (DEDs)—this is based on the assumption that non-breeding waterfowl are food-limited. The LMVJV Waterfowl Working Group recognized that many factors affect DED availability, or energy supply, in any given year, especially in the complex alluvial floodplain ecosystem of the MAV. Energy supply is expressed in DEDs provided through natural flooding ($DED_{Natural\ Flood}$) and managed impoundments on private lands ($DED_{Private}$) and public lands (DED_{Public}). The MAV consists of six states that each has a DED goal based on the difference between energy demand (i.e., NAWMP objective) and energy supply (i.e., bioenergetic model results).

The results of a bioenergetic model analysis indicate that the MAV is below its NAWMP objective for DEDs. Based on satellite imagery from 1999-2005 and public land data from 2010-2014, the bioenergetic model indicates that two states have met or exceeded their goals and four states are below their goals. The reality of landscape conditions, in addition to uncertainties in the bioenergetic model, impacts the degree to which states are above or below their respective goal. For states below their goal, an aspirational goal represents additional energy that is required. At a minimum, partners should strive to maintain current waterfowl habitat, although even this may be difficult in some situations.

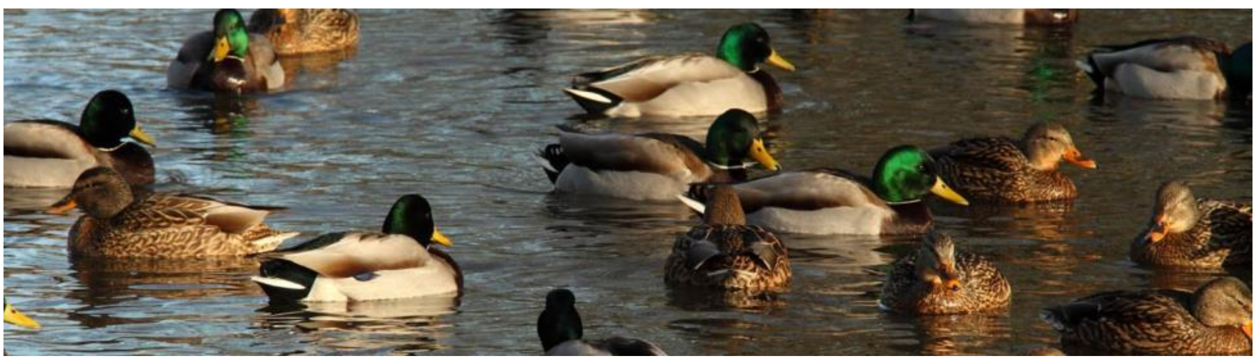
Three overarching conservation approaches were identified that could be used to achieve aspirational goals for wintering waterfowl in the MAV. These include acquisition and public management of additional habitat, restoration of habitat, and enhancement of current habitats. The specific strategies provided as examples within these approaches are intended to provoke thought regarding various management actions and subsequent tradeoffs. The fact that the waterfowl-habitat values of some actions may not immediately accrue (e.g., in 1-2 years), does not discount the activity's ultimate value. Wildlife – including waterfowl – management has always relied on slow but steady progress to achieve cumulative success.

Introduction

The Mississippi Alluvial Valley (MAV) supports a diverse and ecologically rich forested wetland ecosystem – one of the most productive in North America. The nearly 25 million acre, topographically complex floodplain extends from the confluence of the Mississippi and Ohio Rivers, to the northern Gulf of Mexico, featuring a mosaic of ridges, swales, meander belts and backswamps. Small changes in elevation (<1 foot) in the MAV are associated with large shifts in hydrology, which in turn, strongly affect plant and animal community composition and structure. As with many river systems, much of the MAV's natural character has been altered through conversion to agriculture, and the connection between floodplain and river has been significantly altered.

"Historically, the MAV was dominated by forested wetlands and subject to extensive flooding. Today, <20% of the bottomland forests remain, and agriculture is the principal land use."—Reinecke et al. (1989)

Nearly 40% of the Mississippi Flyway's waterfowl and 60% of all U.S. bird species migrate or winter in the MAV. The MAV is identified as the most important wintering location for Mallard (*Anas platyrhyncos*) and Wood Duck (*Aix sponsa*) populations. Additionally, the MAV winters significant numbers of Green-winged Teal (*A. crecca*), Northern Shoveler (*A. clypeata*), and Gadwall (*A. strepera*). Accordingly, the MAV was identified as a priority non-breeding site for waterfowl in the original North American Waterfowl Management Plan (1986) and became a part of one of the first established Joint Ventures. The Lower Mississippi Valley Joint Venture partnership, formed in 1987, continues to improve waterfowl habitat conditions in this heavily altered landscape to support the mission of the North American Waterfowl Management Plan.



"Mallards and Wood Ducks are the most abundant waterfowl species in the MAV during migration and winter..."—Reinecke et al. (1989)

MAV Waterfowl Conservation Planning

To support waterfowl populations, the North American Waterfowl Management Plan set continental population objectives that were to be implemented through Joint Ventures. Currently, continental waterfowl objectives are set at numbers reflective of populations and distribution in the 1970s when duck production varied from excellent to average (NAWMP 1986). The LMVJV, as a predominantly non-breeding habitat Joint Venture, stepped down the continental goals into regional population goals based on bird distributions from mid-winter surveys and county-level harvest statistics (Reinecke and Loesch 1996).

The LMVJV uses an energy-based model to translate regional population goals into habitat-based goals as Duck Energy Days (DEDs). DEDs are defined as the number of ducks that can obtain daily energy requirements from an acre of foraging habitat for a day. The use of DEDs as the currency for objective setting reflects that the limiting factor most thought to affect wintering waterfowl is food availability. State-specific DED objectives are set based on the estimated **energy demand** of the wintering waterfowl population (Fig. 1). Then, to assess how energy demand is being met and to determine the accomplishments of the LMVJV toward meeting habitat goals of NAWMP, **energy supply** is calculated from the existing land base, taking into account the amount and carrying capacity of different habitat types (Fig. 1).

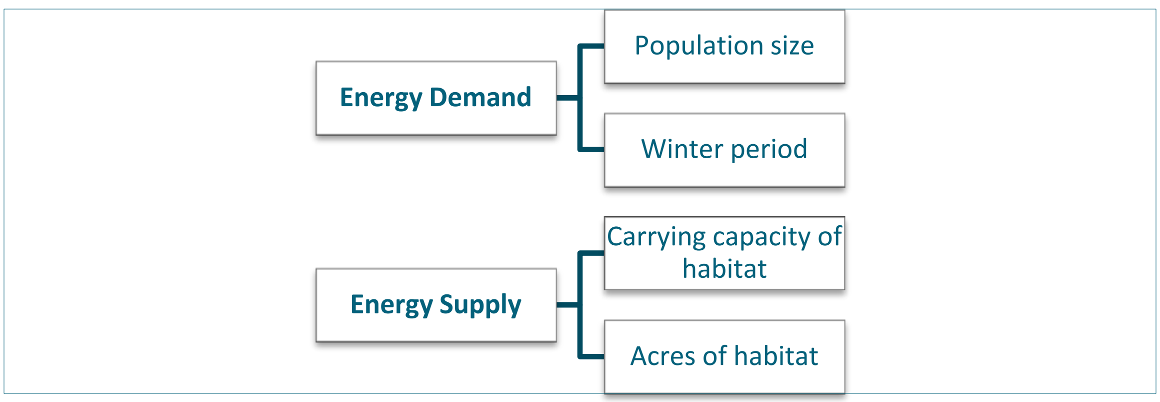


FIGURE 1. GENERAL FRAMEWORK FOR ENERGY ALLOCATION MODELING IN THE LOWER MISSISSIPPI VALLEY JOINT VENTURE.

ENERGY DEMAND[1]

POPULATION SIZE

The total wintering waterfowl population objective in the MAV is 4.2 million (Reinecke and Loesch 1996; LMVJV 2007), which includes Mallard, Northern Pintail, American Black Duck, Gadwall, American Wigeon, Green-winged Teal, Northern Shoveler, Wood Duck, and geese. Dabbling ducks account for 2.9 million and Wood Duck 1.0 million (Table 1). The initial population goals were adjusted for 15% winter mortality (Reinecke and Loesch 1996) and to account for early migrating ducks that winter in Mexico (LMVJV 2007). The

[1] Full details of the LMVJV allocation model can be found in Edwards et al. (2012).

MAV population goal for dabbling ducks represents 8.0% of the 1970-1979 continental goals for all dabbling ducks and 33% of the Wood Duck goal (Reinecke and Loesch 1996). Each state has a population objective that is derived using mid-winter survey totals of each waterfowl species to partition the continental objective among each state, and then county-level harvest estimates to allocate the state midwinter totals among counties within a state. (Reinecke and Loesch 1996). Additionally, geese are considered competitors for a portion of the available energy on the landscape. Therefore, based on mid-winter inventories and an assumed 25% of time spent foraging in flooded habitat, a goose competition "objective" was added into total population goals and energetic calculations (LMVJV 2007).

TABLE 1. TARGET POPULATION OBJECTVES FOR DABBLING DUCKS AND WOOD DUCKS WITH AN ADJUSTMENT FOR EXPECTED GOOSE COMPETITION FOR FOOD IN FLOODED HABITATS. MULTIPLY OBJECTIVE VALUES BY 110 (DAYS) TO CALCULATE DED OBJECTIVES.

State	Dabbling Duck Population Objective	Wood Duck Population Objective	Total Duck Population Objective	Goose Competition	Total Population Objective
Arkansas	1,541,021	322,290	1,863,311	131,483	1,994,794
Kentucky	15,073	6,710	21,783	21,024	42,807
Louisiana	582,015	373,660	955,675	143,536	1,099,211
Mississippi	461,833	179,230	641,113	19,274	660,387
Missouri	79,683	26,020	115,183	58,161	173,344
Tennessee	262,763	35,500	298,263	7,425	305,688
MAV Total	**2,942,389**	**943,410**	**3,885,799**	**380,903**	**4,276,231**

WINTER PERIOD

Waterfowl energy needs are modeled for an overwintering period of 110 days, representing early November to late February (Reinecke and Loesch 1996). Additionally, a goose competition DED objective was added into waterfowl energy (LMVJV 2007). Wood Ducks were constrained to only feed 75% in forested wetlands and 25% in moist-soil wetlands (LMVJV 2007). As a result, across the 110-day period the overall NAWMP goal for the MAV is 469,336,891 DEDs (Table 2).

TABLE 2. DUCK ENERGY DAY (DED) OBJECTIVES BASED ON ENERGY DEMAND OF STEPPED-DOWN NAWMP OBJECTIVES FOR THE MAV PORTION OF THE LMVJV.

State	DED Objective[1]
Arkansas	219,427,337
Kentucky	4,708,843
Louisiana	120,913,290
Mississippi	72,637,077
Missouri	18,025,015
Tennessee	33,625,658
MAV TOTAL	469,336,891

[1]DED objectives were calculated for a 110-day winter period

ENERGY SUPPLY

ACRES OF HABITAT

Acres are calculated separately for naturally flooded habitats and managed public land and private land. Detailed methodology is provided in Edwards et al. (2012).

NATURALLY FLOODED HABITAT. A series of seven LandSAT scenes encompassing the MAV were analyzed for standing surface water based on spectral reflectance. Permanent water, state and federal public water management units, and private land water management units were removed from the geospatial data layer. The resulting layer captured land that was subject to natural flood in winter. The natural flood water layer was then overlaid on National Landcover Database (NLCD) or National Agriculture Statistic Service (NASS) geospatial data layers to determine habitat type.

PRIVATE MANAGED HABITAT. Private lands that are enrolled in a conservation program ("Managed in Program"; MIP) were geospatially delineated based on information from partners (Partners for Fish & Wildlife, WRP, etc.). Geospatial delineation and calculation of private lands that are managed for waterfowl but are not enrolled in a conservation program ("Managed out of Program"; MOP) were evaluated based on a "square-water" algorithm. The square-water algorithm assumes that managed habitats typically have linear features derived from water control levees and field borders, whereas naturally flooded areas tend to be non-linear in shape (Edwards et al. 2012). The resulting MIP and MOP geospatial data layers were overlaid on National Landcover Database (NLCD) or National Agriculture Statistic Service (NASS) geospatial data layers to determine habitat type.

+PUBLIC MANAGED HABITAT. A geospatial database of state and federal water management units has been developed and maintained by the LMVJV Office. The database tracks information on ownership (management agency), habitat (type, % harvested, proportion red oak, etc.), location (area name, physical boundaries, acreage), and hydrology (water control structures and capacity). These data were used to determine the extent and habitat type of public lands in the bioenergetic model.

HABITAT CARRYING CAPACITY

The energy provided by specific habitat types (e.g., bottomland hardwood, moist-soil, harvested or unharvested crops) was valued based on Reinecke and Kaminski (2006). Reinecke and Loesch (1996) outline the steps to calculate carrying capacity of habitats. Daily energy requirements were assumed to be that of an "average" duck that requires 294.25 kcal day^{-1} (LMVJV 2007). We used a foraging threshold or giving up density of 50 kg ha^{-1} and published true metabolizable energy values. The energy provided for a single duck is then represented as DEDs per acre.

TABLE 3. CARRYING CAPACITY OF SELECTED FORAGING HABITATS (EXPRESSED AS DUCK ENERGY-DAYS/AC [DEDS/AC]) FOR A HYPOTHETICAL AVERAGE DABBLING DUCK. SEE REINECKE AND KAMINSKI (2006) FOR SPECIFICS ON CALCULATIONS, ASSUMPTIONS, AND DATA SOURCES, EXCEPT FOR WRP.

Habitat	Food available (kg/ha)	TME (kcal/g)	DEDs/ac
Moist-soil	600	2.47	1,868
Harvested crops			
Rice	80	3.34	138
Soybean	60	2.65	36
Corn	150	3.67	505
Milo	150	3.49	480
Unharvested crops			
Rice	5,240	3.34	23,833
Soybean	1,334	2.65	4,677
Corn	5,716	3.67	28,591
Milo	3,811	3.49	18,046
Millet	1,500	2.61	5,203
Bottomland hardwood			
20% red oak	66	2.76	61
30% red oak	79	2.76	109
40% red oak	91	2.76	156
50% red oak	104	2.76	203
60% red oak	116	2.76	250
70% red oak	128	2.76	297
80% red oak	141	2.76	345
90% red oak	153	2.76	392
100% red oak	166	2.76	439

FACTORS INFLUENCING ENERGY SUPPLY

Energy supply is derived according to the bioenergetic model and represents energy estimated to be provided by different management types (Edwards et al. 2012). In the MAV, dabbling ducks forage in moist-soil, flooded cropland, and forested wetland habitats that are subject to natural flooding and additionally managed via impoundments on public and private land. Accordingly, energy supply is expressed in DEDs provided through natural flooding ($DED_{Natural\ Flood}$) and managed impoundments on private lands ($DED_{Private}$) and public lands (DED_{Public}):

$$DED_{Total} = DED_{Natural\ Flood} + DED_{Private} + DED_{Public}$$

The LMVJV Waterfowl Working Group recognizes that many factors affect DED availability, or energy supply, in any given year, especially in the complex alluvial floodplain ecosystem of the MAV. In 2010, the LMVJV Waterfowl Working Group finalized an energy-based representation of DED provision on the landscape through a process that accounted for a suite of factors, such as flooding extent and disturbance. Due to variable management of forest stands on private land, the LMVJV model assumes a 20% red oak value for private lands. Furthermore, WRP sites were considered 82% bottomland hardwood and 18% moist-soil habitats (based on data from the MAV in Mississippi) with a reduced biomass value (272 kg ha^{-1}) for passive moist-soil habitat management.

The energy provided in each of three management categories (natural flood, public managed or private managed) was ultimately calculates as a function of, or to be influenced by the following factors:

$DED_{Natural\ Flood} = f$ (extent, habitat type, frequency)
$DED_{Private} = f$ (extent, habitat type, status, disturbance)
$DED_{Public} = f$ (extent, habitat type, performance, disturbance)

The following state summaries are intended to:

(1) provide an overview of the bioenergetic model results,

(2) paint a picture of what the landscape looks like for naturally flooded lands, private managed lands, and public managed lands,

(3) set goals to maintain DEDs and/or provide additional DEDs,

(4) discuss the implications of model results to waterfowl conservation in each state, and

(5) discuss how aspirational goals could be met.

MAV Waterfowl Planning

Arkansas

Summary

According to stepped-down North American Waterfowl Management Plan (NAWMP) goals, the state of Arkansas should provide 47% of the Mississippi Alluvial Valley (MAV) objective of 469,337,220 Duck Energy Days (DEDs). This represents a state-level NAWMP objective (energy demand) of 219.4 million DEDs. Based on contributions from three sources—natural flooding, private managed lands, and public managed lands—Arkansas currently supplies 117.5-128.3 million DEDs.

ENERGY DEMAND: **219.4 MILLION DEDS**

Arkansas has a state-level NAWMP objective of 219,427,337 DEDs based on a 110-day wintering period from early November to late February. One DED represents the energy needed to support one average-sized duck requiring 294.35 kcal/day for one day.

Table 1. Population and Duck Energy Day objectives for Arkansas relative to the MAV.[1]

Geography	Dabbler Population Objective	Wood Duck Population Objective	Total Duck Population Objective	Total Duck DED Objective	Goose Competition DEDs	Total DED Objective
Arkansas	1,541,021	322,290	1,863,311	204,964,210	14,463,130	219,427,337
MAV Total	2,942,389	943,410	3,885,799	427,437,890	41,899,001	469,336,891

[1] See Reinecke & Loesch 1996 and LMVJV 2007

ENERGY SUPPLY: **117.5 – 128.3 MILLION DEDS ($\bar{x}$ = 124.2 ± 3.4 MILLION)**

Based on the most current three-year mean, 124.2 million DEDs are estimated as supplied throughout Arkansas from natural flood (40%), private managed (20%), and public managed lands (40%; **Table 2**). After accounting for natural flooding, the remaining energy is distributed as 40% on private managed land (Managed In Program (MIP); Managed Out of Program (MOP)) and 60% on public managed land. Of public managed land, 70% of energy is provided through federal partners and 30% through state partners (**Table 2**).

Table 2. Duck Energy Days estimated on the landscape in Arkansas through an energy-based model that (1) accounts for decomposition/disturbance across all three habitat sources; (2) uses Monte Carlo simulation to generate hypothetical winters based on flood frequency and determine DED values reached or exceeded 80% of the time for natural flood and private managed land; and (3) uses annual data entered into the Water Management Unit database for public managed land wherein units are assumed at full pool capacity and are not linked to flood frequency.[2]

	Natural Flood	Private Managed			Public Managed			
		MIP	MOP	Subtotal	Federal	State	Subtotal	Total
2011-12	55,182,022	11,023,344	16,932,399	28,385,541	27,014,223	13,849,677	40,713,469	117,482,578
2012-13	55,182,022	11,023,344	16,932,399	28,385,541	35,711,809	14,676,543	50,457,903	126,740,782
2013-14	55,182,022	11,023,344	16,932,399	28,385,541	37,101,487	14,860,731	52,033,656	128,320,123
$\bar{x}$	**55,182,022**	**11,023,344**	**16,932,399**	**28,385,541**	**33,275,840**	**14,462,317**	**47,735,010**	**124,181,161**

[2] See Edwards et al. (2012) for details on derivation of DED estimation

Natural flooding in Arkansas supplies energy through cropland and forested wetlands (**Table 3**). The most energy is provided through forested wetlands and rice (80%; **Figure 1**), and these account for the most acreage in addition to soybeans (**Figure 2**).

Table 3. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type through natural flooding in the state of Arkansas (from satellite scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[3]

Natural Flood	Average DEDs	Average Acres
Cropland		
Corn	2,849,376 ± 889,572	5,647
Millet	576 ± 576	0.1
Milo	1,240,687 ± 326,505	2,586
Rice	14,032,008 ± 3,699,716	101,855
Soybeans	4,953,049 ± 1,339,244	135,943
Forested Wetland	23,303,438 ± 5,879,327	373,793

[3] See Edwards et al. (2012) for details

Figure 1. Duck Energy Day provision, prior to decomposition, for each habitat type through natural flooding in the state of Arkansas.

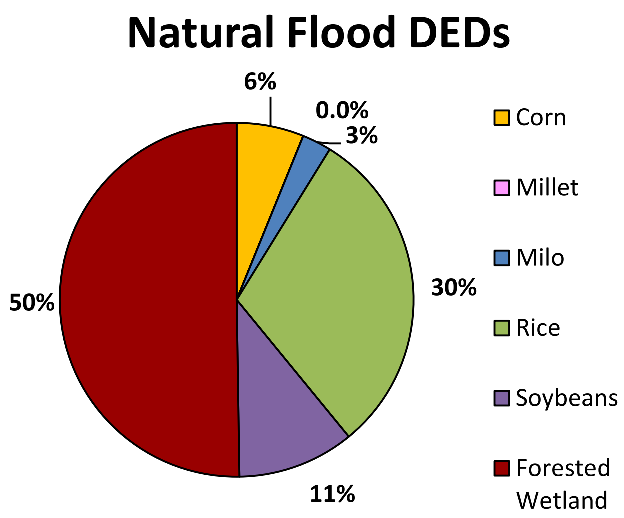
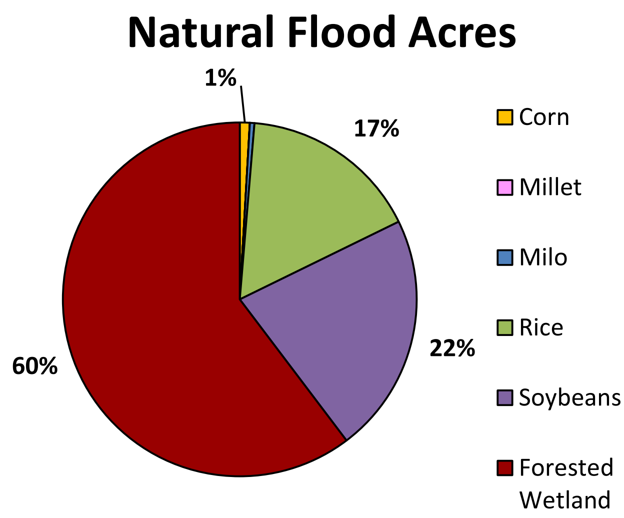


Figure 2. Proportion of acres provided through natural flooding by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



PRIVATE LAND ENERGY SUPPLY

Private lands in Arkansas supply energy through cropland, the Wetland Reserve Program (WRP), and forested wetlands (**Table 4**). The most energy is provided through milo and rice (59%; **Figure 3**), although a significant proportion of acres are soybeans (**Figure 4**).

Table 4. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type on private managed lands in the state of Arkansas (from satellite scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[4]

Private Managed	Average DEDs	Average Acres
Managed Out of Program (MOP)		
Cropland		
Corn	1,960,283 ± 278,631	3,885
Millet	1,728 ± 1,199	0.4
Milo	7,508,717 ± 7,179,441	15,648
Rice	8,861,086 ± 2,022,255	64,320
Soybeans	2,756,427 ± 343,812	75,654
Forested Wetland	374,210 ± 70,493	6,002
Managed In Program (MIP)		
Cropland		
Corn	367,825 ± 60,141	729
Millet	576 ± 576	0.3
Milo	79,572 ± 9,828	166
Rice	2,946,314 ± 356,745	21,387
Soybeans	703,114 ± 79,943	19,297
WRP	6,180,388 ± 1,515,570	32,923
Forested Wetland	954,726 ± 127,406	15,314

[4] See Edwards et al. (2012) for details

Figure 3. Duck Energy Day provision, prior to decomposition, for each habitat type on private managed lands in the state of Arkansas.

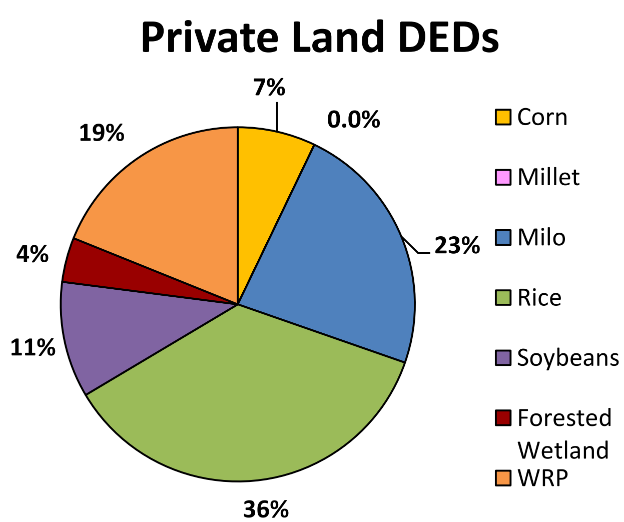
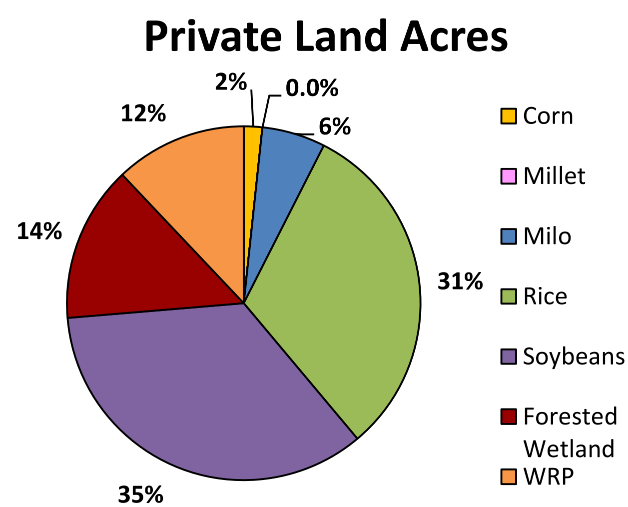


Figure 4. Proportion of acres provided on private land by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



Habitat type influences the amount of energy available and the variability in energy that public partners provide among years (**Table 5**). In general, Arkansas Game and Fish Commission (AGFC) lands provide most energy through forested wetlands and moist-soil wetlands (**Figure 5**) and U.S. Fish and Wildlife Service (USFWS) refuges provide most energy through cropland and moist-soil wetlands (**Figure 6**) in water-managed units.

Table 5. Duck Energy Day provision, prior to decomposition, for each habitat type on public managed lands in the state of Arkansas based on input into the Water Management Unit Database (WMU). [5]

Public Managed Lands	2011/12	2012/13	2013/14	3-year Average
State (AGFC)				
Cropland				
Rice	1,140,088	2,147,770	2,147,770	1,811,876 (± 335,894)
Moist-soil Wetland	5,967,101	5,846,747	6,314,533	6,042,794 (± 140,241)
Forested Wetland	8,153,455	8,218,596	7,981,018	8,117,690 (± 84,467)
Federal (USFWS)				
Cropland				
Corn	466,290	2,991,860	994,819	1,484,323 (± 769,055)
Millet	3,547,574	3,106,254	3,212,062	3,288,630 (± 133,026)
Milo	10,068,611	11,170,519	12,778,972	11,339,368 (± 786,955)
Rice	6,099,339	16,090,123	16,445,943	12,878,469 (± 3,391,121)
Soybeans	454,267	171,788	18,736	214,930 (± 127,564)
Moist-soil Wetland	8,588,852	5,778,681	7,461,852	7,276,462 (± 816,505)
Forested Wetland	1,647,035	1,875,577	1,875,577	1,779,397 (± 76,900)

[5] See Edwards et al. (2012) for details

Figure 5. Proportion of (a) energy (DEDs) and (b) acres provided on state lands by cover type based on a three-year average of WMU data.

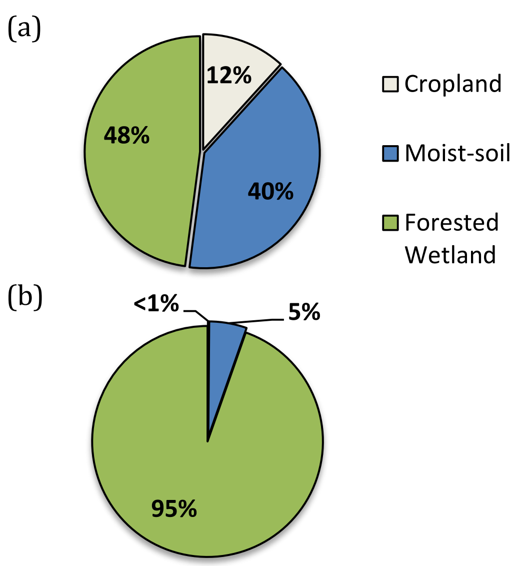
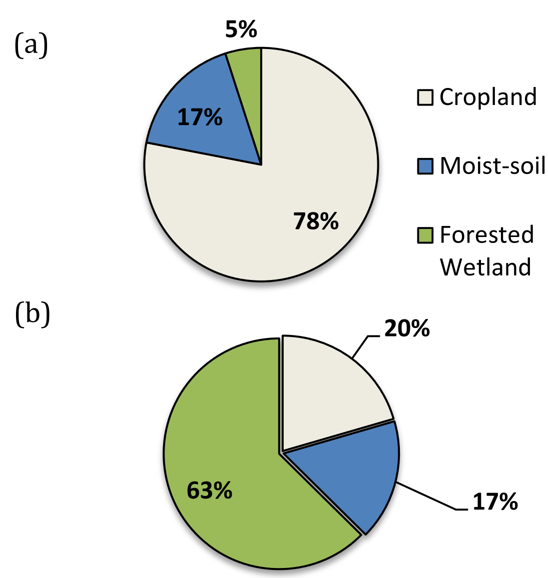


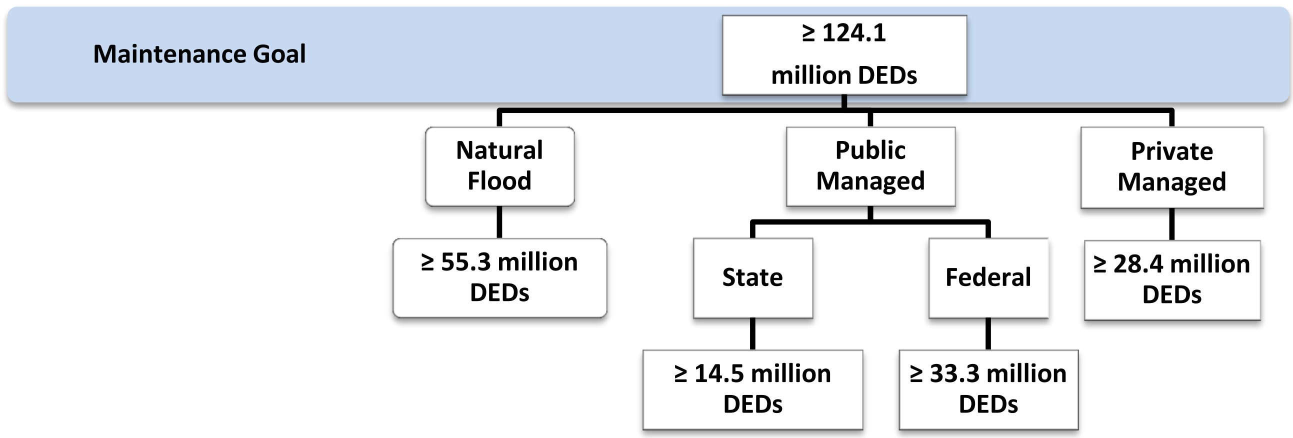
Figure 6. Proportion of (a) energy (DEDs) and (b) acres provided on federal lands by cover type based on a three-year average of WMU data.



WATERFOWL HABITAT CONSERVATION GOALS

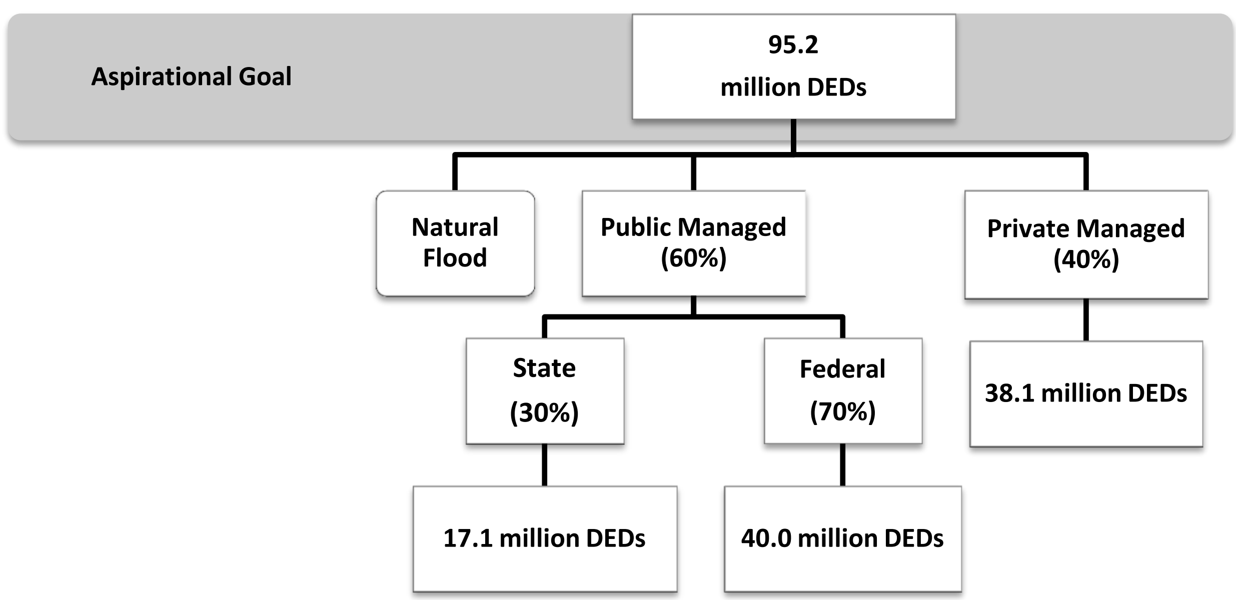
MAINTENANCE GOAL

It is imperative that Arkansas partners, at minimum, maintain current DED production. A **maintenance goal** is set based on the 3-year average at a minimum of 124.1 million DEDs on private and public lands.



ASPRIATIONAL GOAL

Because Arkansas is below its target objective for providing DEDs, an aspirational goal is set at **providing an additional 95.2 million DEDs** across private and public lands to meet the state-level NAWMP objective of 214.1 million DEDs. This aspirational goal will be met through a combination of land acquisition, habitat enhancement and/or restoration on public land, and conservation opportunities on private land through cooperative and coordinated efforts among state, federal, and private partners. The aspirational goal DED targets by ownership are established based on the current distribution of DED provision in the same ownership classes (see above).



IMPLICATIONS OF BIOENERGETIC MODEL RESULTS

Based on discussions at state-level meetings, partners considered what the model results, which demonstrate Arkansas is below objective, meant to waterfowl management efforts and achieving maintenance and aspirational goals in their state.

1) Arkansas' large DED shortfall relative to the NAWMP objective likely is partially a function of the large number of waterfowl wintering in the state and the reduction over time in the DEDs per acre on extensive harvested rice fields.
2) The DED contribution from public lands managed by the USFWS and AGFC approaches, on average, DED contribution from extensive naturally flooded lands, highlighting the key role the public conservation estate has played and should continue to play in regional and, by extension, continental waterfowl conservation.
3) Maintaining DED production and providing adequate staff and funding for other habitat management is important to providing high quality waterfowl habitat in Arkansas.
4) The effect of the USFWS policy to stop genetically modified crop production on National Wildlife Refuges in unknown. The impacts to Duck Energy Day production may not be realized for a number of years. Certain crops, such as rice and milo, are grown with non-Genetically Modified Crop (GMC) seed; these crops may need to be rotated with other crops that are difficult to grow from non-GMC seed, such as soybeans.
5) The contribution of private lands to DED provision is likely underestimated in our bioenergetic model. Improvements in our understanding of unharvested crops or moist-soil wetlands provided for waterfowl on private land could greatly change the DEDs estimated as available to waterfowl in Arkansas.
6) Inadequate management on WRP lands and a lack of infrastructure affect the ability to provide high quality waterfowl habitat. Portions of many non-reforestation sites on WRP tracts in Arkansas are proceeding through succession, and there is potential to improve the foraging value of these areas for waterfowl through a shift from passive to active management. Outreach efforts to inform WRP landowners of and assist with opportunities to improve moist-soil management may be beneficial to increasing DED contribution of these important private lands.
7) The importance of sanctuary and other habitats should not be undervalued when considering overall duck energy needs. Although scrub-shrub wetlands and green tree reservoirs may not provide high energetic value, as compared to other habitats, they have great importance as thermal cover for waterfowl during winter when other habitats may freeze, and aid in dispersal from competition to assist in strengthening pair bonds.
8) Late-winter, pre-spring-migration habitats for waterfowl are likely undervalued. Spring staging habitats include moist-soil, shrub/scrub, and forested wetlands that provide invertebrate biomass. Thus, exploring planning in terms of multiple winter periods (early, mid, and late) may be especially useful. Furthermore, natural flooding is more likely in the spring and may account for a flush of energy provided in Arkansas

habitats, particularly WRP lands. This may not be captured adequately in the current mid-winter satellite scenes.

POTENTIAL STRATEGIES AND SCENARIOS

Partners identified three overarching conservation approaches that could be used to achieve aspirational goals for wintering waterfowl. These approaches include acquisition of additional habitat, restoration of existing habitats, and enhancement of current habitats (Table 6). Addressing aspirational goals through these approaches will require some form of monitoring-- either quantifying seed yields of enhanced habitats or additional acres and cover types added to the current conservation estate. The specific strategies provided as examples are intended to provoke thought regarding various management actions and subsequent tradeoffs and are not intended to be prescriptions for how DEDs should be addressed on a parcel of land. In addition, certain actions would take time to develop and realize DED production (e.g., increasing red oak composition), but nonetheless the action could still be worthy of pursuit. The fact that the waterfowl-habitat values of some actions may not immediately accrue (e.g., in 1-2 years), does not discount the activity's ultimate value. Wildlife – including waterfowl – management has always relied on slow but steady progress to achieve cumulative success.

Acquisition includes the fee title purchase of land or the protection of additional land through conservation easements. Table 6 demonstrates hypothetical strategies and the equivalent acres in various habitat types (if left managed as those initial habitat types) that could be used to meet an aspirational goal of 95.2 million DEDs. It is important to note that acquisition values in this context assume a complete net gain in DEDs; however, many acres within the MAV potentially available for acquisition likely already provide some level of foraging habitat.

Restoration includes reestablishing missing habitats or natural processes where they historically existed with a goal to mimic the original wetland functions and values of a site. Restoration also includes creating habitats with important waterfowl habitat functions, although in areas where they may not have previously existed. Table 6 demonstrates hypothetical restoration strategies and the equivalent change in DEDs given the same amount of acres with a focus on the restoration of existing agricultural land to forested wetland and moist-soil wetlands.

Enhancement includes activities to improve food production on public lands and private lands through improving the quality of waterfowl habitat currently or promoting more waterfowl-friendly agricultural practices. Enhancement could include changes to site design, management, or water-control capabilities that would improve flooding and water holding capacity, crop rotation practices, etc. Incentives to inrcrease production of ratoon rice would be an example of a practical approach to encouraging a waterfowl-friendly agricultural practice. Table 6 demonstrates hypothetical enhancement strategies given current calculated acreages on public and private lands and the equivalent change in energy production.

Table 6. Example strategies to address the aspirational goal for waterfowl management, including acre or DED equivalents where appropriate. These strategies are intended to provoke thought regarding various management actions and subsequent tradeoffs and are not intended to be prescriptions for how DEDs should be addressed on a parcel of land. Acquisition simply lists the equivalent acres in various habitat types providing equal DEDs (95.2 million). Restoration represents the equivalent change in DEDs from one habitat type to another given the same amount of acres. Enhancement represents the equivalent change in energy production if certain practices are enhanced on current calculated acreages on public and private lands.

Acquisition Strategy	Acres	DED value/acre	Total DEDs	
Of **harvested soybean**	2,644,444	36	95.2 million	
Of **forested wetland (30% red oak)**	873,394	109	95.2 million	
Of **harvested rice**	689,855	138	95.2 million	
Of **WRP (20% red oak & 270 kg/ha)**	507,138	61 & 765	95.2 million	
Of **moist-soil wetland (600 kg/ha)**	50,963	1,868	95.2 million	
Of **unharvested millet**	18,927	5,203	95.2 million	
Of **unharvested rice**	3,995	23,833	95.2 million	
Of **unharvested corn**	3,330	28,591	95.2 million	
Restoration Strategy	**Acres[1]**	**DED value/acre**	**Total DEDs**	**Change in DEDs**
From **harvested soybean**	94,951	36	3,418,236	
To **forested wetland (30% red oak)**		109	10,349,659	+ 6,931,423
To **moist-soil wetland (600 kg/ha)**		1,868	177,368,468	+173,950,232
From **harvested rice**	85,617	138	11,815,146	
To **forested wetland (30% red oak)**		109	9,332,253	-2,482,893
To **moist-soil wetland (600 kg/ha)**		1,868	159,932,556	+ 148,117,410
From **harvested corn**	4,614	505	2,330,070	
To **forested wetland (30% red oak)**		109	502,926	-1,827,144
To **moist-soil wetland (600 kg/ha)**		1,868	8,618,952	+ 6,288,882
Enhancement Strategy	**Acres**	**DED value/acre**	**Total DEDs**	**Change in DEDs**
Of **forested wetland (30% red oak)[2]**	72,760	109	7,930,840	
To **40% red oak**		156	11,350,560	+ 3,419,720
Of **moist-soil wetland (600 kg/ha)[3]**	7,136	1,868	13,330,048	
To **moist-soil wetland (750 kg/ha)**		2,377	16,962,272	+3,632,224
To **moist-soil wetland (1,000 kg/ha)**		3,226	23,020,736	+9,690,688
Of **cooperatively farmed rice (80:20)[4]**	2,049	138/23,833	9,992,973	

***To* cooperatively farmed rice (75:25)**			12,420,525	+2,427,552
***To* cooperatively farmed rice (70:30)**			14,848,079	+4,855,106
***Of* harvested rice[5]**	85,617	138	11,815,146	
***To* 10% acreage ratoon rice (395 kg/ha)**		138 & 1,585	24,203,925	+ 12,388,779
***To* 20% acreage ratoon rice (395 kg/ha)**		138 & 1,585	36,592,705	+ 24,777,559
***Of* WRP (270 kg/ha & 20% red oak)[6]**	32,923	765 & 61	6,180,388	
***To* WRP (600 kg/ha & 20% red oak)**		1,868 & 61	12,716,837	+ 6,536,449
***To* WRP (750 kg/ha & 20% red oak)**		2,456 & 61	16,201,408	+ 10,021,020

[1] Acres represent average private land acres of respective crop types in MIP and MOP from Table 4. All crop acres on private land were assumed harvested in bioenergetic model.

[2] Acres represent average public land acres of forested wetland in state and federal ownership from Table 5. DED value of red oak varies based on what managers select in WMU database for percent red oak of a unit, so values may differ from DEDs in Table 5. This scenario assumes an initial 30% red oak across all public land forested units, with that percentage of red oak increased 10%.

[3] Acres represent average public land acres of moist-soil wetlands in state and federal ownership from Table 5. Soil type, timing of water, seed availability, stage of succession and weather can all play a role in determining moist-soil species composition and ultimately the yields produced. Because these various factors can influence year to year variability in moist-soil seed production there is no "cook book" to managing moist-soil wetlands, but qualitative and quantitative data do provide some insight into observed results from various forms of habitat manipulations. The *Moist-soil guidelines for the U.S. Fish and Wildlife Service Southeast Region* (Strader and Stinson 2005) and *Wetland Management for Waterfowl Handbook* (Nelms 2007) provide some general guidance toward management techniques that may improve moist-soil seed production. The assumed average of moist-soil seed production is 600 kg/ha; however, it is possible to increase seed production up to 1,000 kg/ha with active management such as rotation of moist-soil units with cover crops or proper drawdown periods on the right soil types.

[4] Acres represent average public land acres of rice in federal ownership. The ratios represent hypothetical splits of harvested:unharvested crops that may be formulated through cooperative farming agreements. Leaving a greater unharvested share would increase DED production. These do not necessarily represent current standards as individual refuges will have different arrangements for cooperative agreements.

[5] Acres represent private land acres of rice in MIP and MOP from Table 4. All crop acres on private land were assumed harvested in bioenergetic model. Ratoon crops are volunteer crops from a harvested field. Ratoon values were taken from Petrie et al. (2014).

[6] Acres represent private land acres of WRP as calculated for MIP from Table 4. WRP acres were assumed to be 82% bottomland hardwood with a 20% red oak DED value (61 DED/ac) and 18% moist-soil with a minimal moist-soil wetland value (272 kg/ha or 765 DED/ac). In our model, WRP was given a very low value for moist-soil seed production, assuming that the wetlands were not actively managed. Improving moist-soil wetland management through rotation, discing, or other practices could potentially increase seed yields.

MAV Waterfowl Planning

Kentucky

Summary

According to stepped-down North American Waterfowl Management Plan (NAWMP) goals, the state of Kentucky should provide 1% of the Mississippi Alluvial Valley (MAV) objective of 469,337,220 Duck Energy Days (DEDs). This represents a state-level NAWMP objective (energy demand) of 4.7 million DEDs. Based on contributions from three sources—natural flooding, private managed lands, and public managed lands—Kentucky currently supplies 6.9-9.1 million DEDs.

ENERGY DEMAND: **4.7 MILLION DEDS**

Kentucky has a state-level NAWMP objective of 4.7 million DEDs based on a 110-day wintering period from early November to late February. One DED represents the energy needed to support one average-sized duck requiring 294.35 kcal/day for one day.

Table 1. Population and Duck Energy Day objectives for Kentucky relative to the MAV.[1]

Geography	Dabbler Population Objective	Wood Duck Population Objective	Total Duck Population Objective	Total Duck DED Objective	Goose Competition DEDs	Total DED Objective
Kentucky	15,073	6,710	21,783	2,391,180	2,312,640	4,708,843
MAV Total	2,942,389	943,410	3,885,799	427,437,890	41,899,001	469,336,891

[1] See Reinecke & Loesch 1996 and LMVJV 2007

ENERGY SUPPLY: **6.9 – 8.1 MILLION DEDS ($\bar{x}$ = 8.3 ± 0.6 MILLION)**

Based on the most current three-year mean, 8.3 million DEDs are estimated as supplied throughout Kentucky from natural flood (3%), private managed (5%), and public managed lands (92%; **Table 2**). After accounting for natural flooding, the remaining energy is distributed as 5% on private managed land (Managed In Program (MIP); Managed Out of Program (MOP)) and 95% on public managed land. Of public managed land, 21% of energy is provided through federal partners and 79% through state partners (**Table 2**).

Table 2. Duck Energy Days estimated on the landscape in Kentucky through an energy-based model that (1) accounts for decomposition/disturbance across all three habitat sources; (2) uses Monte Carlo simulation to generate hypothetical winters based on flood frequency and determine DED values reached or exceeded 80% of the time for natural flood and private managed land; and (3) uses annual data entered into the Water Management Unit database for public managed land wherein units are assumed at full pool capacity and are not linked to flood frequency.[2]

	Natural Flood	Private Managed			Public Managed			
		MIP	MOP	Subtotal	Federal	State	Subtotal	Total
2011-12	227,881	302,513	39,785	375,434	729,630	5,489,684	6,217,031	6,853,691
2012-13	227,881	302,513	39,785	375,434	1,128,632	7,325,284	8,450,384	9,115,368
2013-14	227,881	302,513	39,785	375,434	2,394,976	5,231,897	7,619,378	8,220,651
$\bar{x}$	**227,881**	**302,513**	**39,785**	**375,434**	**1,622,457**	**6,015,622**	**7,633,001**	**8,264,699**

[2] See Edwards et al. (2012) for details on derivation of DED estimation

NATURAL FLOOD ENERGY SUPPLY

Natural flooding in Kentucky supplies energy through cropland and forested wetlands (**Table 3**). The most energy is provided through forested wetlands and soybeans (93%; **Figure 1**), and these account for the most acreage (**Figure 2**).

Table 3. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type through natural flooding in the state of Kentucky (from satellite scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[3]

Natural Flood	Average DEDs	Average Acres
Cropland		
Corn	4,301 ± 1,541	9
Millet	0	0
Milo	0	0
Rice	0	0
Soybeans	12,128 ± 3,269	333
Forested Wetland	48,876 ± 9,907	784

[3] See Edwards et al. (2012) for details

Figure 1. Duck Energy Day provision, prior to decomposition, for each habitat type through natural flooding in the state of Kentucky.

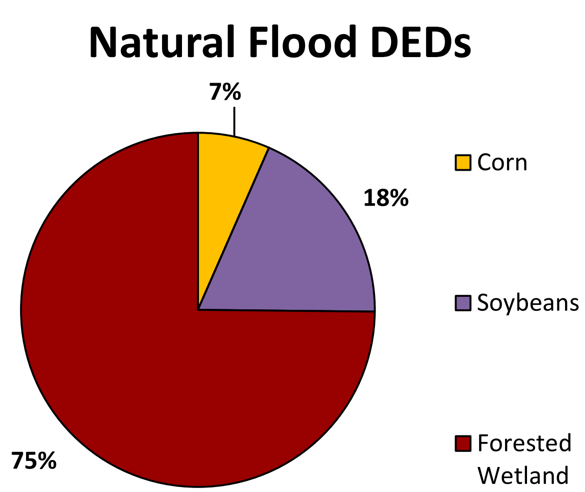
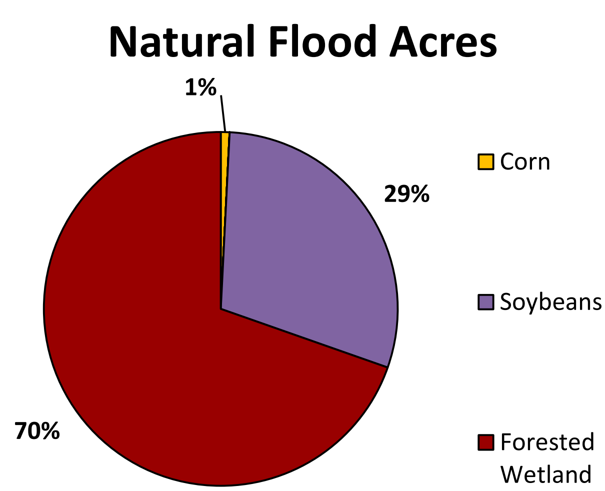


Figure 2. Proportion of acres provided through natural flooding by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



Private lands in Kentucky supply energy through cropland, the Wetland Reserve Program (WRP), and forested wetlands (**Table 4**). The most energy is provided through WRP and corn (79%; **Figure 3**), although a significant proportion of acres are soybeans (**Figure 4**).

Table 4. Average Duck Energy Day provision (prior to decomposition by watershed and Monte Carlo simulation) and acreage for each habitat type on private managed lands in the state of Kentucky (scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[4]

Private Managed	Average DEDs	Average Acres
Managed Out of Program (MOP)		
Cropland		
Corn	22,455 ± 4,731	44
Millet	0	0
Milo	0	0
Rice	0	0
Soybeans	21,465 ± 7,010	589
Forested Wetland	3,513 ± 694	56
Managed In Program (MIP)		
Cropland		
Corn	12,568 ± 4,850	25
Millet	0	0
Milo	0	0
Rice	0	0
Soybeans	2,779 ± 833	76
WRP	70,517 ± 25,442	376
Forested Wetland	973 ± 157	15

Figure 3. Duck Energy Day provision, prior to decomposition, for each habitat type on private managed lands in the state of Kentucky.

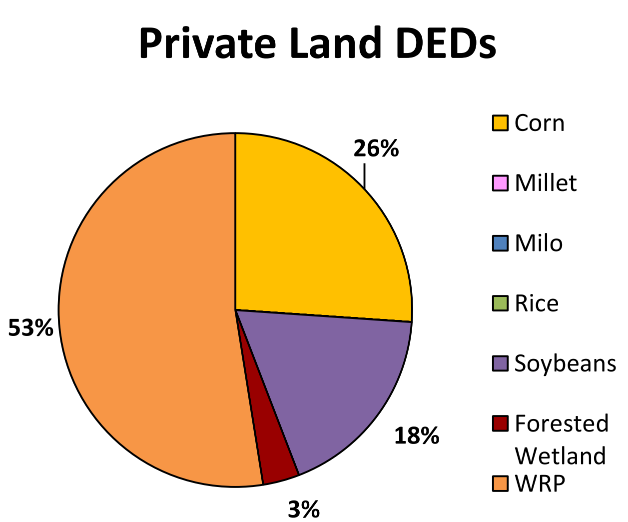
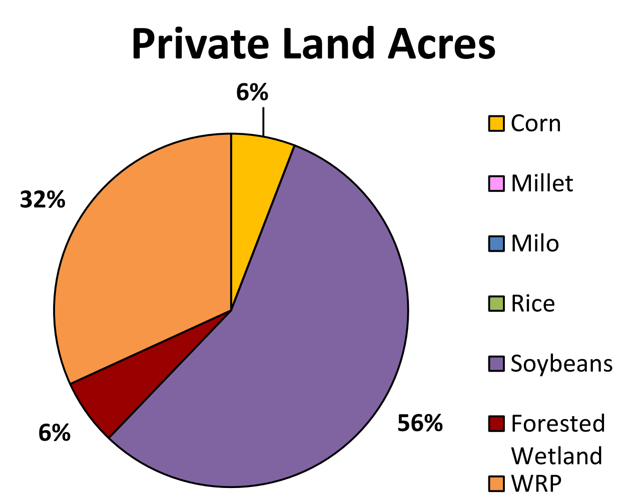


Figure 4. Proportion of acres provided on private land by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



Habitat type influences the amount of energy available and the variability in energy that public partners provide among years (**Table 5**). In general, Kentucky Department of Fish and Wildlife Resources (KDFWR) lands provide most energy through cropland although a significant number of acres are moist-soil wetlands (**Figure 5**) and U.S. Fish and Wildlife Service (USFWS) refuges provide most energy through cropland, although a significant number of acres are moist-soil wetlands (**Figure 6**) in water-managed units.

Table 5. Duck Energy Day provision, prior to decomposition, for each habitat type on public managed lands in the state of Kentucky based on input into the Water Management Unit Database (WMU).[4]

Public Managed Lands	2011/12	2012/13	2013/14	3-year Average
State (KDFWR)				
Cropland				
Corn	5,857,343	8,163,569	5,087,171	6,369,361 (± 924,244)
Millet	46,141	58,879	0	35,007 (± 17,885)
Milo	228,384	391,496	263,015	294,298 (± 49,616)
Soybean	17,324	3,341	2,287	7,651 (± 4,846)
Moist-soil Wetland	1,026,717	943,378	1,495,711	1,155,269 (± 171,913)
Federal (USFWS)				
Cropland				
Corn	524,321	1,029,324	2,532,423	1,362,023 (± 603,085)
Soybeans	1,831	1,831	0	1,220 (± 610)
Moist-soil Wetland	336,979	303,985	300,762	313,909 (± 11,573)

[4] See Edwards et al. (2012) for details

Figure 5. Proportion of (a) energy (DEDs) and (b) acres provided on state lands by cover type based on a three-year average of WMU data.

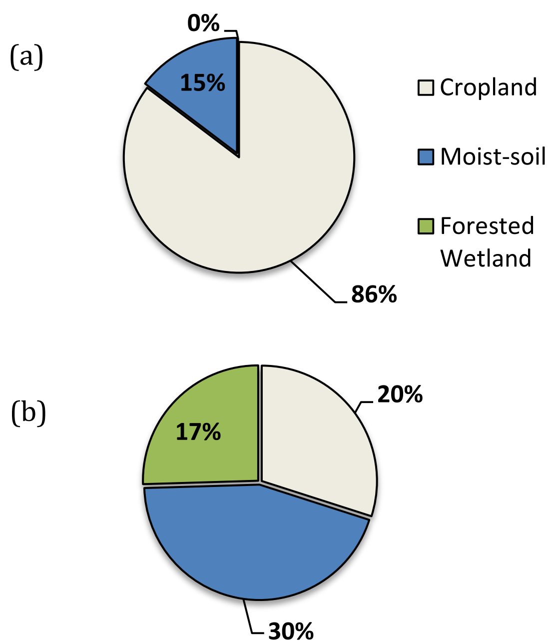
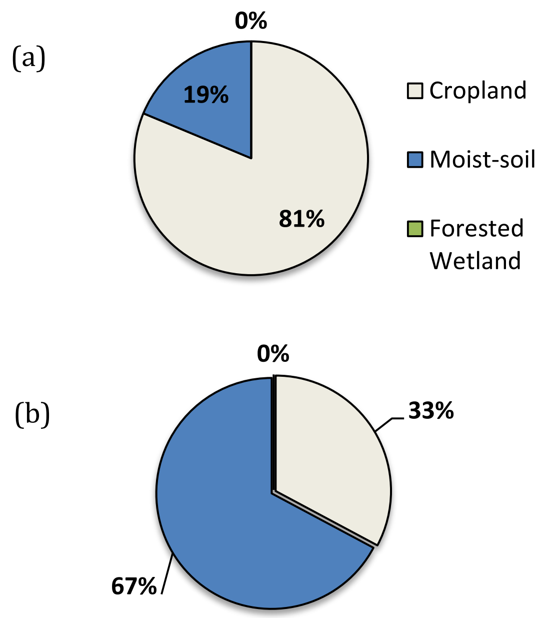
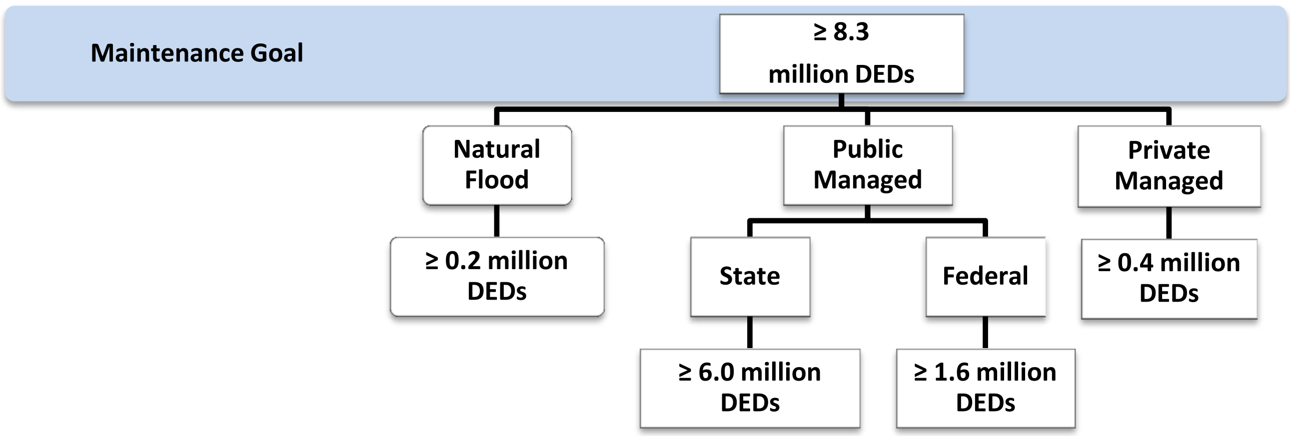


Figure 6. Proportion of (a) energy (DEDs) and (b) acres provided on federal lands by cover type based on a three-year average of WMU data.



MAINTENANCE GOAL

Because Kentucky is above its target objective for providing DEDs, whereas the MAV as a whole remains below objective, it is imperative that partners, at minimum, maintain current DED production. A **maintenance goal** is set based on the 3-year average at a minimum of 8.3 million DEDs on private and public lands.



IMPLICATIONS OF BIOENERGETIC MODEL RESULTS

1) Providing adequate staff and funding capacity for habitat management to maintain DED production and other habitat functions is crucial to providing high quality waterfowl habitat in Kentucky.

MAV Waterfowl Planning

Louisiana

Summary

According to stepped-down North American Waterfowl Management Plan (NAWMP) goals, the state of Louisiana should provide 26% of the Mississippi Alluvial Valley (MAV) objective of 469,337,220 Duck Energy Days (DEDs). This represents a state-level NAWMP objective (energy demand) of 120.9 million DEDs. Based on contributions from three sources—natural flooding, private managed lands, and public managed lands—Louisiana currently supplies 63.0-71.3 million DEDs.

ENERGY DEMAND: **120.9 MILLION DEDS**

Louisiana has a state-level NAWMP objective of 120,913,290 DEDs based on a 110-day wintering period from early November to late February. One DED represents the energy needed to support one average-sized duck requiring 294.35 kcal/day for one day.

Table 1. Population and Duck Energy Day objectives for Louisiana relative to the MAV.[1]

Geography	Dabbler Population Objective	Wood Duck Population Objective	Total Duck Population Objective	Total Duck DED Objective	Goose Competition DEDs	Total DED Objective
Louisiana	582,015	373,660	955,675	105,124,250	15,788,960	120,913,290
MAV Total	2,942,389	943,410	3,885,799	427,437,890	41,899,330	469,336,891

[1] See Reinecke & Loesch 1996 and LMVJV 2007

ENERGY SUPPLY: **63.0 – 71.3 MILLION DEDS ($\bar{x}$ = 67.5 ± 2.7 MILLION)**

Based on the most current three-year mean, 67.5 million DEDs are estimated as supplied throughout Louisiana from natural flood (20%), private managed (16%), and public managed lands (64%; **Table 2**). After accounting for natural flooding, the remaining energy is distributed as 26% on private managed land and 74% on public managed land. Of public managed land, 44% of energy is provided through federal partners and 56% through state partners (**Table 2**).

Table 2. Duck Energy Days estimated on the landscape in Louisiana through an energy-based model that (1) accounts for decomposition/disturbance across all three habitat sources; (2) uses Monte Carlo simulation to generate hypothetical winters based on flood frequency and determine DED values reached or exceeded 80% of the time for natural flood and private managed land; and (3) uses annual data entered into the Water Management Unit database for public managed land wherein units are assumed at full pool capacity and are not linked to flood frequency.[2]

	Natural Flood	**Private Managed**			**Public Managed**			
		MIP	**MOP**	**Subtotal**	**Federal**	**State**	**Subtotal**	**Total**
2011-12	13,177,050	5,838,309	5,284,545	11,076,196	21,484,651	24,008,673	46,140,424	71,312,411
2012-13	13,177,050	5,838,309	5,284,545	11,076,196	17,380,817	19,884,870	37,619,173	63,013,100
2013-14	13,177,050	5,838,309	5,284,545	11,076,196	16,219,976	26,506,274	43,016,876	68,183,419
$\bar{x}$	**13,177,050**	**5,838,309**	**5,284,545**	**11,076,196**	**18,361,815**	**23,466,597**	**42,258,824**	**67,502,977**

[2] See Edwards et al. (2012) for details on derivation of DED estimation

Natural flooding in Louisiana supplies energy through cropland and forested wetlands (**Table 3**). The most energy is provided through forested wetlands and corn (82%; **Figure 1**), and forested wetlands account for the majority of acres (**Figure 2**).

Table 3. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type through natural flooding in the state of Louisiana (from satellite scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[3]

Natural Flood	Average DEDs	Average Acres
Cropland		
Corn	2,237,898 ± 718,345	4,435
Millet	576 ± 576	0.1
Milo	499,101 ± 150,277	1,040
Rice	927,406 ± 301,460	6,731
Soybeans	551,318 ± 159,272	15,132
Forested Wetland	6,829,465 ± 1,859,726	109,546

[3] See Edwards et al. (2012) for details

Figure 1. Duck Energy Day provision, prior to decomposition, for each habitat type through natural flooding in the state of Louisiana.

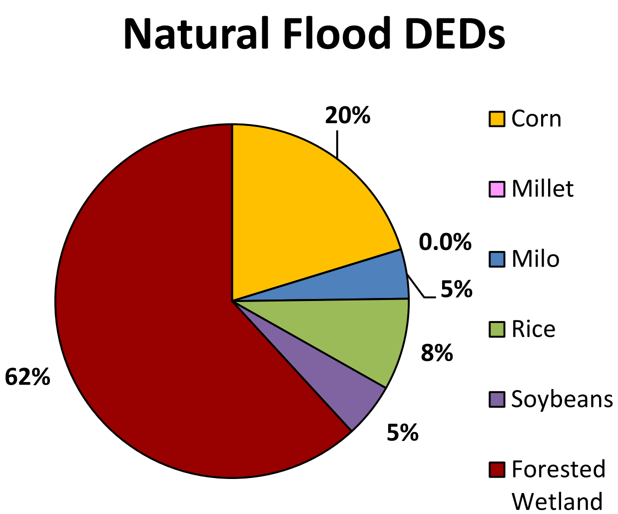
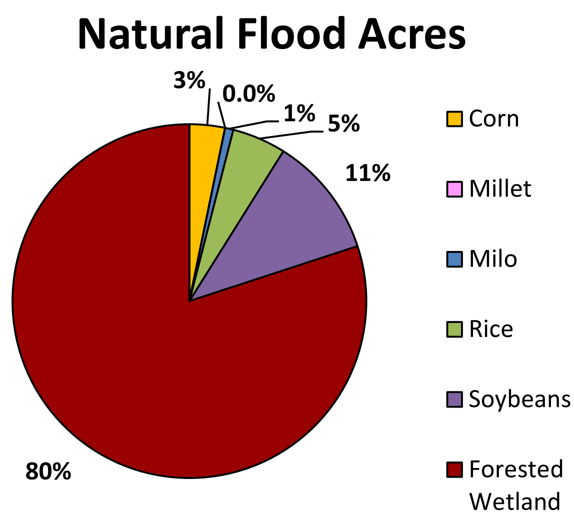


Figure 2. Proportion of acres provided through natural flooding by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



PRIVATE LAND ENERGY SUPPLY

Private lands in Louisiana supply energy through cropland, the Wetland Reserve Program (WRP), and forested wetlands (**Table 4**). The most energy is provided through WRP and rice (58%; **Figure 3**), although a significant proportion of acres are soybeans (**Figure 4**).

Table 4. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type on private managed lands in the state of Louisiana (from satellite scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[4]

Private Managed	Average DEDs	Average Acres
Managed Out of Program (MOP)		
Cropland		
Corn	1,734,617 ± 313,962	3,438
Millet	3,456 ± 2,841	1
Milo	1,305,439 ± 1,075,054	2,721
Rice	1,726,767 ± 575,514	12,535
Soybeans	532,281 ± 103,935	14,609
Forested Wetland	133,515 ± 34,806	2,142
Managed In Program (MIP)		
Cropland		
Corn	346,544 ± 50,541	687
Millet	0	0
Milo	8,233 ± 3,097	17
Rice	608,897 ± 88,898	4,420
Soybeans	158,559 ± 27,800	4,352
WRP	4,011,188 ± 812,028	21,368
Forested Wetland	381,926 ± 81,025	6,126

[4] See Edwards et al. (2012) for details

Figure 3. Duck Energy Day provision, prior to decomposition, for each habitat type on private managed lands in the state of Louisiana.

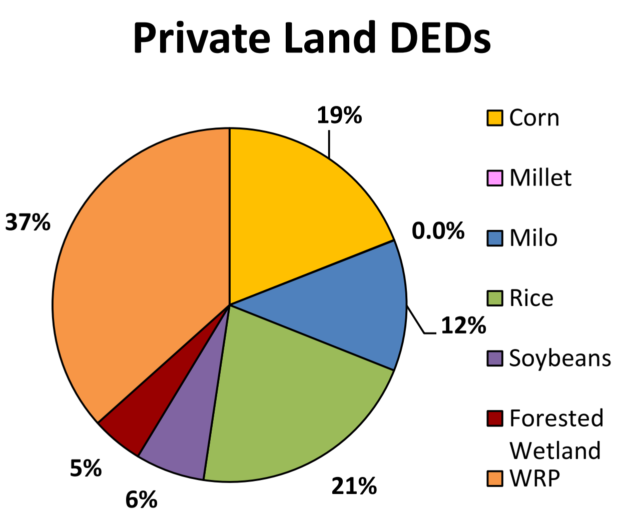
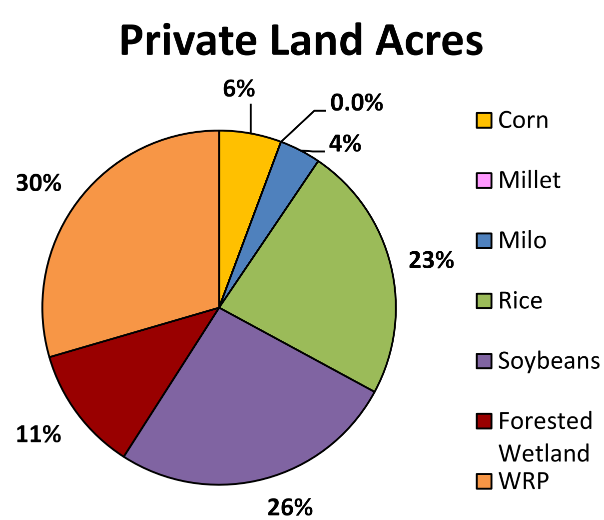


Figure 4. Proportion of acres provided on private land by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



Habitat type influences the amount of energy available and the variability in energy that public partners provide among years (**Table 5**). In general, Louisiana Department of Wildlife and Fisheries (LDWF) lands provide most energy through moist-soil wetlands (**Figure 5**) and U.S. Fish and Wildlife Service (USFWS) refuges provide most energy through cropland and moist-soil wetlands (**Figure 6**) in water-managed units.

Table 5. Duck Energy Day provision, prior to decomposition, for each habitat type on public managed lands in the state of Louisiana based on input into the Water Management Unit Database (WMU).[5]

Public Managed Lands	2011/12	2012/13	2013/14	3-year Average
State (LDWF)				
Cropland				
Milo	762,038	0	0	254,013 (± 254,013)
Soybean	31,218	228,801	228,801	162,940 (± 65,861)
Moist-soil Wetland	24,859,294	20,681,876	28,348,934	24,630,035 (± 2,216,255)
Forested Wetland	1,165,381	1,137,682	1,129,913	1,144,326 (± 11,823)
Federal (USFWS)				
Cropland				
Corn	520,382	520,382	0	346,921 (± 173,461)
Milo	18,853,571	15,109,553	14,428,349	16,130,491 (± 1,375,668)
Rice	48,261	46,779	45,607	46,882 (± 768)
Soybeans	1,051,806	18,784	18,784	363,125 (± 344,341)
Moist-soil Wetland	5,263,679	5,134,032	4,861,169	5,086,293 (± 118,621)
Forested Wetland	1,079,176	273,120	338,967	300,088 (± 23,211)

[5] See Edwards et al. (2012) for details

Figure 5. Proportion of (a) energy (DEDs) and (b) acres provided on state lands by cover type based on a three-year average of WMU data.

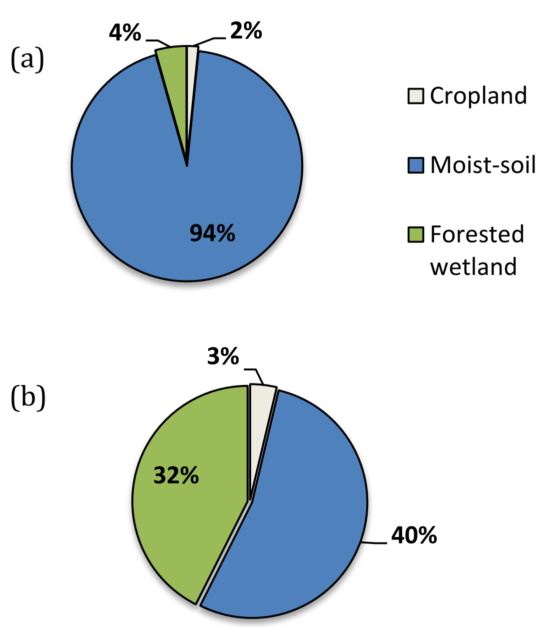
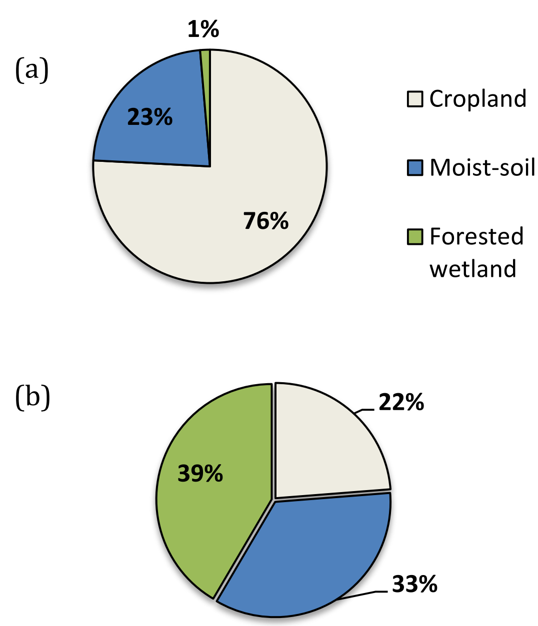


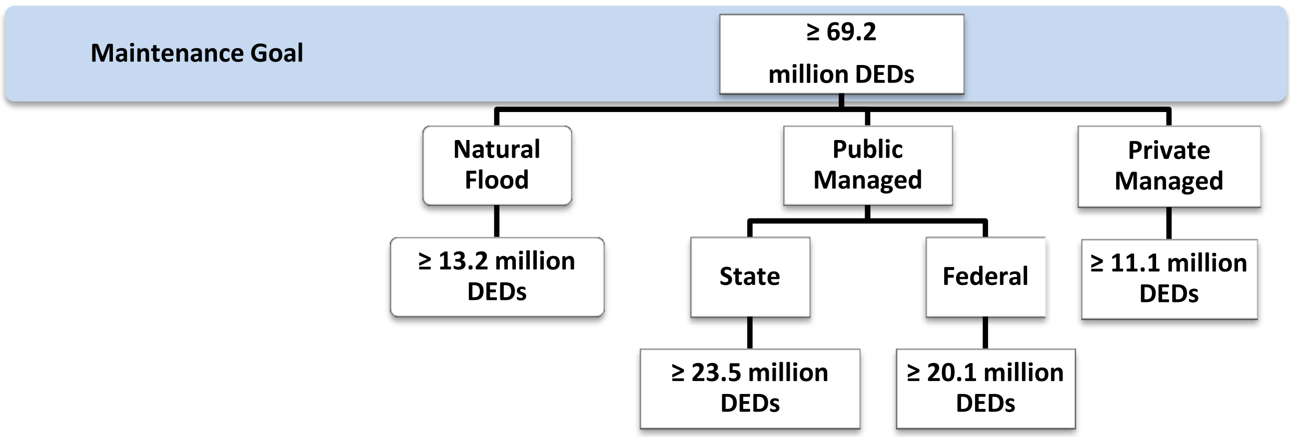
Figure 6. Proportion of (a) energy (DEDs) and (b) acres provided on federal lands by cover type based on a three-year average of WMU data.



WATERFOWL HABITAT CONSERVATION GOALS

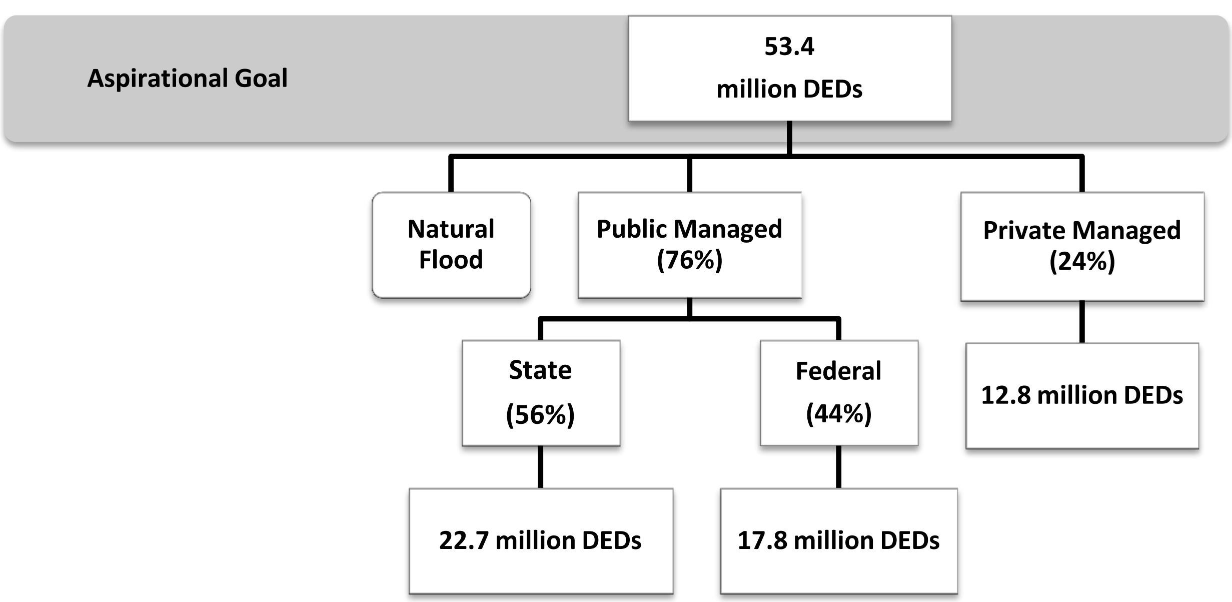
MAINTENANCE GOAL

It is imperative that Louisiana partners, at minimum, maintain current DED production. A **maintenance goal** is set based on the 3-year average at a minimum of 69.2 million DEDs on private and public lands.



ASPRIATIONAL GOAL

Because Louisiana is below its target objective for providing DEDs, an aspirational goal is set at **providing an additional 53.4 million DEDs** across private and public lands to meet the state-level NAWMP objective of 120.9 million DEDs. This aspirational goal will be met through a combination of land acquisition, habitat enhancement and/or restoration on public land, and conservation opportunities on private land through cooperative and coordinated efforts among state, federal, and private partners.   The aspirational goal DED targets by ownership are established based on the current distribution of DED provision in the same ownership classes (see above).



IMPLICATIONS OF BIOENERGETIC MODEL RESULTS

Based on discussions at state-level meetings, partners considered what the model results, which demonstrate Louisiana is below objective, meant to overall waterfowl management efforts and achieving maintenance and aspirational goals in their state.

1) LDWF needs to be able to improve the quality of habitat on land that they currently manage. A lack of staff and funding hinders the ability to improve habitat quality.

2) Restoration in Louisiana has placed emphasis on reforestation for the Louisiana Black Bear and Partners in Flight objectives. However, reforestation is not necessarily the best management technique to provide waterfowl food. At a minimum, partners should strive to be more strategic about reforestation, such as reforesting those areas that are difficult to manage as moist-soil wetlands.

3) Inadequate management on WRP lands and a lack of infrastructure affect the ability to provide high quality waterfowl habitat. Portions of many non-reforestation sites on WRP tracts in Louisiana are proceeding through succession, and there is potential to improve the foraging value of these areas for waterfowl through a shift from passive to active management. Outreach efforts to inform WRP landowners of and assist with opportunities to improve moist-soil management may be beneficial to increasing DED contribution of these important private lands. However, $3.84 million in WRP enhancements (mainly rehabilitation to set back succession), which amounted to 16,878 acres of existing habitat, were initiated by the MBHI for migratory birds and other wetland wildlife within Louisiana. This endeavor should have had significant improvements to waterfowl habitat and there is great potential for MBHI (and/or similar approaches) to contribute to MAV goals.

4) The contribution of private lands to DED provision is likely underestimated in our bioenergetic model. Improvements in our understanding of unharvested crops or moist-soil wetlands provided for waterfowl on private land could greatly change the DEDs estimated as available to waterfowl in Louisiana.

5) The effect of the USFWS policy to stop genetically modified crop production on National Wildlife Refuges is unknown. The impacts to Duck Energy Day production may not be realized for a number of years. Certain crops, such as rice and milo, are grown with non-GMC seed; however, these crops may need to be rotated with other crops that are difficult to grow from non-GMC seed, such as soybeans.

POTENTIAL STRATEGIES AND SCENARIOS

Partners identified three overarching conservation approaches that could be used to achieve aspirational goals for wintering waterfowl. These approaches include acquisition of additional habitat, restoration of existing habitats, and enhancement of current habitats (Table 6). Addressing aspirational goals through these approaches will require some form of monitoring-- either quantifying seed yields of enhanced habitats or additional acres and cover types added to the current conservation estate. The specific strategies provided as examples are intended to provoke thought regarding various management actions and subsequent tradeoffs and are not intended to be prescriptions for how DEDs should be addressed on a parcel of land. In addition, certain actions would take time to develop and realize DED production (e.g., increasing red oak composition), but nonetheless the action could still be worthy of pursuit. The fact that the waterfowl-habitat values of some actions may not immediately accrue (e.g., in 1-2 years), does not discount the activity's ultimate value. Wildlife – including waterfowl – management has always relied on slow but steady progress to achieve cumulative success.

Acquisition includes the fee title purchase of land or the protection of additional land through conservation easements. Table 6 demonstrates hypothetical strategies and the equivalent acres in various habitat types (if left managed as those initial habitat types) that could be used to meet an aspirational goal of 53.4 million DEDs. It is important to note that acquisition values in this context assume a complete net gain in DEDs; however, many acres within the MAV potentially available for acquisition likely already provide some level of foraging habitat.

Restoration includes reestablishing missing habitats or natural processes where they historically existed with a goal to mimic the original wetland functions and values of a site. Restoration also includes creating habitats with important waterfowl habitat functions, although in areas where they may not have previously existed. Table 6 demonstrates hypothetical restoration strategies and the equivalent change in DEDs given the same amount of acres with a focus on the restoration of existing agricultural land to forested wetland and moist-soil wetlands.

Enhancement includes activities to improve food production on public lands and private lands through improving the quality of waterfowl habitat currently or promoting more waterfowl-friendly agricultural practices. Enhancement could include changes to site design, management, or water-control capabilities that would improve flooding and water holding capacity, crop rotation practices, etc. Incentives to inrcrease production of ratoon rice would be an example of a practical approach to encouraging a waterfowl-friendly agricultural practice. Table 6 demonstrates hypothetical enhancement strategies given current calculated acreages on public and private lands and the equivalent change in energy production.

Table 6. Example strategies to address the aspirational goal for waterfowl management, including acre or DED equivalents where appropriate. These strategies are intended to provoke thought regarding various management actions and subsequent tradeoffs and are not intended to be prescriptions for how DEDs should be addressed on a parcel of land. Acquisition simply lists the equivalent acres in various habitat types providing equal DEDs (53.4 million). Restoration represents the equivalent change in DEDs from one habitat type to another given the same amount of acres. Enhancement represents the equivalent change in energy production if certain practices are enhanced on current calculated acreages on public and private lands.

Acquisition Strategy	Acres	DED value/acre	Total DEDs	
Of harvested soybean	1,483,333	36	53.4 million	
Of forested wetland (30%)	489,908	109	53.4 million	
Of harvested rice	386,957	138	53.4 million	
Of WRP (30% red oak & 270 kg/ha)	235,159	109 & 765	53.4 million	
Of moist-soil wetland (600 kg/ha)	28,587	1,868	53.4 million	
Of unharvested millet	10,263	5,203	53.4 million	
Of unharvested rice	2,241	23,833	53.4 million	
Of unharvested corn	1,868	28,591	53.4 million	
Restoration Strategy	**Acres[1]**	**DED value/acre**	**Total DEDs**	**Change in DEDs**
From harvested soybean	18,961	36	682,596	
To forested wetland (30% red oak)		109	2,066,749	+ 1,384,153
To moist-soil wetland (600 kg/ha)		1,868	35,419,148	+ 34,736,552
From harvested rice	16,955	138	2,339,790	
To forested wetland (30% red oak)		109	1,848,095	- 491,695
To moist-soil wetland (600 kg/ha)		1,868	31,671,940	+ 29,332,150
From harvested corn	4,125	505	2,083,125	
To forested wetland (30% red oak)		109	449,625	-1,633,500
To moist-soil wetland (600 kg/ha)		1,868	7,705,500	+5,622,375
Enhancement Strategy	**Acres**	**DED value/acre**	**Total DEDs**	**Change in DEDs**
Of forested wetland (30% red oak)[2]	13,727	109	1,496,243	
To 40% red oak		156	2,141,412	+ 645,169
Of moist-soil wetland (600 kg/ha)[3]	15,919	1,868	29,736,692	
To moist-soil wetland (750 kg/ha)		2,377	37,842,510	+8,105,818
To moist-soil wetland (1,000 kg/ha)		3,226	51,357,692	+21,621,000
Of cooperatively farmed rice (80:20)[4]	340	138/23,833	1,658,180	
To cooperatively farmed rice (75:25)			2,060,995	+402,815

To **cooperatively farmed rice (70:30)**			2,463,810	+805,630
Of **harvested rice[5]**	16,955	138	2,335,664	
To 10% acreage **ratoon rice (395 kg/ha)**		138 & 1,585	4,793,179	+ 2,453,389
To 20% acreage **ratoon rice (395 kg/ha)**		138 & 1,585	7,246,567	+ 4,906,777
Of **WRP (270 kg/ha & 30% red oak)[6]**	21,368	765 & 109	4,852,245	
To **WRP (600 kg/ha & 30% red oak)**		1,868 & 109	9,094,648	+ 4,242,403
To **WRP (750 kg/ha & 30% red oak)**		2,456 & 109	11,356,237	+ 6,503,992

[1] Acres represent average private land acres of respective crop types in MIP and MOP from Table 4. All crop acres on private land were assumed harvested in bioenergetic model.

[2] Acres represent average public land acres of forested wetland in state and federal ownership from Table 5. DED value of red oak varies based on what managers select in WMU database for percent red oak of a unit, so values may differ from DEDs in Table 5. This scenario assumes an initial 30% red oak across all public land forested units, with that percentage of red oak increased 10%.

[3] Acres represent average public land acres of moist-soil wetlands in state and federal ownership from Table 5. Soil type, timing of water, seed availability, stage of succession and weather can all play a role in determining moist-soil species composition and ultimately the yields produced. Because these various factors can influence year to year variability in moist-soil seed production there is no "cook book" to managing moist-soil wetlands, but qualitative and quantitative data do provide some insight into observed results from various forms of habitat manipulations. The *Moist-soil guidelines for the U.S. Fish and Wildlife Service Southeast Region* (Strader and Stinson 2005) and *Wetland Management for Waterfowl Handbook* (Nelms 2007) provide some general guidance toward management techniques that may improve moist-soil seed production. The assumed average of moist-soil seed production is 600 kg/ha; however, it is possible to increase seed production up to 1,000 kg/ha with active management such as rotation of moist-soil units with cover crops or proper drawdown periods on the right soil types.

[4] Acres represent average public land acres of rice in federal ownership. The ratios represent hypothetical splits of harvested:unharvested crops that may be formulated through cooperative farming agreements. Leaving a greater unharvested share would increase DED production. These do not necessarily represent current standards as individual refuges will have different arrangements for cooperative agreements.

[5] Acres represent private land acres of rice in MIP and MOP from Table 4. All crop acres on private land were assumed harvested in bioenergetic model. Ratoon crops are volunteer crops from a harvested field. Ratoon values were taken from Petrie et al. (2014).

[6] Acres represent private land acres of WRP as calculated for MIP from Table 4. In Louisiana, WRP acres were assumed to be 82% bottomland hardwood with a 30% red oak DED value (109 DED/ac) and 18% moist-soil with a minimal moist-soil wetland value (272 kg/ha or 765 DED/ac). In our model, WRP was given a very low value for moist-soil seed production, assuming that the wetlands were not actively managed. Improving moist-soil wetland management through rotation, discing, or other practices could potentially increase seed yields.

MAV Waterfowl Planning

Mississippi

Summary

According to stepped-down North American Waterfowl Management Plan (NAWMP) goals, the state of Mississippi should provide 15% of the Mississippi Alluvial Valley (MAV) objective of 469,337,220 Duck Energy Days (DEDs). This represents a state-level NAWMP objective (energy demand) of 72.6 million DEDs. Based on contributions from three sources—natural flooding, private managed lands, and public managed lands—Mississippi currently supplies 64.7-75.4 million DEDs.

ENERGY DEMAND: **72.6 MILLION DEDS**

Mississippi has a state-level NAWMP objective of 72.6 million DEDs based on a 110-day wintering period from early November to late February. One DED represents the energy needed to support one average-sized duck requiring 294.35 kcal/day for one day.

Table 1. Population and Duck Energy Day objectives for Mississippi relative to the MAV.[1]

Geography	Dabbler Population Objective	Wood Duck Population Objective	Total Duck Population Objective	Total Duck DED Objective	Goose Competition DEDs	Total DED Objective
Mississippi	461,833	179,230	641,113	70,522,430	2,120,140	72,637,077
MAV Total	2,942,389	943,410	3,885,799	427,437,890	41,899,001	469,336,891

[1] See Reinecke & Loesch 1996 and LMVJV 2007

ENERGY SUPPLY: **64.7 – 75.4 MILLION DEDS ($\bar{x}$ = 71.0 ± 3.2 MILLION)**

Based on the most current three-year mean, 71.0 million DEDs are estimated as supplied throughout Mississippi from natural flood (37%), private managed (15%), and public managed lands (48%; **Table 2**). After accounting for natural flooding, the remaining energy is distributed as 23% on private managed land (Managed In Program (MIP); Managed Out of Program (MOP)) and 77% on public managed land. Of public managed land, 71% of energy is provided through federal partners and 29% through state partners (**Table 2**).

Table 2. Duck Energy Days estimated on the landscape in Mississippi through an energy-based model that (1) accounts for decomposition/disturbance across all three habitat sources; (2) uses Monte Carlo simulation to generate hypothetical winters based on flood frequency and determine DED values reached or exceeded 80% of the time for natural flood and private managed land; and (3) uses annual data entered into the Water Management Unit database for public managed land wherein units are assumed at full pool capacity and are not linked to flood frequency.[2]

	Natural Flood	Private Managed			Public Managed			
		MIP	**MOP**	**Subtotal**	**Federal**	**State**	**Subtotal**	**Total**
2011-12	25,735,375	8,044,187	2,121,829	10,160,278	22,549,411	12,485,325	35,024,519	72,643,642
2012-13	25,735,375	8,044,187	2,121,829	10,160,278	29,645,994	8,169,496	37,773,504	75,408,124
2013-14	25,735,375	8,044,187	2,121,829	10,160,278	18,640,878	8,516,440	27,126,745	64,646,786
$\bar{x}$	**25,735,375**	**8,044,187**	**2,121,829**	**10,160,278**	**23,612,094**	**9,723,754**	**33,308,255**	**70,899,518**

[2] See Edwards et al. (2012) for details on derivation of DED estimation

Natural flooding in Mississippi supplies energy through cropland and forested wetlands (**Table 3**). The most energy is provided through forested wetlands and corn (80%; **Figure 1**), and forested wetlands account for the most acreage (**Figure 2**).

Table 3. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type through natural flooding in the state of Mississippi (from satellite scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[3]

Natural Flood	Average DEDs	Average Acres
Cropland		
Corn	3,938,664 ± 1,067,074	7,805
Millet	576 ± 576	0.1
Milo	638,271 ± 171,979	1,330
Rice	2,373,546 ± 873,250	17,229
Soybeans	2,160,980 ± 601,851	59,311
Forested Wetland	17,003,839 ± 1,033,076	272,745

[3] See Edwards et al. (2012) for details

Figure 1. Duck Energy Day provision, prior to decomposition, for each habitat type through natural flooding in the state of Mississippi.

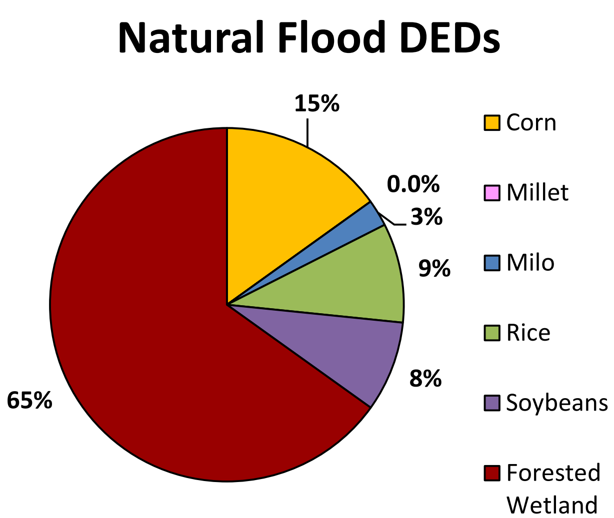
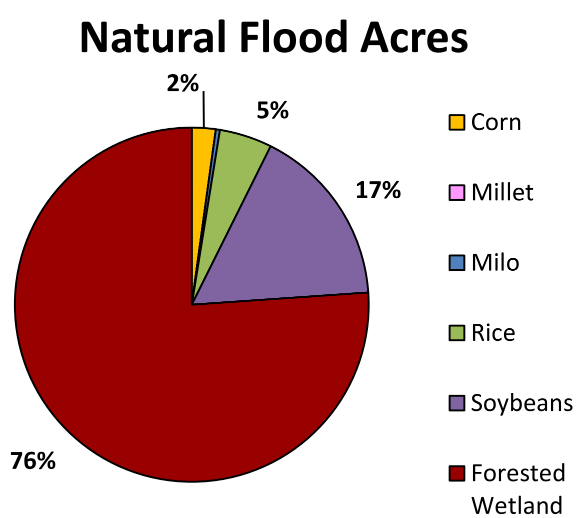


Figure 2. Proportion of acres provided through natural flooding by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



PRIVATE LAND ENERGY SUPPLY

Private lands in Mississippi supply energy through cropland, the Wetland Reserve Program (WRP), and forested wetlands (**Table 4**). The most energy is provided through WRP (**Figure 3**), although a significant proportion of acres are also forested wetland and soybeans (62%; **Figure 4**).

Table 4. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type on private managed lands in the state of Mississippi (scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[4]

Private Managed	Average DEDs	Average Acres
Managed Out of Program (MOP)		
Cropland		
Corn	1,122,412 ± 275,302	2,225
Millet	576 ± 576	0.1
Milo	742,968 ± 585,677	1,548
Rice	1,214,560 ± 365,037	8,817
Soybeans	722,453 ± 178,857	19,829
Forested Wetland	143,971 ± 42,760	2,309
Managed In Program (MIP)		
Cropland		
Corn	689,680 ± 145,904	1,367
Millet	576 ± 576	0.1
Milo	195,688 ± 49,177	408
Rice	1,082,550 ± 236,113	7,858
Soybeans	596,238 ± 122,015	16,365
WRP	6,074,840 ± 1,378,708	21,368
Forested Wetland	1,252,406 ± 316,288	20,089

[4] See Edwards et al. (2012) for details

Figure 3. Duck Energy Day provision, prior to decomposition, for each habitat type on private managed lands in the state of Mississippi.

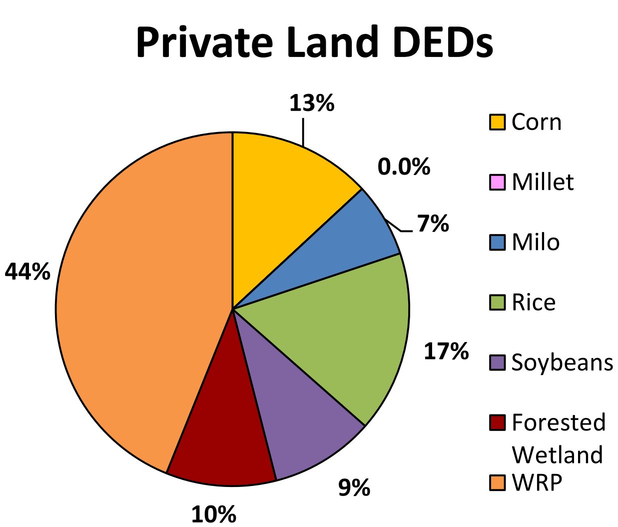
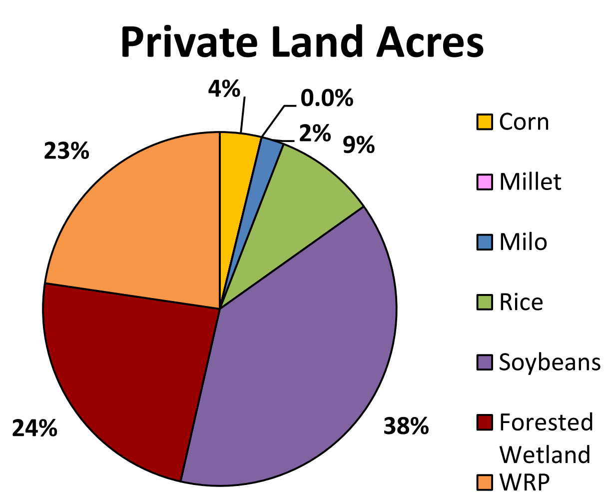


Figure 4. Proportion of acres provided on private land by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



Habitat type influences the amount of energy available and the variability in energy that public partners provide among years (**Table 5**). In general, Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) lands provide most energy through moist-soil wetlands, although a significant number of acres are forested wetland (**Figure 5**) and U.S. Fish and Wildlife Service (USFWS) refuges provide most energy through cropland and moist-soil wetlands, although a significant number of acres are forested wetland (**Figure 6**) in water-managed units.

Table 5. Duck Energy Day provision, prior to decomposition, for each habitat type on public managed lands in the state of Mississippi based on input into the Water Management Unit Database (WMU).[5]

Public Managed Lands	2011/12	2012/13	2013/14	3-year Average
State (MDWFP)				
Cropland				
Corn	5,274,247	0	0	1,758,082 (± 1,758,082)
Millet	1,415,442	0	1,081,663	832,368 (± 427,192)
Rice	77,286	116,086	178,645	124,006 (± 29,526)
Soybean	1,032,835	42,387	54,665	376,629 (± 328,122)
Moist-soil Wetland	6,295,065	8,415,949	7,706,116	7,472,377 (± 623,301)
Forested Wetland	1,979,138	1,943,252	1,943,252	1,955,214 (± 11,962)
Federal (USFWS)				
Cropland				
Corn	8,898,966	9,861,326	1,329,052	6,696,458 (± 2,698,043)
Millet	1,572,373	1,532,207	2,917,411	2,007,330 (± 455,188)
Milo	5,544,352	6,224,937	11,047,159	7,605,483 (± 1,732,017)
Rice	4,202,708	9,463,687	0	4,555,465 (± 2,737,619)
Soybeans	1,265,116	2,095,712	118,202	1,159,677 (± 573,287)
Moist-soil Wetland	6,038,087	6,207,643	7,043,503	6,429,744 (± 310,758)
Forested Wetland	678,454	803,480	800,729	760,888 (± 41,355)

[5] See Edwards et al. (2012) for details

Figure 5. Proportion of (a) energy (DEDs) and (b) acres provided on state lands by cover type based on a three-year average of WMU data.

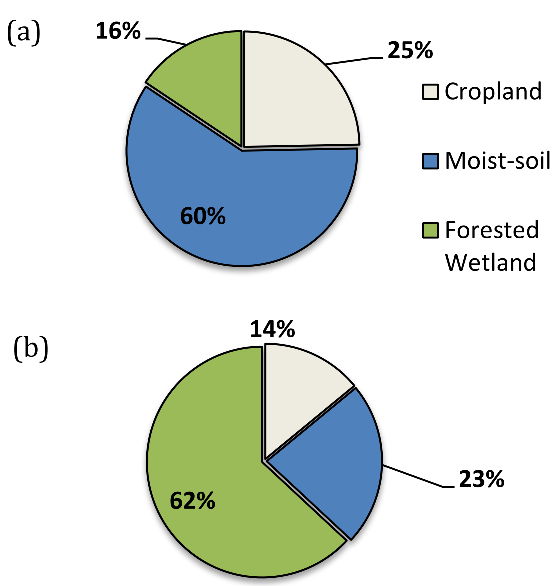
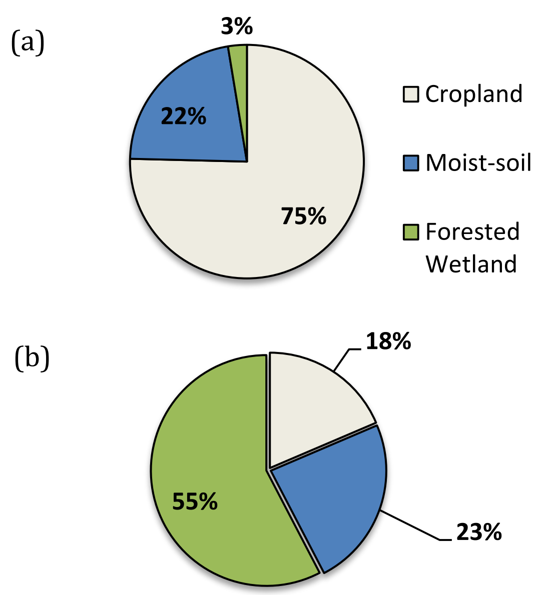


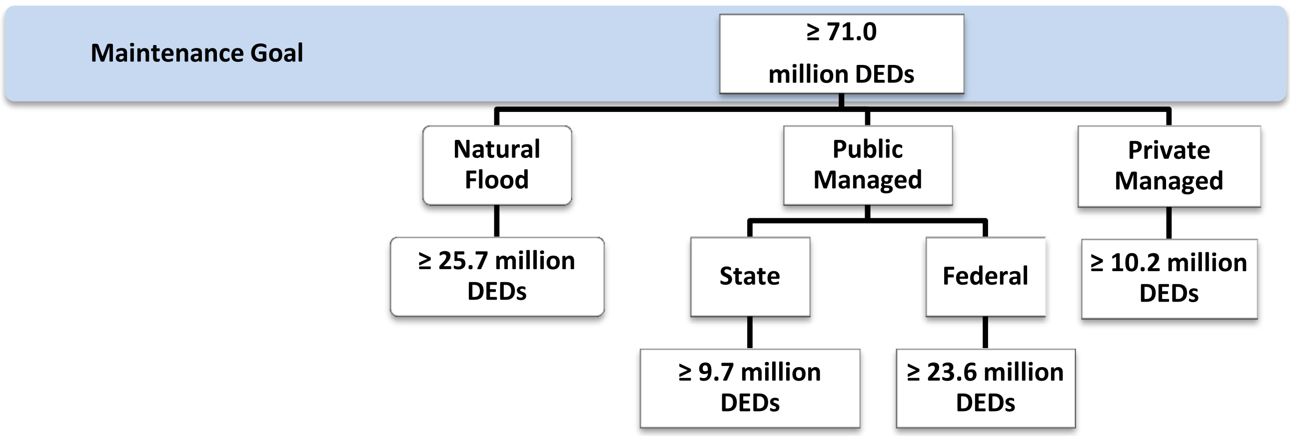
Figure 6. Proportion of (a) energy (DEDs) and (b) acres provided on federal lands by cover type based on a three-year average of WMU data.



WATERFOWL HABITAT CONSERVATION GOALS

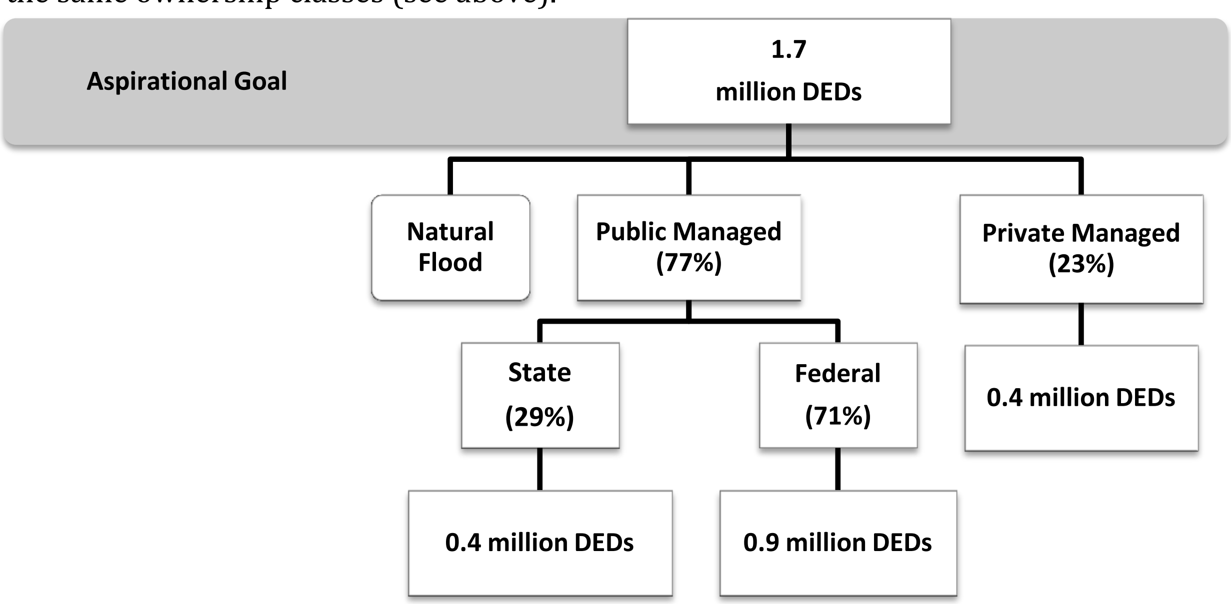
MAINTENANCE GOAL

Because Mississippi is below its target objective for providing DEDs and has variation in its DED production, it is imperative that Mississippi partners, at minimum, strive to maintain current DED production. A **maintenance goal** is set based on the 3-year average at a minimum of 71.0 million DEDs on private and public lands.



ASPRIATIONAL GOAL

Because Mississippi is below its target objective for providing DEDs, an aspirational goal is set at **providing an additional 1.7 million DEDs** across private and public lands to meet the state-level NAWMP objective of 72.6 million DEDs. This aspirational goal will be met through a combination of land acquisition, habitat enhancement and/or restoration on public land, and conservation opportunities on private land through cooperative and coordinated efforts among state, federal, and private partners. The aspirational goal DED targets by ownership are established based on the current distribution of DED provision in the same ownership classes (see above).



IMPLICATIONS OF BIOENERGETIC MODEL RESULTS

Based on discussions at state-level meetings, partners considered what the model results, which demonstrate Mississippi is below objective, meant to waterfowl management efforts and achieving maintenance and aspirational goals in their state.

1) Maintaining DED production from cooperative farming and providing adequate staff and funding for other habitat management is important to providing high quality waterfowl habitat. However, given limited resources, maintaining the current 3-year average of DED production may be challenging in coming years.
2) Inadequate management on WRP lands and a lack of infrastructure affect the ability to provide high quality waterfowl habitat. WRP sites are in need of enhancement (e.g., disking) followed by provision or encouragement of continued maintenance.
3) The variability in DED production on public land in Mississippi may be in part due to wet and dry years experienced on St. Catherine's Creek National Wildlife Refuge, which leads to variable planting of crops. Additionally, phasing out of genetically modified crops (GMCs) on National Wildlife Refuges (NWRs) may have been responsible for a portion of the variability.
4) Given new policies necessitating non-GMCs be farmed on NWRs, continuing to monitor DED production on public lands will be important to assessing the impact on waterfowl food production.

POTENTIAL STRATEGIES AND SCENARIOS

Partners identified three overarching conservation approaches that could be used to achieve aspirational goals for wintering waterfowl. These approaches include acquisition of additional habitat, restoration of existing habitats, and enhancement of current habitats (Table 6). Addressing aspirational goals through these approaches will require some form of monitoring-- either quantifying seed yields of enhanced habitats or additional acres and cover types added to the current conservation estate. The specific strategies provided as examples are intended to provoke thought regarding various management actions and subsequent tradeoffs and are not intended to be prescriptions for how DEDs should be addressed on a parcel of land. In addition, certain actions would take time to develop and realize DED production (e.g., increasing red oak composition), but nonetheless the action could still be worthy of pursuit. The fact that the waterfowl-habitat values of some actions may not immediately accrue (e.g., in 1-2 years), does not discount the activity's ultimate value. Wildlife – including waterfowl – management has always relied on slow but steady progress to achieve cumulative success.

Acquisition includes the fee title purchase of land or the protection of additional land through conservation easements. Table 6 demonstrates hypothetical strategies and the equivalent acres in various habitat types (if left managed as those initial habitat types) that could be used to meet an aspirational goal of 1.7 million DEDs. It is important to note that acquisition values in this context assume a complete net gain in DEDs; however, many acres within the MAV potentially available for acquisition likely already provide some level of foraging habitat.

Restoration includes reestablishing missing habitats or natural processes where they historically existed with a goal to mimic the original wetland functions and values of a site. Restoration also includes creating habitats with important waterfowl habitat functions, although in areas where they may not have previously existed. Table 6 demonstrates hypothetical restoration strategies and the equivalent change in DEDs given the same amount of acres with a focus on the restoration of existing agricultural land to forested wetland and moist-soil wetlands.

Enhancement includes activities to improve food production on public lands and private lands through improving the quality of waterfowl habitat currently or promoting more waterfowl-friendly agricultural practices. Enhancement could include changes to site design, management, or water-control capabilities that would improve flooding and water holding capacity, crop rotation practices, etc. Incentives to inrcrease production of ratoon rice would be an example of a practical approach to encouraging a waterfowl-friendly agricultural practice. Table 6 demonstrates hypothetical enhancement strategies given current calculated acreages on public and private lands and the equivalent change in energy production.

The scenario of loss of cropland on National Wildlife Refuges (NWRs) represents a situation in which crops are no longer farmed on NWRs. Table 6 demonstrates hypothetical strategies and the equivalent acres in other habitat types that could be used to meet the equivalent of DEDs provided through cropland on NWRs.

Table 6. Example strategies to address the aspirational goal for waterfowl management, including acre or DED equivalents where appropriate. These strategies are intended to provoke thought regarding various management actions and subsequent tradeoffs and are not intended to be prescriptions for how DEDs should be addressed on a parcel of land. Acquisition simply lists the equivalent acres in various habitat types providing equal DEDs (1.7 million). Restoration represents the equivalent change in DEDs from one habitat type to another given the same amount of acres. Enhancement represents the equivalent change in energy production if certain practices are enhanced on current calculated acreages on public and private lands.

Acquisition Strategy	Acres	DED value/acre	Total DEDs	
Of **harvested soybean**	47,222	36	1.7 million	
Of **forested wetland (30%)**	15,596	109	1.7 million	
Of **harvested rice**	12,319	138	1.7 million	
Of **WRP (20% red oak & 270 kg/ha)**	9,056	61 & 765	1.7 million	
Of **moist-soil wetland (600 kg/ha)**	910	1,868	1.7 million	
Of **unharvested millet**	326	5,203	1.7 million	
Of **unharvested rice**	71	23,833	1.7 million	
Of **unharvested corn**	59	28,591	1.7 million	
Restoration Strategy	**Acres[1]**	**DED value/acre**	**Total DEDs**	**Change in DEDs**
From **harvested soybean**	36,194	36	1,302,984	
To **forested wetland (30% red oak)**		109	3,945,146	+ 2,642,162
To **moist-soil wetland (600 kg/ha)**		1,868	67,610,392	+ 66,307,408
From **harvested rice**	16,675	138	2,301,150	
To **forested wetland (30% red oak)**		109	1,817,575	-483,575
To **moist-soil wetland (600 kg/ha)**		1,868	31,148,900	+ 28,847,750
From **harvested corn**	3,592	505	1,813,960	
To **forested wetland (30% red oak)**		109	391,528	-1,422,432
To **moist-soil wetland (600 kg/ha)**		1,868	6,709,856	+4,895,896
Enhancement Strategy	**Acres**	**DED value/acre**	**Total DEDs**	**Change in DEDs**
Of **forested wetland (30% red oak)[2]**	20,212	109	2,203,108	
To **40% red oak**		156	3,153,072	+ 949,964
Of **moist-soil wetland (600 kg/ha)[3]**	7,792	1,868	14,555,456	
To **moist-soil wetland (750 kg/ha)**		2,377	18,521,584	+3,966,128
To **moist-soil wetland (1,000 kg/ha)**		3,226	25,136,992	+10,581,536
Of **cooperatively farmed rice (80:20)[4]**	433	138/23,833	2,111,741	

To **cooperatively farmed rice (75:25)**			2,624,738	+512,997
To **cooperatively farmed rice (70:30)**			3,137,735	+1,025,994
Of **harvested rice**[5]	16,675	138	2,301,150	
To **10% acreage ratoon rice (395 kg/ha)**		138 & 1,585	4,714,022	+ 2,412,872
To **20% acreage ratoon rice (395 kg/ha)**		138 & 1,585	7,126,895	+ 4,825,745
Of **WRP (20% red oak & 270 kg/ha)**[6]	21,368	61 & 765	6,074,840	
To **WRP (20% red oak & 600 kg/ha)**		61 & 1,868	8,253,603	+ 2,178,763
To **WRP (20% red oak & 750 kg/ha)**		61 & 2,456	10,515,192	+ 4,440,352
Loss of cropland on NWRs	**Acres**	**DED value/acre**	**Total DEDs**	
From **all cropland**	2,958		22,024,413	
To **moist-soil wetland (600 kg/ha)**	11,790	1,868	22,024,413	
To **moist-soil & forested wetland (50:50)**	106,924	1,868 + 109	22,024,413	
To **forested wetland (30% red oak)**	202,058	109	22,024,413	

[1] Acres represent average private land acres of respective crop types in MIP and MOP from Table 4. All crop acres on private land were assumed harvested in bioenergetic model.

[2] Acres represent average public land acres of forested wetland in state and federal ownership from Table 5. DED value of red oak varies based on what managers select in WMU database for percent red oak of a unit, so values may differ from DEDs in Table 5. This scenario assumes an initial 30% red oak across all public land forested units, with that percentage of red oak increased 10%.

[3] Acres represent average public land acres of moist-soil wetlands in state and federal ownership from Table 5. Soil type, timing of water, seed availability, stage of succession and weather can all play a role in determining moist-soil species composition and ultimately the yields produced. Because these various factors can influence year to year variability in moist-soil seed production there is no "cook book" to managing moist-soil wetlands, but qualitative and quantitative data do provide some insight into observed results from various forms of habitat manipulations. The *Moist-soil guidelines for the U.S. Fish and Wildlife Service Southeast Region* (Strader and Stinson 2005) and *Wetland Management for Waterfowl Handbook* (Nelms 2007) provide some general guidance toward management techniques that may improve moist-soil seed production. The assumed average of moist-soil seed production is 600 kg/ha; however, it is possible to increase seed production up to 1,000 kg/ha with active management such as rotation of moist-soil units with cover crops or proper drawdown periods on the right soil types.

[4] Acres represent average public land acres of rice in federal ownership. The ratios represent hypothetical splits of harvested:unharvested crops that may be formulated through cooperative farming agreements. Leaving a greater unharvested share would increase DED production. These do not necessarily represent current standards as individual refuges will have different arrangements for cooperative agreements.

[5] Acres represent private land acres of rice in MIP and MOP from Table 4. All crop acres on private land were assumed harvested in bioenergetic model. Ratoon crops are volunteer crops from a harvested field. Ratoon values were taken from Petrie et al. (2014).

[6] Acres represent private land acres of WRP as calculated for MIP from Table 4. WRP acres were assumed to be 82% bottomland hardwood with a 20% red oak DED value (61 DED/ac) and 18% moist-soil with a minimal moist-soil wetland value (272 kg/ha or 765 DED/ac). In our model, WRP was given a very low value for moist-soil seed production, assuming that the wetlands were not actively managed. Improving moist-soil wetland management through rotation, discing, or other practices could potentially increase seed yields.

MAV Waterfowl Planning

Missouri

Summary

According to stepped-down North American Waterfowl Management Plan (NAWMP) goals, the state of Missouri should provide 4% of the Mississippi Alluvial Valley (MAV) objective of 469,337,220 Duck Energy Days (DEDs). This represents a state-level NAWMP objective (energy demand) of 18.0 million DEDs. Based on contributions from three sources—natural flooding, private managed lands, and public managed lands—Missouri currently supplies 25.4-29.5 million DEDs.

ENERGY DEMAND: **18.0 MILLION DEDS**

Missouri has a state-level NAWMP objective of 18.0 million DEDs based on a 110-day wintering period from early November to late February. One DED represents the energy needed to support one average-sized duck requiring 294.35 kcal/day for one day.

Table 1. Population and Duck Energy Day objectives for Missouri relative to the MAV.[1]

Geography	Dabbler Population Objective	Wood Duck Population Objective	Total Duck Population Objective	Total Duck Population DEDs	Goose Competition DEDs	Total DED Objective
Missouri	79,683	26,020	115,183	12,670,130	6,397,710	18,025,015
MAV Total	2,942,389	943,410	3,885,799	427,437,890	41,899,330	469,336,891

[1] See Reinecke & Loesch 1996 and LMVJV 2007

ENERGY SUPPLY: **25.4 – 29.5 MILLION DEDS ($\bar{x}$ = 27.6 ± 1.2 MILLION)**

Based on the most current three-year mean, 27.6 million DEDs are estimated as supplied throughout Missouri from natural flood (11%), private managed (13%), and public managed lands (76%; **Table 2**). After accounting for natural flooding, the remaining energy is distributed as 15% on private managed land (Managed In Program (MIP); Managed Out of Program (MOP)) and 85% on public managed land. Of public managed land, 23% of energy is provided through federal partners and 77% through state partners (**Table 2**).

Table 2. Duck Energy Days estimated on the landscape in Missouri through an energy-based model that (1) accounts for decomposition/disturbance across all three habitat sources; (2) uses Monte Carlo simulation to generate hypothetical winters based on flood frequency and determine DED values reached or exceeded 80% of the time for natural flood and private managed land; and (3) uses annual data entered into the Water Management Unit database for public managed land wherein units are assumed at full pool capacity and are not linked to flood frequency.[2]

	Natural Flood	Private Managed			Public Managed			
		MIP	MOP	Subtotal	Federal	State	Subtotal	Total
2011-12	2,905,141	1,581,514	1,940,051	3,609,862	4,343,980	16,488,213	20,801,767	27,891,182
2012-13	2,905,141	1,581,514	1,940,051	3,609,862	7,064,650	15,597,759	22,390,746	29,456,740
2013-14	2,905,141	1,581,514	1,940,051	3,609,862	2,620,447	15,597,759	18,308,948	25,435,109
$\bar{x}$	**2,905,141**	**1,581,514**	**1,940,051**	**3,609,862**	**4,676,359**	**15,894,577**	**20,500,487**	**27,594,344**

[2] See Edwards et al. (2012) for details on derivation of DED estimation

Natural flooding in Missouri supplies energy through cropland and forested wetlands (**Table 3**). Most energy is provided through forested wetland and rice (60%; **Figure 1**), although a significant number of acres are soybeans (**Figure 2**).

Table 3. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type by natural flooding in the state of Missouri (from satellite scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[3]

Natural Flood	Average DEDs	Average Acres
Cropland		
Corn	1,167,769 ± 483,898	2,315
Milo	85,414 ± 42,261	178
Rice	1,672,399 ± 815,546	12,140
Soybeans	945,320 ± 339,868	25,946
Forested Wetland	1,595,283 ± 366,098	25,589

[3] See Edwards et al. (2012) for details

Figure 1. Duck Energy Day provision, prior to decomposition, for each habitat type by natural flooding in the state of Missouri.

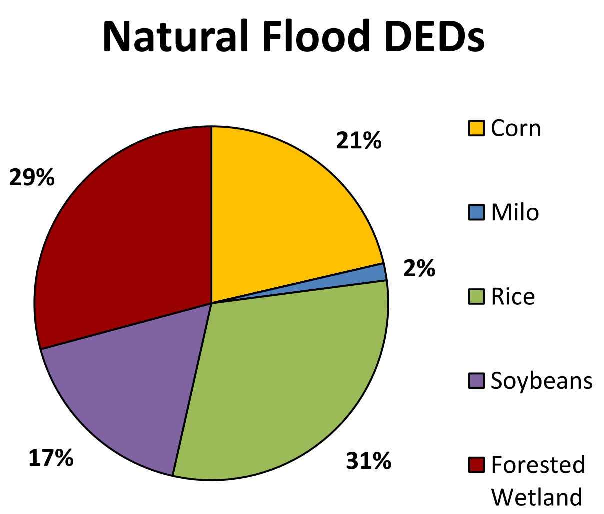
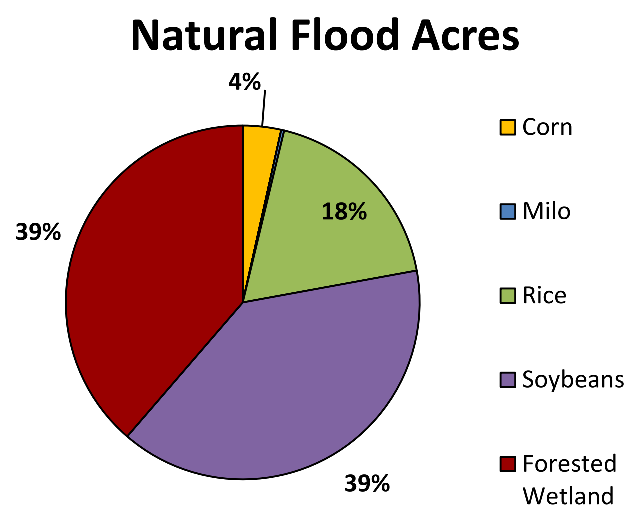


Figure 2. Proportion of acres provided by natural flooding by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



Private lands in Missouri supply energy through cropland, the Wetland Reserve Program (WRP), and forested wetlands (**Table 4**). The most energy is provided through WRP and rice (60%; **Figure 3**), although a significant proportion of acres are soybeans (**Figure 4**).

Table 4. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type on private managed lands in the state of Missouri (scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[4]

Private Managed	Average DEDs	Average Acres
Managed In Program (MOP)		
Cropland		
Corn	633,207 ± 129,089	1,255
Millet	0	0
Milo	583,772 ± 544,061	1,217
Rice	849,170 ± 230,485	6,164
Soybeans	322,990 ± 68,663	8,865
Forested Wetland	28,600 ± 6,203	459
Managed In Program (MIP)		
Cropland		
Corn	140,063 ± 25,125	278
Millet	0	0
Milo	7,596 ± 2,211	16
Rice	453,737 ± 112,333	3,294
Soybeans	87,488 ± 20,288	2,401
WRP	1,409,774 ± 399,869	7,510
Forested Wetland	5,921 ± 1,100	95

[4] See Edwards et al. (2012) for details

Figure 3. Duck Energy Day provision, prior to decomposition, for each habitat type on private managed lands in the state of Missouri.

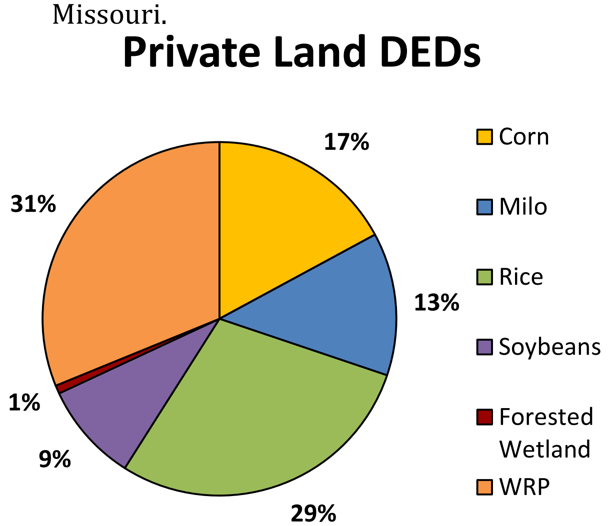
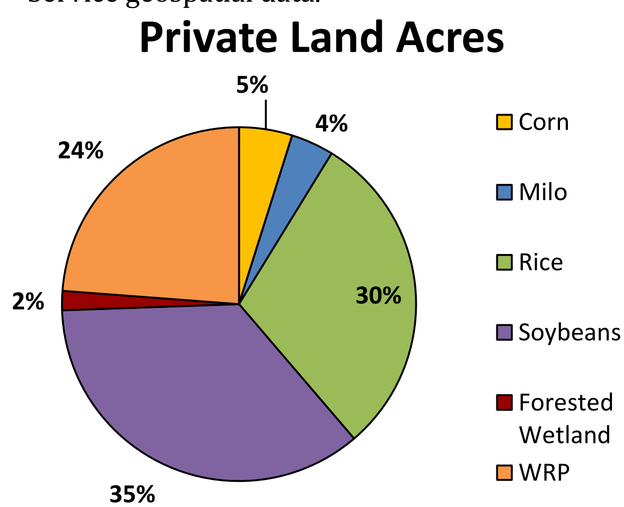


Figure 4. Proportion of acres provided on private land by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



PUBLIC LAND ENERGY SUPPLY

Habitat type influences the amount of energy available and the variability in energy that public partners provide among years (**Table 5**). In general, Missouri Department of Conservation (MDC) lands provide most energy through cropland and moist-soil wetlands, which also account for a significant number of acres (**Figure 5**), and U.S. Fish and Wildlife Service (USFWS) refuges provide most energy through moist-soil wetlands, although a significant number of acres are forested wetland (**Figure 6**) in water-managed units.

Table 5. Duck Energy Day provision, prior to decomposition, for each habitat type on public managed lands in the state of Missouri based on input into the Water Management Unit Database (WMU).[5]

Public Managed Lands	2011/12	2012/13	2013/14	3-year Average
State (MDC)				
Cropland				
Corn	9,156,839	9,156,836	9,156,836	9,156,837
Milo	665,509	665,509	665,509	665,509
Soybean	527,065	527,065	527,065	527,065
Moist-soil	10,261,521	9,005,775	9,005,775	9,424,357 (± 418,582)
Forested wetland	408,476	526,521	526,521	487,172 (± 39,348)
Federal (USFWS)				
Cropland				
Corn	0	1,966,378	0	655,459 (± 655,459)
Millett	324,083	434,461	336,257	364,934 (± 34,941)
Milo	216,419	981,324	0	399,248 (± 297,668)
Rice	0	272,039	0	90,680 (± 90,680)
Soybean	0	470,199	0	156,733 (±156,733)
Moist-soil Wetland	3,139,141	2,679,898	1,363,931	2,394,323 (± 531,980)
Forested Wetland	1,309,361	1,309,361	1,309,361	1,309,361

[5] See Edwards et al. (2012) for details

Figure 5. Proportion of (a) energy (DEDs) and (b) acres provided on state lands by cover type based on a three-year average of WMU data.

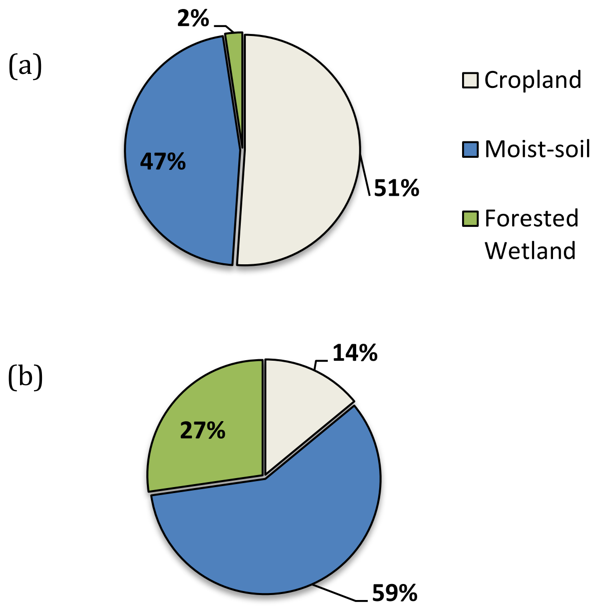
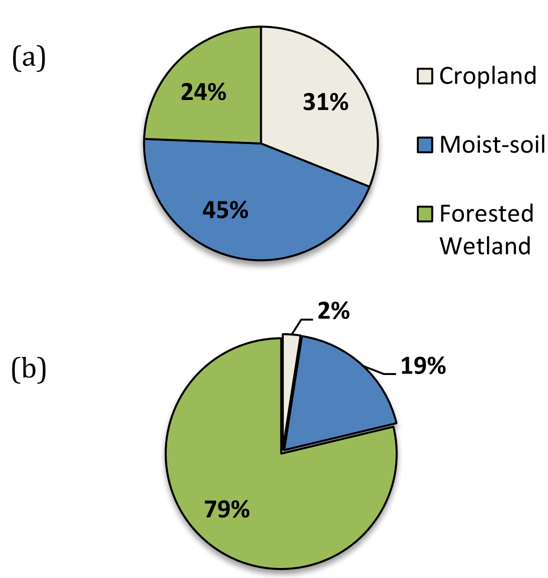
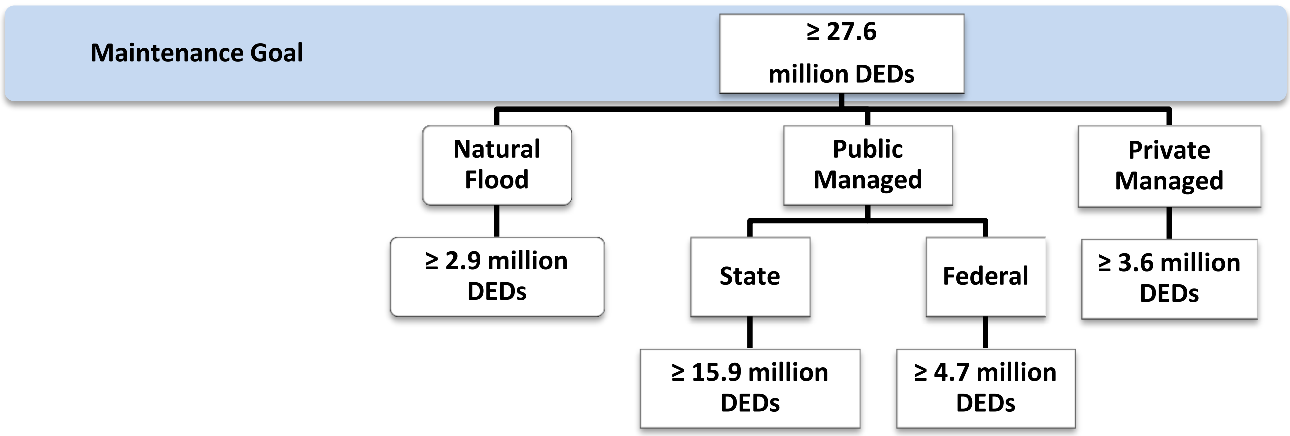


Figure 6. Proportion of (a) energy (DEDs) and (b) acres provided on federal lands by cover type based on a three-year average of WMU data.



MAINTENANCE GOAL

Although Missouri is above its target objective for providing DEDs, whereas the MAV as a whole remains below objective, it is imperative that Missouri partners, at minimum, strive to maintain current DED production. A **maintenance goal** is set based on the 3-year average at a minimum of 27.6 million DEDs on private and public lands.



IMPLICATIONS OF BIOENERGETIC MODEL RESULTS

Based on discussions at a state-level conference call, partners considered what the model results, which demonstrate Missouri is below objective, meant to waterfowl management efforts and achieving maintenance and aspirational goals in their state.

1) Maintaining DED production and providing adequate staff and funding for other habitat management is important to providing high quality waterfowl habitat in Missouri.

2) In Missouri, spring staging habitats for waterfowl may be equally as important as wintering habitat. Spring staging habitats include moist-soil, shrub/scrub, and forested wetlands that provide invertebrate biomass. Thus, exploring planning in terms of multiple winter periods (early, mid, and late) may be especially useful. Furthermore, natural flooding is more likely in the spring and may account for a flush of energy provided in Missouri habitats. This may not be captured adequately in the current mid-winter satellite scenes.

3) The importance of sanctuary and other habitats should not be undervalued when considering overall duck energy needs. Although scrub-shrub wetlands and green tree reservoirs may not provide high energetic value, as compared to other habitats, they have great importance as thermal cover for waterfowl during winter when other habitats may freeze, and aid in dispersal from competition to assist in strengthening pair bonds.

MAV Waterfowl Planning

Tennessee

Summary

According to stepped-down North American Waterfowl Management Plan (NAWMP) goals, the state of Tennessee should provide 7% of the Mississippi Alluvial Valley (MAV) objective of 469,337,220 Duck Energy Days (DEDs). This represents a state-level NAWMP objective (energy demand) of 33.6 million DEDs. Based on contributions from three sources—natural flooding, private managed lands, and public managed lands—Tennessee currently supplies 25.2-28.5 million DEDs.

ENERGY DEMAND: **33.6 MILLION DEDS**

Tennessee has a state-level NAWMP objective of 33,625,658 DEDs based on a 110-day wintering period from early February to late November. One DED represents the energy needed to support one average-sized duck requiring 294.35 kcal/day for one day.

Table 1. Population and Duck Energy Day objectives for Tennessee relative to the MAV.[1]

Geography	Dabbler Population Objective	Wood Duck Population Objective	Total Duck Population Objective	Total Duck DED Objective	Goose Competition DEDs	Total DED Objective
Tennessee	262,763	35,500	298,263	32,808,908	816,750	33,625,658
MAV Total	2,942,389	943,410	3,885,799	427,437,890	41,899,330	469,336,891

[1] See Reinecke & Loesch 1996 and LMVJV 2007

ENERGY SUPPLY: **25.2 – 28.5 MILLION DEDS ($\bar{x}$ = 27.2 ± 1.0 MILLION)**

Based on the most current three-year mean, 27.2 million DEDs are estimated as supplied throughout Tennessee from natural flood (7%), private managed (2%), and public managed lands (91%; **Table 2**). After accounting for natural flooding, the remaining energy is distributed as 2% on private managed land (Managed In Program (MIP); Managed Out of Program (MOP)) and 98% on public managed land. Of public managed land, 36% of energy is provided through federal partners and 64% through state partners (**Table 2**).

Table 2. Duck Energy Days estimated on the landscape in Tennessee through an energy-based model that (1) accounts for decomposition/disturbance across all three habitat sources; (2) uses Monte Carlo simulation to generate hypothetical winters based on flood frequency and determine DED values reached or exceeded 80% of the time for natural flood and private managed land; and (3) uses annual data entered into the Water Management Unit database for public managed land wherein units are assumed at full pool capacity and are not linked to flood frequency.[2]

	Natural Flood	Private Managed			Public Managed			
		MIP	MOP	Subtotal	Federal	State	Subtotal	Total
2011-12	1,928,788	444,430	48,686	501,838	8,953,947	14,061,309	22,724,065	25,205,372
2012-13	1,928,788	444,430	48,686	501,838	10,606,430	15,751,675	26,042,276	28,513,715
2013-14	1,928,788	444,430	48,686	501,838	7,159,163	18,571,358	25,304,727	27,755,068
$\bar{x}$	**1,928,788**	**444,430**	**48,686**	**501,838**	**8,906,514**	**16,128,114**	**24,690,356**	**27,158,052**

[2] See Edwards et al. (2012) for details on derivation of DED estimation

Natural flooding in Tennessee supplies energy through cropland and forested wetlands (**Table 3**). The most energy is provided through forested wetlands (**Figure 1**), and these account for the most acreage in addition to soybeans (**Figure 2**).

Table 3. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type through natural flooding in the state of Tennessee (from satellite scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[3]

Natural Flood	Average DEDs	Average Acres
Cropland		
Corn	581,874 ± 287,099	1,153
Millet	0	0
Milo	80,315 ± 45,328	167
Rice	7,473 ± 3,439	54
Soybeans	843,514 ± 429,527	23,151
Forested Wetland	2,893,494 ± 1,033,076	46,413

[3] See Edwards et al. (2012) for details

Figure 1. Duck Energy Day provision, prior to decomposition, for each habitat type through natural flooding in the state of Tennessee.

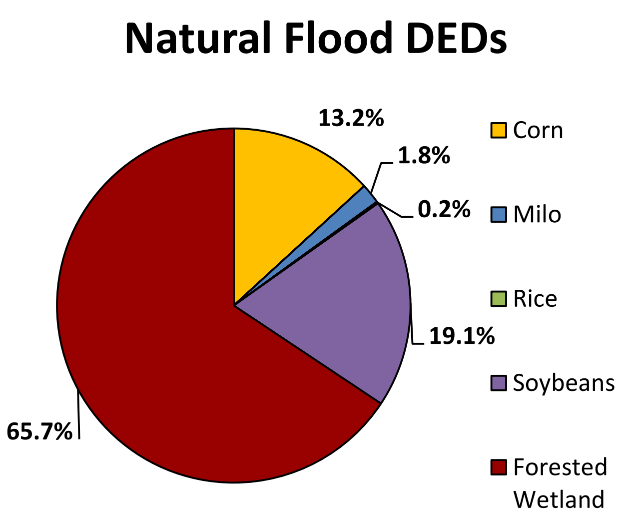
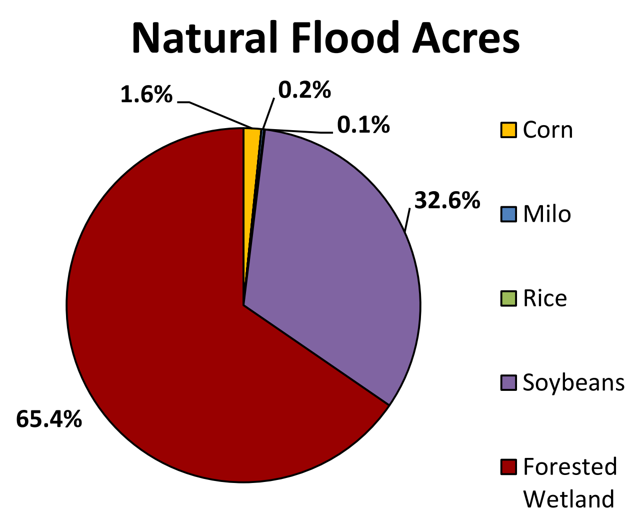


Figure 2. Proportion of acres provided through natural flooding by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



Private lands in Tennessee supply energy through cropland, the Wetland Reserve Program (WRP), and forested wetlands (**Table 4**). The most DEDs are provided through WRP (**Figure 3**), although a significant number of acres (45%) are cropland (**Figure 4**).

Table 4. Average Duck Energy Day provision (prior to Monte Carlo simulation and decomposition by watershed) and acreage for each habitat type on private managed lands in the state of Tennessee (from satellite scenes: 12/27/99; 11/14/01; 12/24/01; 02/02/02; 01/04/03; 12/30/03; 01/17/05)[4]

Private Managed	Average DEDs	Average Acres
Managed Out of Program (MOP)		
Cropland		
Corn	67,756 ± 15,515	134
Milo	3,931 ± 1,709	8
Rice	2,440 ± 1,158	18
Soybeans	93,090 ± 26,360	2,555
Forested Wetland	16,784 ± 3,893	269
Managed In Program (MIP)		
Cropland		
Corn	51,725 ± 16,929	103
Milo	2,178 ± 809	5
Rice	428 ± 214	4
Soybeans	47,057 ± 14,323	1,292
WRP	647,234 ± 272,092	3,448
Forested Wetland	85,067 ± 28,871	1,365

[4] See Edwards et al. (2012) for details

Figure 3. Duck Energy Day provision, prior to decomposition, for each habitat type on private managed lands in the state of Tennessee.

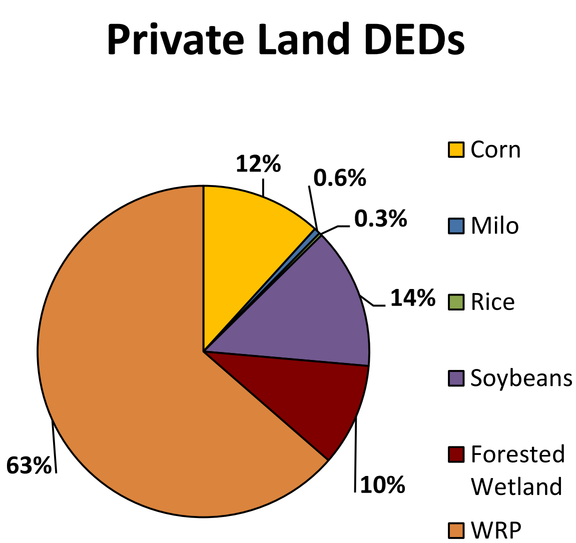
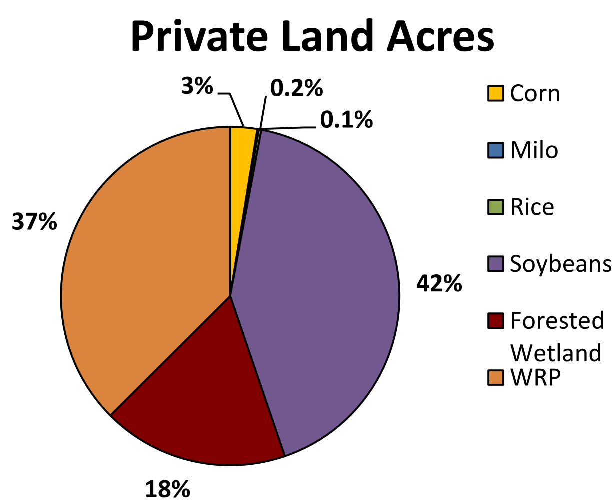


Figure 4. Proportion of acres provided on private land by cover type based on an average of seven satellite images overlaid with National Landcover Database and National Agriculture Statistics Service geospatial data.



Habitat type influences the amount of energy available and the variability in energy that public partners provide among years (**Table 5**). In general, Tennessee Wildlife Resources Agency (TWRA; **Figure 5**) lands and U.S. Fish and Wildlife Service (USFWS; **Figure 6**) refuges provide most energy through cropland and moist-soil wetlands in water-managed units.

Table 5. Duck Energy Day provision, prior to decomposition, for each habitat type on public managed lands in the state of Tennessee based on input into the Water Management Unit Database (WMU).[5]

Public Managed Lands	2011/12	2012/13	2013/14	3-year Average
State (TWRA)				
Cropland				
Corn	15,467,731	17,812,193	20,691,493	17,990,472 ± 1,510,603
Soybeans	5,076	5,076	4,968	5,040 ± 36
Millet	1,108,239	988,570	1,638,945	1,245,251 ± 199,855
Moist-soil Wetland	1,047,948	964,822	904,112	972,294 ± 41,690
Forested Wetland	8,720	8,720	8,720	8,720
Federal (USFWS)				
Cropland				
Corn	9,720,940	12,008,220	7,204,932	9,644,697 ±1,387,114
Millet	0	0	327,789	109,263 ± 109,263
Soybeans	540	252	1,548	780 ± 393
Moist-soil Wetland	1,819,432	1,684,936	1,813,828	1,772,732 ± 43,928

[5]See Edwards et al. (2012) for details

Figure 5. Proportion of (a) energy (DEDs) and (b) acres provided on state lands by cover type based on a three-year average of WMU data.

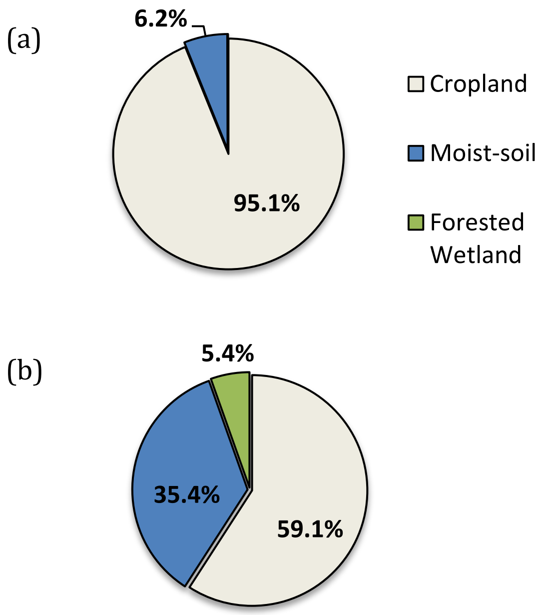
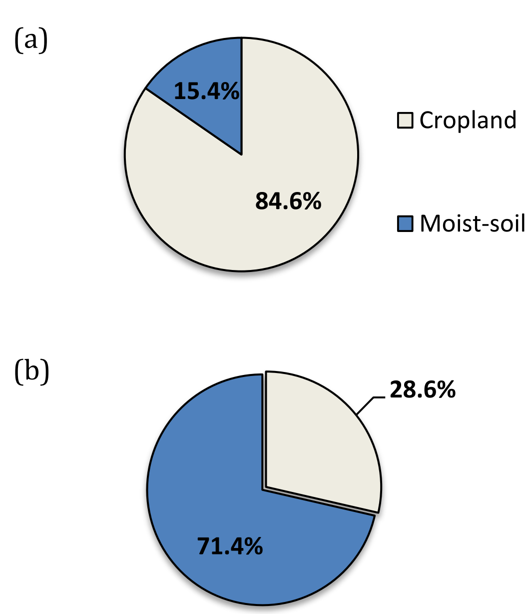


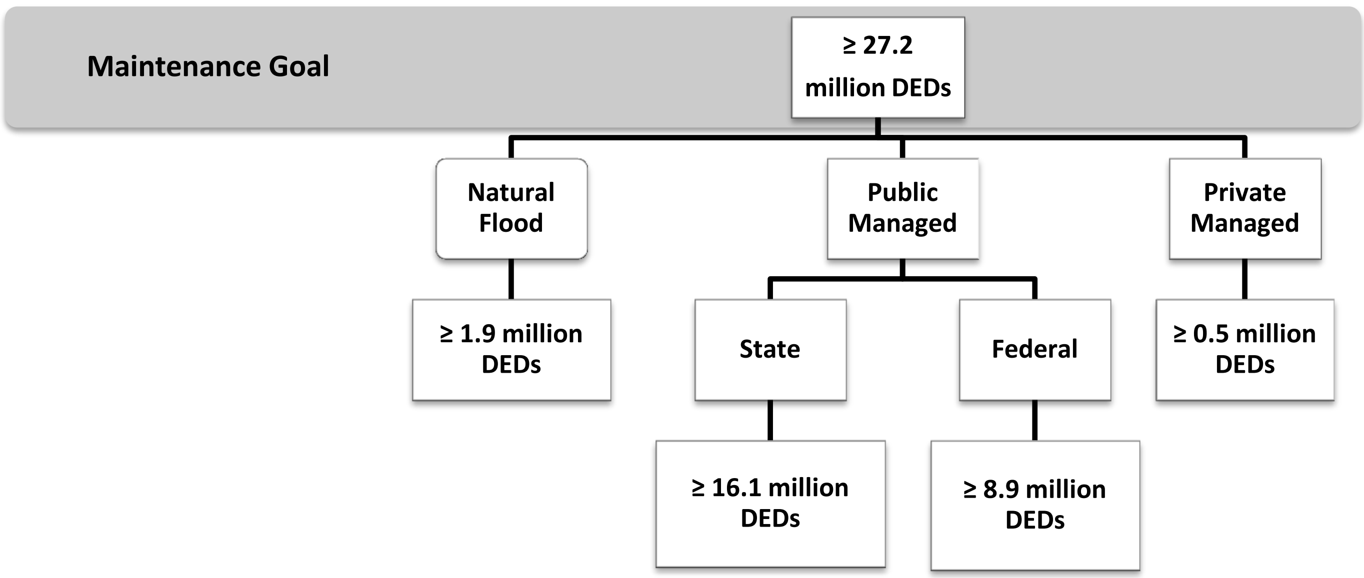
Figure 6. Proportion of (a) energy (DEDs) and (b) acres provided on federal lands by cover type based on a three-year average of WMU data.



WATERFOWL HABITAT CONSERVATION GOALS

MAINTENANCE GOAL

It is imperative that Tennessee partners, at minimum, maintain current DED production. A **maintenance goal** is set based on the 3-year average at a minimum of 27.2 million DEDs on private and public lands.



ASPIRATIONAL GOAL

Because Tennessee is below its target objective for providing DEDs, an aspirational goal is set at **providing an additional 6.5 million DEDs** across private and public lands to meet the state-level NAWMP objective of 33.6 million DEDs. This aspirational goal will be met through a combination of land acquisition, habitat enhancement and/or restoration on public land, and conservation opportunities on private land through cooperative and coordinated efforts among state, federal, and private partners.

IMPLICATIONS OF BIOENERGETIC MODEL RESULTS

Based on discussions at a state-level meeting, partners considered what the model results, which demonstrate Tennessee is below objective, meant to waterfowl management efforts and achieving maintenance and aspirational goals in their state.

1) In Tennessee, TWRA is likely at capacity for guaranteed water, based on available and foreseeable funds, which could impact the ability to provide and increase high quality waterfowl habitat.

2) Farming is important to waterfowl management in Tennessee due in large measure to perceived hunter/constituent expectations.

3) Land acquisition and habitat restoration are key for meeting aspirational goals.

POTENTIAL STRATEGIES AND SCENARIOS

Partners identified three overarching conservation approaches that could be used to achieve aspirational goals for wintering waterfowl. These approaches include acquisition of additional habitat, restoration of existing habitats, and enhancement of current habitats (Table 6). Addressing aspirational goals through these approaches will require some form of monitoring-- either quantifying seed yields of enhanced habitats or additional acres and cover types added to the current conservation estate. The specific strategies provided as examples are intended to provoke thought regarding various management actions and subsequent tradeoffs and are not intended to be prescriptions for how DEDs should be addressed on a parcel of land. In addition, certain actions would take time to develop and realize DED production (e.g., increasing red oak composition), but nonetheless the action could still be worthy of pursuit. The fact that the waterfowl-habitat values of some actions may not immediately accrue (e.g., in 1-2 years), does not discount the activity's ultimate value. Wildlife – including waterfowl – management has always relied on slow but steady progress to achieve cumulative success.

Acquisition includes the fee title purchase of land or the protection of additional land through conservation easements. Table 6 demonstrates hypothetical strategies and the equivalent acres in various habitat types (if left managed as those initial habitat types) that could be used to meet an aspirational goal of 6.5 million DEDs. It is important to note that acquisition values in this context assume a complete net gain in DEDs; however, many acres within the MAV potentially available for acquisition likely already provide some level of foraging habitat.

Restoration includes reestablishing missing habitats or natural processes where they historically existed with a goal to mimic the original wetland functions and values of a site. Restoration also includes creating habitats with important waterfowl habitat functions, although in areas where they may not have previously existed. Table 6 demonstrates hypothetical restoration strategies and the equivalent change in DEDs given the same amount of acres with a focus on the restoration of existing agricultural land to forested wetland and moist-soil wetlands.

Enhancement includes activities to improve food production on public lands and private lands through improving the quality of waterfowl habitat currently or promoting more waterfowl-friendly agricultural practices. Enhancement could include changes to site design, management, or water-control capabilities that would improve flooding and water holding capacity, crop rotation practices, etc. Incentives to inrcrease production of ratoon rice would be an example of a practical approach to encouraging a waterfowl-friendly agricultural practice. Table 6 demonstrates hypothetical enhancement strategies given current calculated acreages on public and private lands and the equivalent change in energy production.

Table 6. Example strategies to address the aspirational goal for waterfowl management, including acre or DED equivalents where appropriate. These strategies are intended to provoke thought regarding various management actions and subsequent tradeoffs and are not intended to be prescriptions for how DEDs should be addressed on a parcel of land. Acquisition simply lists the equivalent acres in various habitat types providing equal DEDs (6.5 million). Restoration represents the equivalent change in DEDs from one habitat type to another given the same amount of acres. Enhancement represents the equivalent change in energy production if certain practices are enhanced on current calculated acreages on public and private lands.

Acquisition Strategy	Acres	DED value/acre	Total DEDs	
Of **harvested soybean**	180,556	36	6.5 million	
Of **forested wetland (30%)**	59,633	109	6.5 million	
Of **harvested rice**	47,101	138	6.5 million	
Of **WRP (20% red oak & 270 kg/ha)**	34,626	187.72	6.5 million	
Of **moist-soil wetland (600 kg/ha)**	3,480	1,868	6.5 million	
Of **unharvested millet**	1,249	5,203	6.5 million	
Of **unharvested rice**	273	23,833	6.5 million	
Of **unharvested corn**	227	25,891	6.5 million	
Restoration Strategy	**Acres[1]**	**DED value/acre**	**Total DEDs**	**Change in DEDs**
From **harvested soybean**	3,847	36	138,492	
To **forested wetland (30% red oak)**		109	419,323	+ 280,831
To **moist-soil wetland (600 kg/ha)**		1,868	7,186,196	+ 7,047,704
From **harvested rice**	12	138	1,656	
To **forested wetland (30% red oak)**		109	1,308	-348
To **moist-soil wetland (600 kg/ha)**		1,868	22,416	+ 20,760
From **harvested corn**	237	505	119,685	
To **forested wetland (30% red oak)**		109	25,833	-93,852
To **moist-soil wetland (600 kg/ha)**		1,868	442,716	+323,031
Enhancement Strategy	**Acres**	**DED value/acre**	**Total DEDs**	**Change in DEDs**
Of **forested wetland (30% red oak)[2]**	80	109	8,720	
To **40% red oak**		156	12,480	+ 3,760
Of **moist-soil wetland (600 kg/ha)[3]**	1,470	1,868	2,745,960	
To **moist-soil wetland (750 kg/ha)**		2,377	3,494,190	+748,230
To **moist-soil wetland (1,000 kg/ha)**		3,226	4,742,220	+1,996,260
Of **WRP (20% red oak & 270 kg/ha)[4]**	3,448	187.72	647,259	

***To* WRP (20% red oak & 600 kg/ha)**	386.26	1,331,824	+ 684,565
***To* WRP (20% red oak & 750 kg/ha)**	492.1	1,696,760	+ 1,049,502

[1] Acres represent average private land acres of respective crop types in MIP and MOP from Table 4. All crop acres on private land were assumed harvested in bioenergetic model.

[2] Acres represent average public land acres of forested wetland in state and federal ownership from Table 5. DED value of red oak varies based on what managers select in WMU database for percent red oak of a unit, so values may differ from DEDs in Table 5. This scenario assumes an initial 30% red oak across all public land forested units, with that percentage of red oak increased 10%.

[3] Acres represent average public land acres of moist-soil wetlands in state and federal ownership from Table 5. Soil type, timing of water, seed availability, stage of succession and weather can all play a role in determining moist-soil species composition and ultimately the yields produced. Because these various factors can influence year to year variability in moist-soil seed production there is no "cook book" to managing moist-soil wetlands, but qualitative and quantitative data do provide some insight into observed results from various forms of habitat manipulations. The *Moist-soil guidelines for the U.S. Fish and Wildlife Service Southeast Region* (Strader and Stinson 2005) and *Wetland Management for Waterfowl Handbook* (Nelms 2007) provide some general guidance toward management techniques that may improve moist-soil seed production. The assumed average of moist-soil seed production is 600 kg/ha; however, it is possible to increase seed production up to 1,000 kg/ha with active management such as rotation of moist-soil units with cover crops or proper drawdown periods on the right soil types.

[4] Acres represent private land acres of WRP as calculated for MIP from Table 4. WRP acres were assumed to be 82% bottomland hardwood with a 20% red oak DED value (61 DED/ac) and 18% moist-soil with a minimal moist-soil wetland value (272 kg/ha or 765 DED/ac). In our model, WRP was given a very low value for moist-soil seed production, assuming that the wetlands were not actively managed. Improving moist-soil wetland management through rotation, discing, or other practices could potentially increase seed yields.

MAV Waterfowl Planning

Future Considerations

Future Considerations in MAV Waterfowl Planning

Several uncertainties were identified in the planning process, which represent information/research needs and future considerations (Edwards et al. 2012). Future prioritization of these items would ensure efficient partnership time commitment to addressing these identified needs and potentially seeking funding for projects. All of these items are priorities and need to be addressed; however, some will likely lead to more immediate returns to improve LMVJV modeling efforts. These are, in no particular order:

<u>Natural flooding</u>

- Assess remaining uncertainties in the natural flood component of the model
- Characterize how flow, frequency and duration of natural flooding, as well as ground water recharge, impact the landscape perhaps through a model that ties rainfall and flooding patterns to classified satellite imagery

<u>Private Land</u>

- Quantify provision of unharvested crops and moist-soil wetlands on managed private lands. This habitat category is likely underrepresented in modeling efforts.
- Reassess squareness algorithm used to determine Managed out of Program acres
- Determine sanctuary on private land
- Determine ratoon rice crop availability and DED value/acre

<u>Public Land</u>

- Reassess the hydrologic performance of public lands based on remote sensing
- Revise the WMU tool to reflect impoundments more accurately. The WMU Tool assigns a habitat class to each polygon based on the dominant category, so the DED value used is the one that characterizes ≥51% of the impoundment. So, 51% harvested corn and 49% moist soil within a water management unit is calculated in the WMU Tool as 100% harvested corn (in progress)

<u>Overall model</u>

- Update the managed water GIS layer using remote sensing of water on the landscape for more recent years (in progress)
- Streamline the bioenergetic model to allow for scenario planning and ease of data manipulation (in progress)
- Revise and finalize the 2012 allocation report for archival purposes and publication (in progress)
- Conduct sensitivity analysis of variables in bioenergetic model
- Reassess the amount of Snow Goose competition
- Quantify the spatial distribution of DEDs on the landscape and compare to waterfowl distribution from mid-winter surveys
- Compare historic county-level harvest distribution (data from which state population distributions were calculated) to current DED distribution

- Provide a measure of variance on estimates of current DEDs provided in each habitat and objectives
- Incorporate changes to waterfowl population objectives based on 2012 NAWMP revision (when those are developed)
- Incorporate appropriate people/user objectives in accordance with 2012 NAWMP

References

Edwards, T., D. Fuqua, D. James, T. Kreher, P. Link, L. Naylor, F. Nelson, E. Penny, G. Pogue, S. Reagan, K. Reinecke, and J. Tirpak. 2012. Allocation of Waterfowl Habitat Objectives within the Mississippi Alluvial Valley: An Analytical Framework and Results. Lower Mississippi Valley Joint Venture. 49 pp. Available for download at: <http://www.lmvjv.org/library/WWG_literature/WWGTS_AllocationReport_Approved_6-5-12.pdf>

Fredrickson, L. H., and M. E. Heitmeyer. 1988. Waterfowl use of forested wetlands of the southern United States: an overview. Pages 307-323 in M. W. Weller, editor. Waterfowl in winter. University of Minnesota Press, Minneapolis, Minnesota, USA.

Lower Mississippi Valley Joint Venture. 2007. Waterfowl Working Group Report to the Management Board—June 2007. Unpublished report, Lower Mississippi Valley Joint Venture. 55 pp.

Lower Mississippi Valley Joint Venture Management Board. 2013. Lower Mississippi Valley Joint Venture Operational Plan. Vicksburg, MS. 39 pp.

North American Waterfowl Management Plan, Plan Committee. 1986. North American Waterfowl Management Plan. Canadian Wildlife Service, U.S. Fish and Wildlife Service. 26 pp.

North American Waterfowl Management Plan, Plan Committee. 2004. North American Waterfowl Management Plan 2004. Implementation Framework: Strengthening the Biological Foundation. Canadian Wildlife Service, U.S. Fish and Wildlife Service, Secretaria de Medio Ambiente y Recursos Naturales. 106 pp.

Nelms, K. D. (editor). 2007. Wetland Management for Waterfowl Handbook. Mississippi River Trust, Stoneville, MS. Available for download at: <http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_016986.pdf >

Petrie, M., M. Brasher, and D. James. 2014. Estimating the biological and economic contributions that rice habitats make in support of North American Waterfowl. The Rice Foundation, Stuttgart, Arkansas, USA.

Reinecke, K. J., and C. R. Loesch. 1996. Integrating Research and Management to Conserve Wildfowl (Anatidae) and Wetlands in the Mississippi Alluvial Valley, U.S.A. Pages 927-940 in M. Birkan, editor. Anatidae 2000: an international conference on the conservation, habitat management and wise use of ducks, geese and swans: Strasbourg, France, December 5-9, 1994. Gibier Faune Sauvage, Game and Wildlife 13(3).

Reinecke, K.J., and R. Kaminski. 2006. Final revision of Table 5 (Duck energy-days; DEDs). Memorandum to LMVJV Waterfowl Working Group.

Strader, R.W., and P.H. Stinson. 2005. Moist-soil guidelines for the U.S. Fish and Wildlife Service Southeast Region. U.S. Fish and Wildlife Service, Migratory Bird Field Office, Jackson, MS.