# Estimating the Biological and Economic Contributions that Rice Habitats Make in Support of North American Waterfowl Populations

A Report to the Rice Foundation from Ducks Unlimited Inc.


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## Executive Summary

Virtually all of the rice grown in the U.S. is produced in California's Central Valley, the lower Mississippi Alluvial Valley, and the Gulf Coast of Texas and Louisiana. These areas overlap with North America's three most important wintering habitats, recognized by the North American Waterfowl Management Plan (NAWMP) as the Central Valley Joint Venture (CVJV), the Lower Mississippi Valley Joint Venture (LMVJV), and the Gulf Coast Joint Venture (GCJV). Over fifty percent of all dabbling ducks that winter in the U.S. occur in these three Joint Ventures.

Winter-flooded rice habitats provide forty-four percent of all the food energy available to dabbling ducks in the CVJV, and forty-two percent of the food energy available to dabbling ducks in the GCJV. Flooded rice habitats provide eleven percent of all dabbling duck food energy in the LMVJV. Winter-flooded rice habitats in the CVJV, LMVJV, and GCJV total just over one million acres. The capital costs of replacing these rice habitats with managed wetlands in order to provide a similar amount of food energy approaches 3.5 billion dollars.

Significant challenges exist in each of the three major rice landscapes. Water supplies used for winter-flooding are under increasing pressure in the Central Valley, and many producers may be forced to adopt straw decomposition practices that provide far fewer waterfowl benefits than winter flooding. In the Mississippi Alluvial Valley seed variety improvements now allow rice to be harvested in August and September, well in advance of waterfowl migration. The loss of rice seed to germination, decomposition, and consumption by other wildlife appears to be extensive after harvest and before waterfowl arrive. Research and extension programs that increase the feasibility of second crop or ratooned rice are needed to increase the amount of food provided by ricefields in the LMVJV. Long-term declines in rice acreage on the Gulf Coast, particularly on the Texas Coast, are especially worrisome. Halting this decline and winter-flooding a greater percentage of the acres that still remain will be necessary to meet the needs of GCJV waterfowl in the future. Policy makers and waterfowl managers need to fully understand the importance of rice to meeting the population goals of the NAWMP, and how difficult it may be to achieve these goals in the absence of rice.

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## Introduction

Virtually all of the rice grown in the U.S. is produced in California's Central Valley, the lower Mississippi Alluvial Valley, and the Gulf Coast of Texas and Louisiana (Figure 1). These areas overlap with North America's three most important wintering habitats, recognized by the North American Waterfowl Management Plan (NAWMP) the Central Valley Joint Venture (CVJV), the Lower Mississippi Valley Joint Venture, and 3) the Gulf Coast Joint Venture (GCJV; Eadie et al. 2008).

Waterfowl managers have long recognized the importance of the U.S. and Canadian prairies to breeding duck populations. Although the prairies include multiple states and provinces we tend to view the prairies in their entirety. Doing so has allowed us to better articulate the importance of these prairie landscapes to North American duck populations. While the waterfowl benefits of rice have been well documented at the field and regional level (Eadie et al. 2008), the contribution that rice makes in support of North American waterfowl populations is less understood. Documenting the biological importance of these rice habitats in the context of the North American Waterfowl Management Plan may provide the national recognition that these rice landscapes warrant.

Conservation efforts on behalf of wintering and migrating waterfowl continue to evolve. For much of our history those efforts focused on public lands and the establishment of state and federal refuges in areas where waterfowl traditionally concentrated. Beginning in the 1980's there was growing recognition that these efforts would have to be expanded to private lands if waterfowl needs were to be fully met. This awareness led to publically funded initiatives like the Wetland Reserve Program (WRP) that were largely aimed at retiring marginal farmland and restoring wetland functions on these retired properties. The WRP and similar set-aside programs continue to play a critical role in waterfowl conservation. However, public land efforts and set-aside programs on private lands need to be combined with actions that recognize and support the critical role that many working landscapes play in sustaining North American waterfowl populations. This is hardly a new idea.

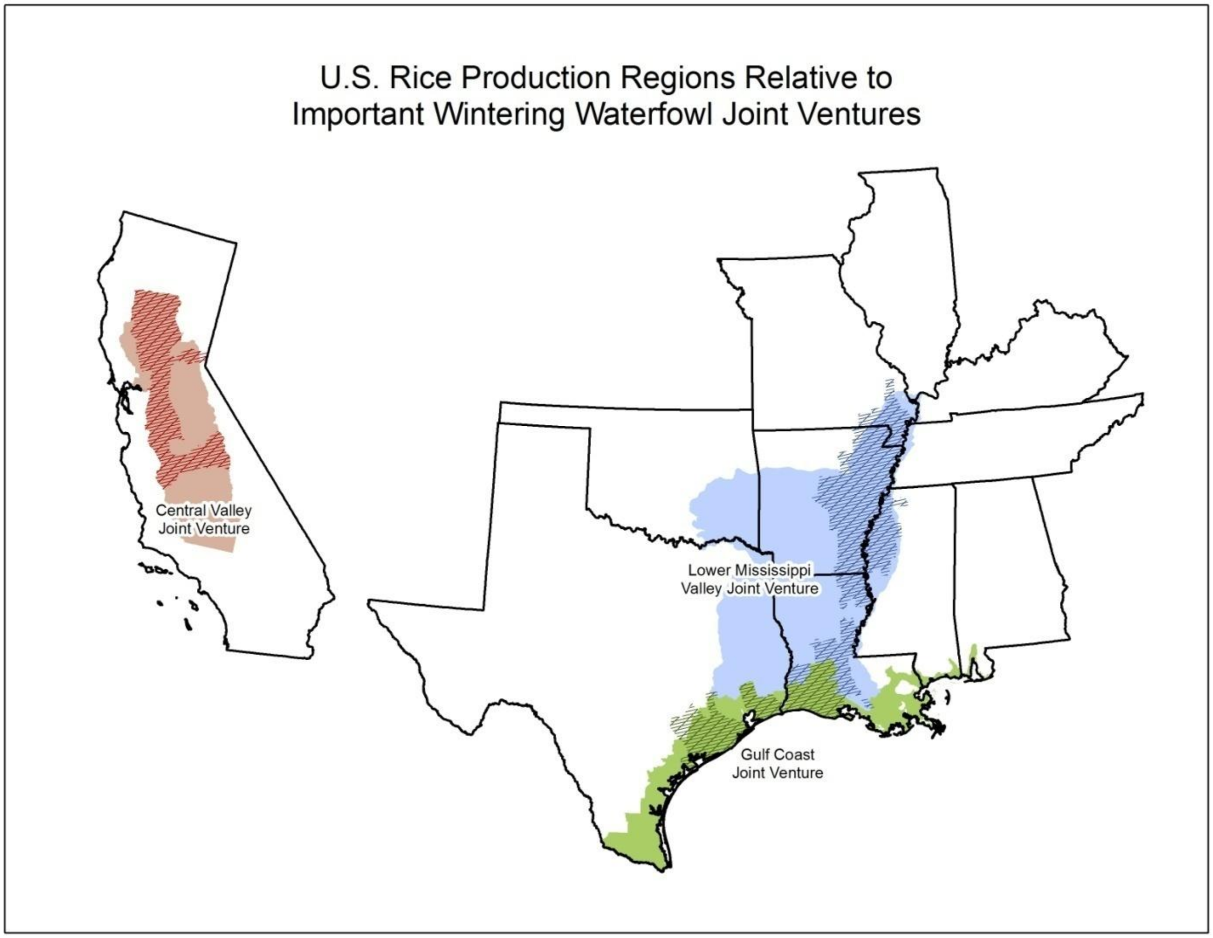


Figure 1. The distribution of U.S. rice production regions relative to the most important areas for wintering waterfowl in North America. Areas of rice production within a Joint Venture are indicated by cross-hatching.

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Ranchers in the U.S. prairies play a critical role in maintaining native grasslands and prairie wetlands, and conservation programs that recognize and support this kind of land stewardship have been in place for decades.

For wintering and migrating waterfowl rice production areas may be the most important of all working landscapes. Fifty percent of all dabbling ducks winter in the CVJV, LMVJV, and GCJV where they rely heavily on rice. Yet, many of these rice landscapes are under increasing pressure. Drought and declining rice acreage in Texas is already impacting Gulf Coast waterfowl populations, while California's record drought will result in less rice being planted and fewer acres being winter-flooded. Policy makers and waterfowl managers need to fully understand the importance of rice relative to the goals of the North American Waterfowl Management Plan (NAWMP), and how difficult it may be to achieve these goals in the absence of rice.

To better understand the contribution that rice habitats make in support of North American waterfowl populations we established the following objectives for this report; 1) Determine the biological importance of rice habitats relative to the population goals of the NAWMP , 2) Evaluate how declines in rice habitat may impact waterfowl populations, and 3) Estimate the financial cost of replacing U.S. ricelands with wetlands that provide a similar amount of food for wintering and migrating waterfowl.

## Rice Growing Regions

This section provides a general overview of current rice production in each of the major rice growing regions. The food resources provided by rice are dependent on the amount of rice grown, and on post harvest practices that determine the amount and availability of foods that remain in harvested rice fields. As a result, we discussed possible changes in rice acreage and post-harvest practices within each Joint Venture. This material serves as a background for model simulations described later in the report that attempt to quantify the effects of changing rice acreages and post-harvest practices on waterfowl.

### Central Valley Joint Venture

Rice production in the CVJV is concentrated in a six county area within the Sacramento Valley (Figure 2). Commercial production of rice began in Butte County in 1912. By 1930, more than 100,000 acres of rice were being planted annually. Rice production increased through the early 1950's and in 1954 over 500,000 acres were planted. Since 1954 rice acreage has ranged from a low of 228,000 acres to a high of 600,000 acres (Figure 3).

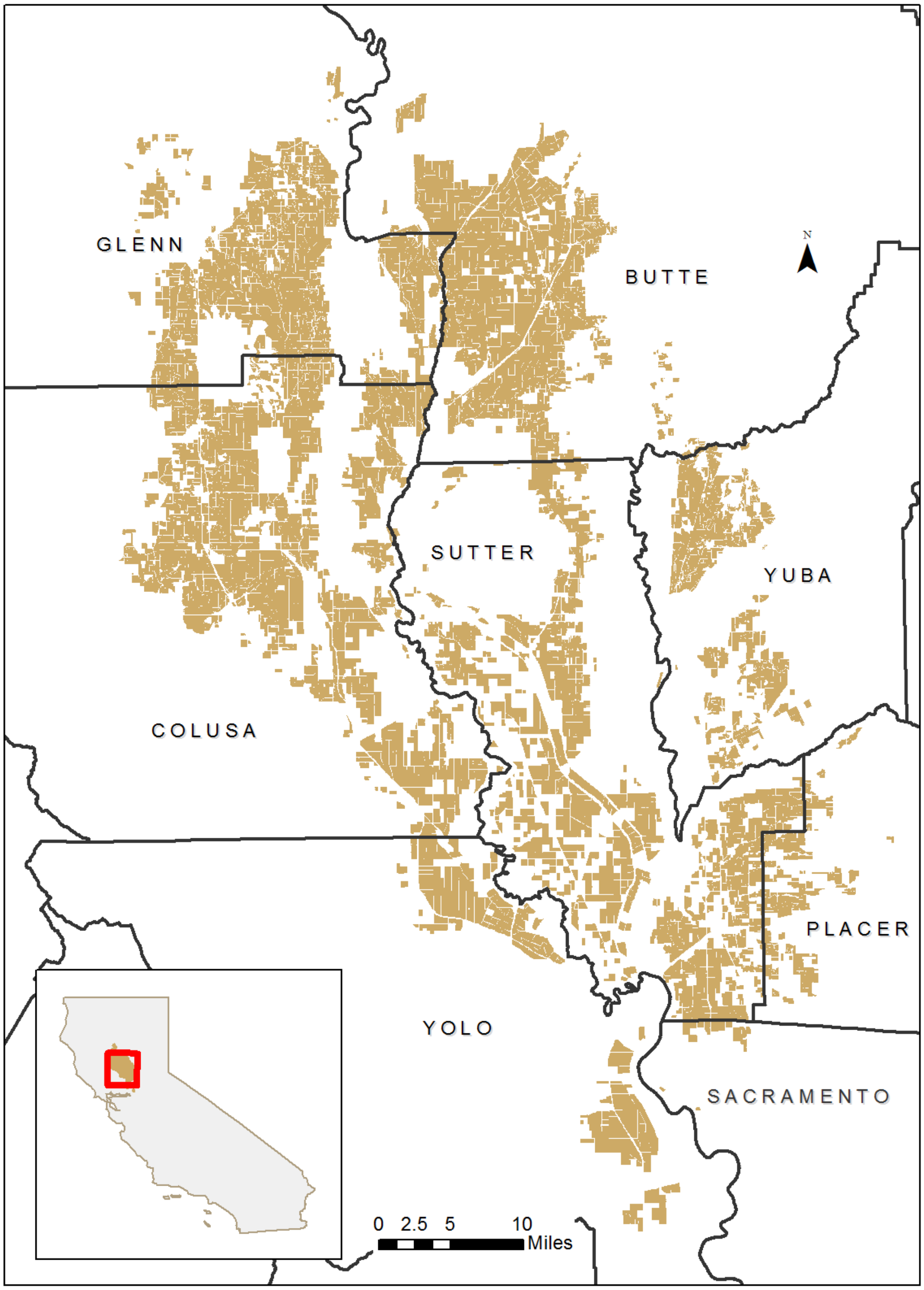


Figure 2. Areas of rice production in the Sacramento Valley. The Sacramento Valley constitutes the northern half of California's Central Valley.

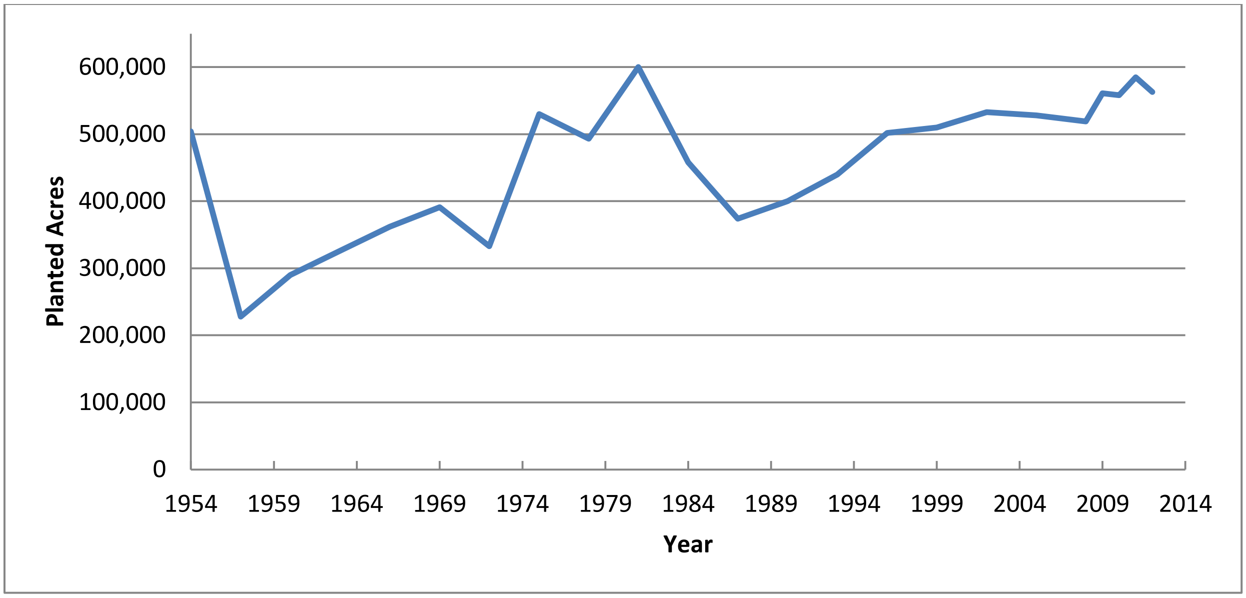


Figure 3. Acres of planted rice in the Central Valley between 1954 and 2012.

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Over the past five years Central Valley farmers have harvested an average of 557,200 acres of rice, most of which is planted to short and medium grain japonica rice. The Central Valley produces over two million tons of rice annually making California the second largest rice growing state in the nation and contributing over 1.8 billion dollars to the state's economy (California Rice Commission 2013).

Rice acreage in the Central Valley has been generally stable over the past decade (Figure 3). This stability may partially be due to the growing importance of Japan as a market for California rice. Under World Trade Organization tariff-rate-quota arrangements Japan has become a stable and significant importer of California rice.

The amount of rice straw remaining in harvested fields in the Central Valley can exceed 5000 lbs/acre (Bird et al. 2000). Rice straw is high in silicate and other components that make it difficult to decompose, unlike the straw of wheat or other small grains. Eliminating this straw before the growing season is necessary to improve seedling establishment and reduce the likelihood of disease. Prior to the early 1990's, burning was the principal method of straw disposal used by

California rice producers. Burning was both inexpensive and an effective means of disease control. However, burning was largely phased out as a decomposition alternative under the Rice Straw Burning Reduction Act of 1991 (AB-1378). Today, less than 10% of all harvested rice fields are annually burned in the Sacramento Valley.

Burning is a waterfowl-friendly practice. Although fire is effective at removing straw most waste rice seeds survive the burning process. Moreover, burning exposes waste rice seeds at the soil surface making them more easily consumed by waterfowl**.** Prior to the burn ban, rice producers purposely flooded between 60,000 and 80,000 acres of harvested fields to provide duck hunting opportunities (Eadie et al. 2008). However, burned fields that were not flooded still provided the majority of food available to ducks and geese in the Central Valley during this time. These "dry" fields were often made more attractive by rainfall that puddled in a field and provided shallowly flooded habitat.

The period following the burn ban was one of transition for the rice industry. Rice producers still needed an economic way to dispose of straw and limit disease problems. In general, they had three options; 1) bailing the straw and removing it from the field, 2) incorporating rice straw into the soil by plowing or disking with no intentional flooding (dry incorporation), and 3) incorporating rice straw into the soil by disking and rolling followed by intentional flooding (winter-flooding). Each of these options had different implications for waterfowl and other wetland dependent birds.

Bailing proved to be unfeasible. There were limited markets for rice straw and rice straw products, and the cost of bale transport was high. Some growers did turn to dry incorporation as a means of disposal. However, the number and type of field operations needed to achieve a good straw/soil mixture could be affected by field type. Rice growing soils are finely textured and tend to be wet, heavy, and hard to penetrate, making incorporation more difficult. In addition, temperature, moisture, and available oxygen are all essential factors affecting decomposition. The majority of producers did not adopt this option following the burn ban. Presumably, they judged the costs of dry incorporation too high or were not satisfied with the level of decomposition achieved. The higher costs of dry incorporation may have included higher fuel costs associated with multiple field passes, higher fertilizer costs because straw was not fully decomposed by spring, and greater seedbed preparation costs.

In contrast, winter flooding quickly became a popular approach for decomposing straw. A decade after the burn ban over 350,000 acres of harvested rice fields were being fall flooded, or nearly 70% of the planted rice base (CVJV 2006). Winter flooding not only provided an economic means to decompose rice straw it provided tremendous waterfowl benefits. Moreover, the feeding activity of waterfowl further mixes the straw and soil and contributes to the decomposition process (Eadie et al. 2008). It was a classic win-win: an economical farming practice that provided most of the habitat in an area hosting one of the highest densities of wintering waterfowl in the world.

The feasibility of winter flooding as a decomposition alternative is dependent on reliable and affordable water supplies. During the winters of 2007 and 2008, dry incorporation of harvested rice fields reached record levels (Miller et al. 2010). The reason for this was likely two-fold. Rice growers were learning how to better incorporate straw into soil to achieve acceptable levels of decomposition even without flooding. Second, a smaller amount of water was expected to be available for winter flooding in these two years. The previous winters had been very dry and the state had proposed reducing water deliveries to maintain water quality in the Sacramento-San Joaquin River Delta. Although these water bans were not enacted, many rice growers were under the impression that *less water would be available*. Because growers need a reliable method for decomposing straw some undoubtedly sought options other than winter flooding.

Long-term trends in straw decomposition alternatives could have substantial impacts on the value of rice habitats to waterfowl. Although burning is a waterfowl friendly practice it will never again be practiced on a wide scale in the Central Valley. To date, bailing has not proved to be an economically feasible method of straw removal. Still, market forces can change and it's important to understand the impacts of bailing on waterfowl if the practice was to become widespread. A recent study in California examined the effects of bailing on waterbird use of winter flooded rice fields. Duck densities were seven times higher in fields that were not baled prior to flooding compared to fields that were baled, while shorebird densities were twelve times higher in non-baled fields (Sesser et al. 2013).

Changes in the current balance of straw decomposition alternatives will most likely involve winter-flooding and dry incorporation. To what extent dry incorporation reduces the foraging value of harvested rice fields to waterfowl has not been formally studied in California. However, a recent study in Arkansas examined the effects of five post-harvest treatments on the abundance of waste rice in unflooded fields (stubble left standing, burned, mowed, rolled, and disked). Late autumn abundance of waste rice was lowest for disked fields when waste rice was sampled to a depth of 10 cm, and the authors recommended against this practice because of decreased waste rice abundance (Kross et al. 2008). To what degree dry incorporation reduces the abundance of waste rice in California rice fields is probably dependent on the field implements used, the number of field passes made, and extent to which rainfall softens the soil and makes subsurface waste rice more easy to obtain. However it's reasonable to assume that winter flooding, not dry incorporation optimizes foraging conditions for ducks.

California is now in a record drought as a result of three years of below average precipitation. Surface water supplies that have traditionally been used to winter-flood rice may be unavailable in 2014, and there is speculation that only landowners with access to groundwater supplies will have the option to flood. In addition, planted rice acreage may be substantially reduced compared to the previous five years.

The ongoing drought in California has already reduced winter-flooding of rice in much of the Sacramento Valley. In fall 2013, the California State Water Board began imposing restrictions on water diversions. The result was a significant decline in the amount of winter- flooded rice west of the Sacramento River (Figure 4). Winter- flooding of rice east of the Sacramento River was less affected, presumably because of the seniority of water rights associated with east side diversions. Mid-winter surveys of waterfowl in the Central Valley during January, 2014 were consistent with this disparity in winter-flooded rice, with large concentrations of ducks observed east of the Sacramento River and few birds observed west of the river (USFWS 2014).

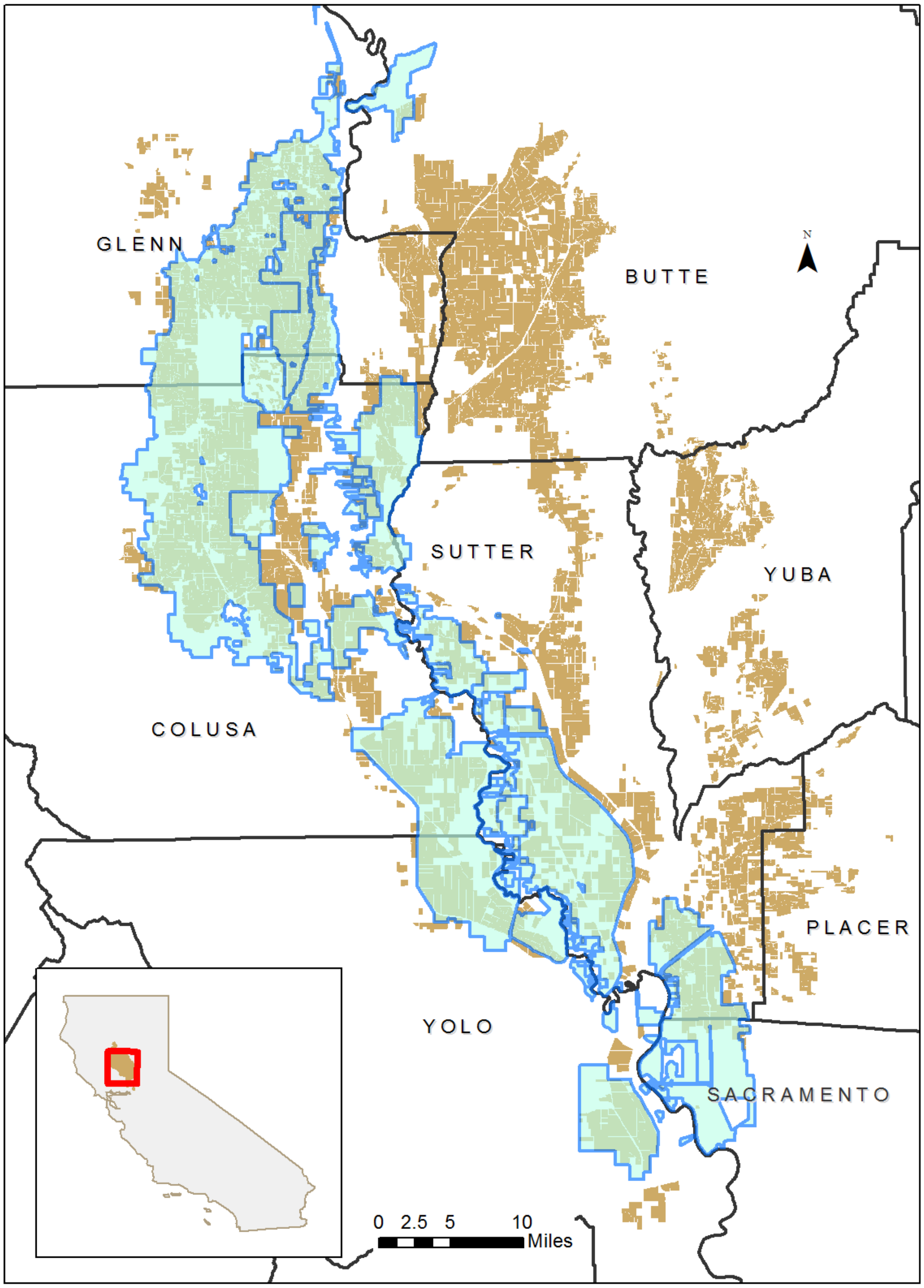


Figure 4. Areas of rice production in the Sacramento Valley (outlined in blue) where surface water supplies for winter-flooding of harvested ricefields was restricted in fall 2013.

With the drought worsening, the restrictions on surface water diversions for winter-flooding are likely to impact the entire Sacramento Valley in 2014.

Water supplies for winter-flooding of rice are not only being impacted by drought. There are few, if any, environmental issues in California that rival the debate over instream flows in the Sacramento River and the downstream effects on endangered fish species. Most of the water used for winter flooding of rice originates from the federally operated Central Valley Project and the State Water Project. Both of these water projects store water in upstream reservoirs that is released as needed for beneficial uses, and both projects must be operated in a manner that meets the needs of endangered fish species and other public trust resources. To meet these obligations, instream flow and water quality standards have been established for the Sacramento River and the Sacramento – San Joaquin River Delta (the Delta).

Water supplies used for winter-flooding are now being eyed by agencies responsible for meeting in-stream flow requirements in the Sacramento River and the Delta and by NGO's concerned with ESA fish. None of this suggests that these water supplies will become more available, predictable, or cheaper in the long-run. Interests that argue for less winter flooding can rightly point out that this practice occupies a small window in the history of California rice. However, this ignores the legal reality that we cannot return to large scale burning, a practice that was consistent with waterfowl needs. Rice producers that otherwise would have used winter flooding to decompose straw may have to increasingly rely on dry incorporation because of unavailable or unaffordable water supplies. Understanding how this shift in decomposition alternatives may affect waterfowl is critical.

<u>Lower Mississippi Valley Joint Venture</u>

Rice cultivation in the lower Mississippi Alluvial Valley (MAV) first occurred on a small scale around 1900. Today nearly 2 million acres of long and medium grain rice is grown throughout the delta regions of Arkansas, Mississippi, Missouri and Louisiana, as well as the non-delta Grand Prairie of Arkansas (Figure 5). Arkansas is currently the largest producer of rice in the U.S., planting and harvesting nearly 48% of all rice acres . Regionally Arkansas produces 72% of all rice in the MAV followed by 10 percent in Mississippi and nine percent in the Missouri and Louisiana portions of the MAV. Rice production and processing play important roles in each of the MAV states with rice farmers and millers contributing nearly $10 billion to the region's annual economy and accounting for over 40,000 jobs (Richardson and Outlaw 2010).

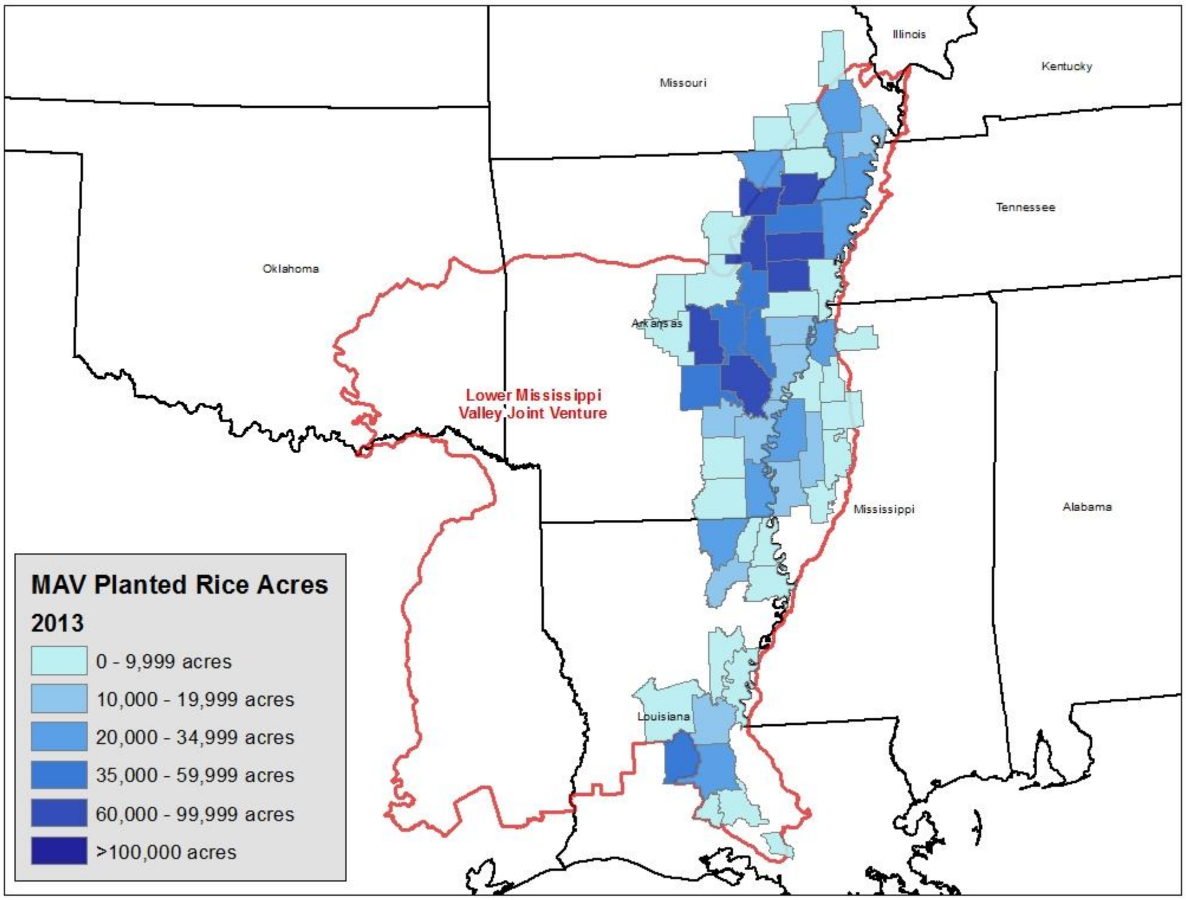


Figure 5. Distribution of rice production in the Mississippi Alluvial Valley (MAV).

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Historically, rice fields in the MAV produced only a single crop each year with harvest occurring late enough in fall to provide an abundance of waste rice for waterfowl (Reinecke et al. 1989). However, changes in the timing of harvest appear to have significantly reduced rice food supplies for waterfowl. Over the last two decades, rice farming in the MAV has changed as a result of rice variety improvements, compressed planting and harvest dates, and increased growing season length. Most studies indicate that waste rice has remained abundant in rice fields as it is positively correlated with rice yields (Miller et al. 1989, Stafford et al. 2010). However, most rice fields in the MAV are now harvested in late summer (August-September), several months prior to the arrival of most wintering waterfowl (November-December). Thus waste rice has more time to decompose, germinate and be consumed by other wildlife making less rice available for wintering waterfowl (Manley 2005, Eadie et al. 2008).

Volunteer ratoon or second crop rice is becoming increasingly common in the MAV due to development of rice varieties that mature more rapidly and are more tolerant to cold temperatures (Stafford et al. 2010). Recent research In Arkansas suggests ratoon crop yields range from ~630 lbs/acre with no inputs to ~1620 lbs/acre with significant inputs of fertilizer (Roberts et al. 2012). Emergence of the ratoon crop is potentially a very important development for wintering waterfowl in the MAV, and could increase food energy availability and carrying capacity for waterfowl over that provided by harvested single crop rice fields. To what extent this practice can become more common is currently unknown, however this report will examine the potential effects of rice availability from ratoon crops on waterfowl carrying capacity in the LMVJV.

Most of the rice produced in the MAV is planted using conventional tillage methods which includes fall tillage followed by spring tillage to prepare the seedbed. Various methods are implemented to manage straw stubble for the next crop including burning, tilling, rolling and winter-flooding. Many of the post-harvest and water supply issues faced in other rice growing regions such as the Central Valley and Gulf Coast will need to be monitored and evaluated in the MAV. As with most of the U.S., measures to maintain and sustain water supplies for rice agriculture in the MAV will be important. Most ricelands in the MAV are underlain by the Sparta and the Mississippi River Valley Alluvial Aquifers which are the primary sources of irrigation (Popp et al. 2004, Clark and Hart 2009). In eastern Arkansas alone about 4 million acres of cropland is irrigated from groundwater derived from these aquifers. In many areas, ground water pumping rates often exceed recharge rates which have caused ground water levels to decline. Water level data within the alluvial aquifer of Arkansas suggests an average decline of 0.6 ft/yr from 1975-2000 (Shrader 2001). Because rice farming relies heavily on water use, increased attention has been focused on improved utilization of groundwater resources and capture of surface water via on-farm reservoirs, tail water recovery systems and other water conservation practices (Popp et al. 2004). As water usage in this region increases, any efforts that have the ability to increase water conservation will ultimately help sustain riceland habitats important to wintering waterfowl in the LMVJV.

Gulf Coast Joint Venture

Rice production first appeared on the Gulf Coast during the mid 1800s in the parishes and counties of southwest Louisiana and southeast Texas. By the early 1900s, rice agriculture had become more profitable and was expanding into the Mid-Coast of Texas. Rice farming along the Gulf Coast is associated with the historical coastal prairies of Texas and Louisiana because of its relatively flat topography and limited subsoil permeability, thus supporting the shallow flooding conditions required for successful rice production (Figure 6). The coastal tallgrass prairies of Louisiana and Texas once covered over 2.5 million acres from Lafayette to Corpus Christi, extending inland 20-100 miles from the adjacent coastal marshes (Smeins et al. 1991). Historically, minor variations in topography and the relatively poorly drained soils of the coastal prairies resulted in high densities of seasonal wetland basins interspersed among vast grassland tracts. When flooded by winter rains or autumn tropical storms, these basins provided valuable foraging habitat to numerous waterfowl and other waterbirds that spend winter months in this region. Most of these natural wetlands were converted to alternative land uses as the region was settled and agriculture expanded. Rice agriculture established a dominant footprint on the landscape, and because of its requirements for a wetland-based production system, proved an effective replacement for many of the wetland functions once provided by natural wetlands, including habitat for wintering waterfowl and other migratory waterbirds.

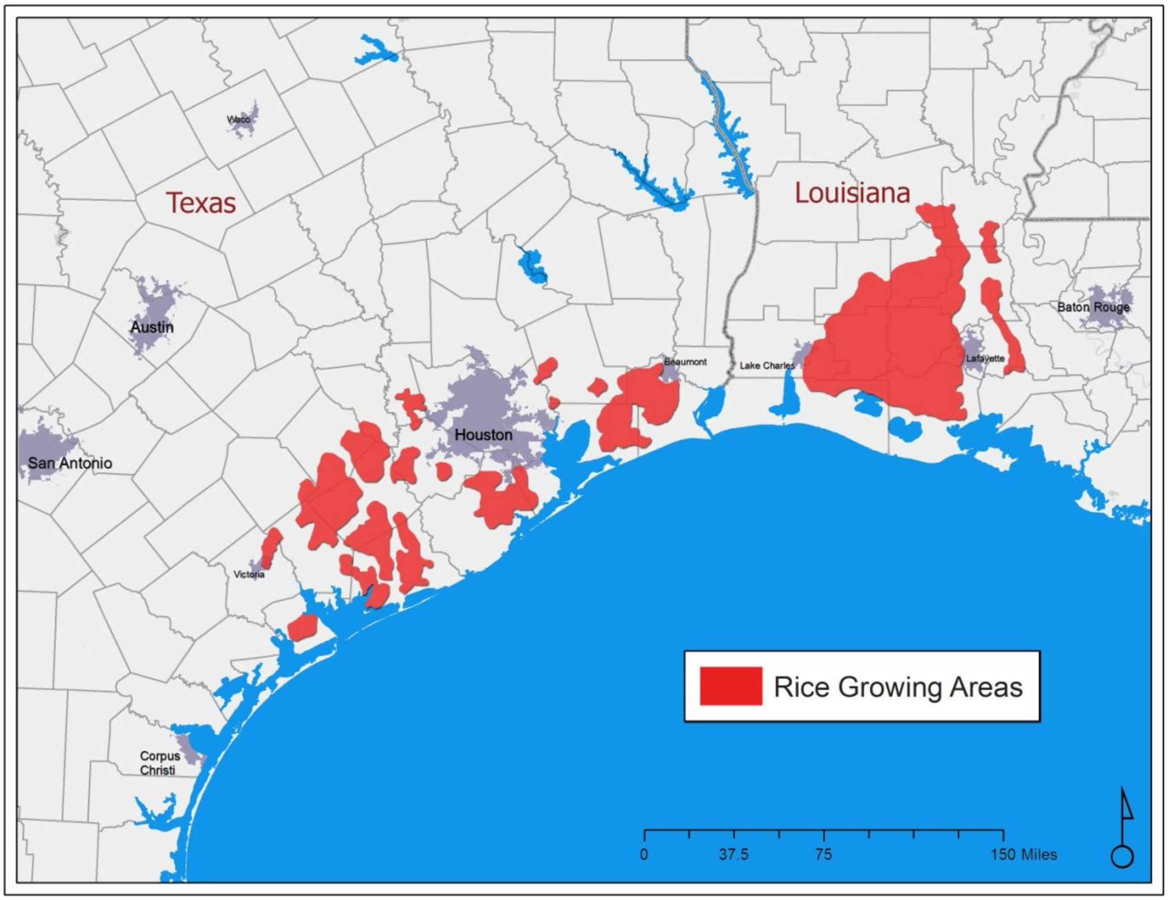


Figure 6. Distribution of rice production on the Gulf Coast.

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Rice agriculture expanded rapidly in the Gulf Coast following the turn of the 20th century, and until 1950 Louisiana and Texas annually accounted for greater than 60% of the total U.S. rice acreage. For more than a half-century, Louisiana and Texas led the nation in annual rice acreage, peaking in 1954 with a combined 1.3 million acres. Louisiana and Texas were overtaken as the leading rice producers in the mid-1970s, not because of declines in production within their boundaries, but rather by explosive growth of the rice industry in Arkansas. In fact, with a few notable exceptions, rice production in Louisiana and Texas was relatively stable from 1941 – 1982, averaging 1 million acres annually and varying from 896,000 – 1,324,000 acres. While rice production was slowly expanding into the Mississippi River floodplain in northeast Louisiana, the vast majority (>82%) of the Louisiana acreage was still being produced in the coastal parishes.

Patterns of rice production along the Gulf Coast began to change dramatically in the 1980s (Figure 7). Average rice acreage in coastal Texas and Louisiana from 1970 – 1982 was approximately 982,000 acres. Responding to excessive global production and depressed rice prices, a Federal Acreage Reduction Program was implemented in 1983 (i.e., Payment in Kind; Brewer 1984), resulting in Gulf Coast rice production immediately dropping to 582,000 acres during the 1983 growing season, a level not seen since 1935.

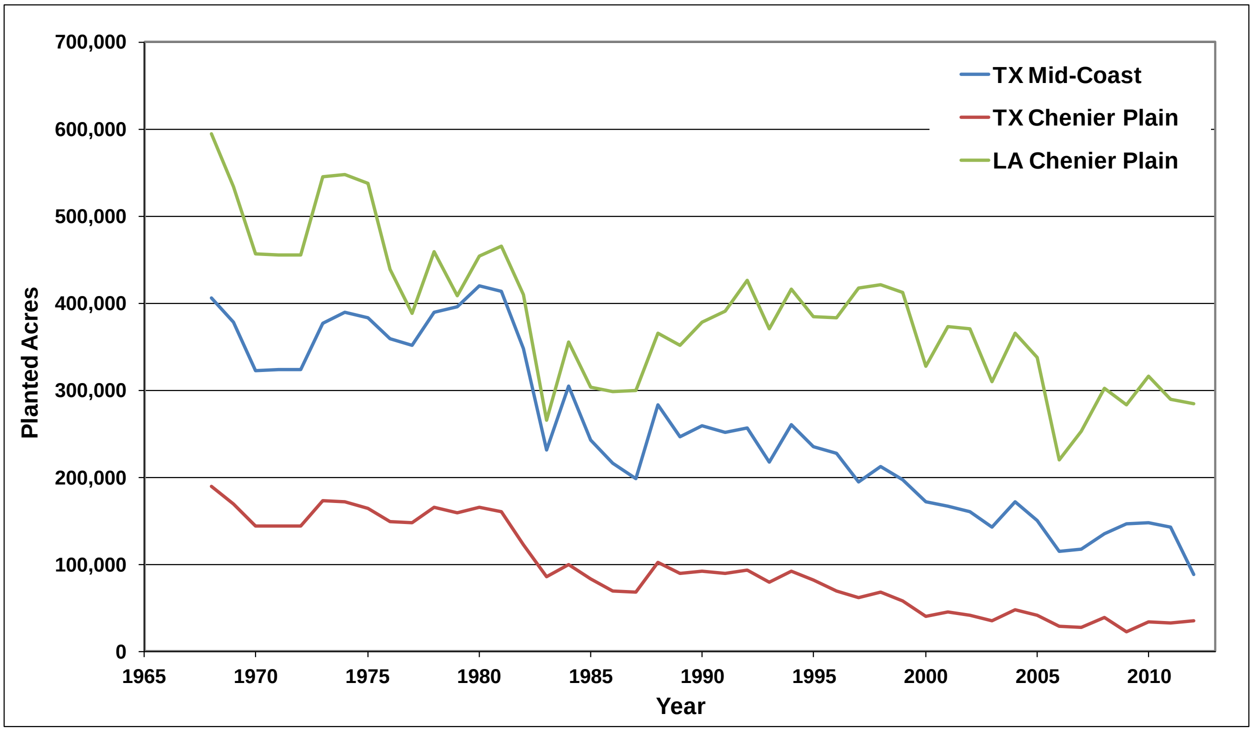


Figure 7. Planted rice acreage, 1965 – 2012, in three Initiative Areas where rice is grown in the Gulf Coast Joint Venture region

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While rice production in Louisiana and other states generally recovered from these policy-driven declines, and many even increased, the same was not true for Texas. A number of factors were emerging to make rice production on the Texas coast an increasingly costly and challenging proposition. Among these were rising land prices, higher land opportunity costs, and increased competition and higher costs for limited water, all of which were driven largely by a burgeoning human population in the Houston metropolis that was expanding westward into several rice growing regions. These factors, coupled with depressed long-grain rice prices and increases in costs of other agricultural inputs, made it increasingly difficult for Texas rice farmers to maintain profitable operations. From a high of 642,000 acres in 1954, rice production in Texas declined to 320,000 acres by 1983. Although there were minor recoveries in subsequent years (e.g., 410,000 acres in 1984; 390,000 acres in 1988), the overall decline continued. From 2007 – 2011, average rice acreage along the Texas coast was 168,600 acres, representing a 67% decline (i.e., decrease of 349,000 acres) from the 1970s (i.e., average annual production of 517,700 acres).

Following the steep declines of 1983, rice acreage in coastal Louisiana recovered to an average of 402,000 acres annually during the 1990s. Beginning in 2000, however, coastal Louisiana rice production entered a gradual decline, driven by higher production costs, depressed rice prices, and impaired riceland productivity caused by saltwater storm surge resulting from several strong hurricanes that impacted southeast Texas and southwest Louisiana. From 2007 – 2011, average planted acreage in coastal Louisiana was approximately 290,000 acres, representing a 39% decline (i.e., decrease of 186,000 acres) from the 1970s (i.e., average annual production of 476,000 acres). Among U.S. rice growing states, only Texas and Louisiana have experienced declining trends in rice acreage from the 1970s, and these declines may continue and possibly intensify in the future (Baldwin et al. 2011).

Although no single factor was responsible for past declines in Gulf Coast rice acreage, the factor potentially having the greatest impact on future trends is the availability and affordability of reliable water supplies. In no place has this become more evident and immediate than the Texas Mid-Coast (TMC). Within the TMC, rice is grown primarily in the counties of Brazoria, Calhoun, Colorado, Fort Bend, Jackson, Matagorda, Waller, and Wharton, which encompass the rice prairies west and southwest of Houston. The primary sources of water for rice production along the Texas coast are either from groundwater wells or surface water provided by various irrigation districts. The primary provider of water to irrigation districts in the TMC is the Lower Colorado River Authority (LCRA), providing water to approximately 42% (60,000) of the rice acreage in this region from 2007-11. The primary reservoirs for LCRA storage water are Lakes Buchanan and Travis, upstream of Austin, Texas. The timing and rate of water releases from Lakes Buchanan and Travis are determined by municipal, industrial, agricultural, recreational, and environmental demands, but subject to release triggers based on combined storage levels outlined in the state-approved LCRA water plans. During March 2012 and in response to drought-induced low lake levels, LCRA curtailed irrigation water for downstream rice farmers for the first time in its history. This decision led to an immediate 52,000 acre reduction in planted rice on the TMC, representing a 30% decline from state-wide totals in 2011. With lake levels still suffering from the persistent drought, LCRA once again curtailed the release of water for downstream rice farmers in 2013 and 2014. The short-term economic and environmental impacts of these decisions have been substantial, yet it is the consequences of additional curtailments on the longer-term future of a rice-based agricultural economy in the Texas Mid-Coast that are of greatest concern.

While declines in rice agriculture are concerning across all U.S. rice-growing regions because of the impact it will have on abundance of wintering waterfowl habitat, several unique aspects of Gulf Coast rice agriculture enhance their ecological value and amplify the worry about their decline. The greatest difference is the growth of a second crop of rice immediately following the first harvest (i.e., ratoon crop) in ricefields of the Gulf Coast region. Owing to the region's long growing season and early maturing varieties, ratoon rice production became possible on large scales in coastal Texas and Louisiana during the 1960s, and now 30 – 65% of acres are ratooned annually, depending on location. Harvest of the first crop normally occurs during late July – early August, after which the field is fertilized and reflooded to encourage growth of the ratoon crop. The ratoon crop is harvested October - November, although low yields may result in some ratoon crops being unharvested. Residual rice and natural seed biomass is greater in post-harvest ratoon fields than following harvest of the first crop (Marty 2013), and because the timing of ratoon harvest is generally coincident with arrival of migrating waterfowl into the Gulf Coast region, these fields provide an immediate and abundant source of high quality waterfowl foods when flooded after harvest. This second pulse of rice and natural seeds compliments that made available following first harvest. This contrasts with what occurs in other rice growing regions where germination and consumption by other granivorous animals following a single harvest in August can substantially reduce the abundance of residual rice by the time waterfowl arrive several months later.

Gulf Coast ricelands also differ from other regions in their rotational cropping systems. In most regions, rice cultivation is rotated annually with soybeans or another grain crop as part of a weed control or soil fertility management system. On the Gulf Coast, however, soil properties and a warm, humid climate provide few opportunities for rotational crops. Instead, rice fields are often left idle or used for crawfish aquaculture during years when not in active rice production. In Louisiana, this normally occurs as a 2-year rotation cycle, where fields rotate every other year between active rice production and an idled state (or crawfish production). In Texas, a 3-year rotation is typical, where rice is grown the first year and the field remains idle the subsequent 2 years. It is worth noting, however, that substantial variation exists among regions, producers, and fields in the precise details of how a rotation system is developed and applied. Nevertheless, generally speaking, for each acre of active rice there are approximately 1 – 2 acres of riceland that has been idled or used for crawfish production. A small percentage may be planted to an alternate crop, most often soybeans. Idled ricelands frequently become established with annual grasses and sedges, producing seed densities that rival those of intensively managed moist-soil impoundments and making them another important source of high quality foraging resources when flooded (Marty 2013). Beyond their value as potential foraging habitat for wintering waterfowl, idled ricelands function to some extent as surrogate grasslands, providing potential nesting habitat for breeding mottled ducks and migratory landbirds. Indeed, the ecological values of Gulf Coast ricelands are diverse and extensive, and quantifying these values is essential to understand the potential impact of declining acreage on the wildlife that depends upon them.

## Methods

We used the bioenergetic model TRUEMET to evaluate the importance of rice agriculture to migrating and wintering waterfowl within the CVJV, LMVJV, and GCJV. TRUEMET has been used by several Joint Ventures to estimate waterfowl population energy demands and evaluate habitat conditions for waterfowl during specified time periods of the non-breeding season (CVJV 2006, Petrie 2013, Petrie et al. 2013). Population energy demand is a function of period specific population objectives and the daily dietary energy requirement of individual birds during that period. Population energy supply is a function of the foraging habitats available and the biomass and nutritional quality of foods contained in these habitats. A comparison of energy supply vs. energy demand provides a measure of how well existing habitats meet the energy needs of target waterfowl populations. Conceptually, TRUEMET is a daily ration model (Goss-Custard et al. 2003) with a model structure that assumes birds are ideal free foragers that do not incur costs associated with travelling between patches (e.g., moving between ricefields). There are seven explicit inputs required for each model run:

1) Number of days or time periods being modeled within the overall season of interest.

2) Population objectives for each waterfowl foraging guild during each time period.

3) Daily energy requirement of a single bird within a foraging guild.

4) Acreage of individual habitat types available during each time period.

5) Biomass of food in each habitat at the start of the overall season of interest.

6) Nutritional quality (i.e. metabolizable energy content) and decomposition of each food type.

7) Habitat types used by each waterfowl foraging guild to satisfy daily energy requirements.

Where appropriate, we tried to standardize these model inputs across Joint Ventures. However, the assumptions made by the CVJV, GCJV, and LMVJV sometimes differed. To increase the likelihood that our results would be relevant to existing conservation planning efforts, we adopted Joint Venture specific assumptions when necessary.

Note to Reader: All tables and figures associated with the “Model Inputs” section below are found in Appendix I. The single exception is a table that describes the mid-winter distribution of dabbling ducks in the U.S. for Joint Ventures where rice is grown and Joint Ventures where rice is not grown. Tables and figures that have been relegated to Appendix I are identified with an “A” prefix (e.g. Table A-1).

Model Inputs

*Number of Days and Time Periods Modeled.*--For all Joint Ventures population energy demand and supply was modeled at fifteen or sixteen day intervals depending on total numbers of days within a month. However, the total number of days within the overall season of interest varied among Joint Ventures, reflecting differences in migration chronology and the time periods upon which existing conservation planning efforts are based. Migrating and wintering waterfowl in the CVJV and GCJV were assumed to be present from mid-August through the end of March, while waterfowl in the LMVJV were assumed to be present from the beginning of October through the end of March.

*Waterfowl Foraging Guild Population Objectives.* -- Joint Ventures generally recognize three waterfowl foraging guilds; 1) dabbling ducks, 2) diving ducks, and 3) geese. Dabbling duck population objectives included all dabbling duck species present in a Joint Venture with the exception of wood ducks. We excluded wood ducks from the dabbling duck guild as they largely occur in non-rice habitats within each Joint Venture. However, wood ducks were included as a separate foraging guild for some LMVJV simulations when rice was being modeled in conjunction with foraging habitats that are heavily used by both wood ducks and other dabbling duck species. Because diving ducks do not typically forage on rice we did not incorporate population objectives for this foraging guild for either the CVJV or LMVJV. However population objectives for diving ducks were required for some GCJV simulations where multiple foraging habitats were being modeled, and diving ducks and dabbling ducks overlapped in the use of these habitats.

Population objectives were incorporated for geese in each Joint Venture. Although this report focuses on dabbling ducks, geese also rely heavily on residual seed and green browse that is available in harvested rice fields (Hobaugh 1984). Geese are exploitive competitors that potentially reduce the amount of food available to dabbling ducks. Thus, it was necessary to model the competitive effects of geese to properly estimate the food energy provided by rice for dabbling ducks. However, we also evaluated the importance of rice to geese where data permitted.

Dabbling Ducks.--The North American Waterfowl Management Plan (NAWMP) established continental breeding population goals for common dabbling duck species based on observed abundances in primary breeding areas during the 1970's (NAWMP 1986). Continental breeding population goals have been translated into mid-winter population objectives for Joint Ventures that support migrating and wintering waterfowl using a process that incorporates mid-winter waterfowl survey data, county-level harvest data, and estimate of winter survival (Reinecke and Loesch 1996, Koneff 2003). Application of a consistent process for linking winter waterfowl population objectives and associated habitat objectives to a singular continental population goal enables efficient regional-scale conservation planning (Petrie et al. 2011). For our analyses, application of a consistent method for establishing winter population objectives ensures reliable and coherent comparisons among rice growing regions.

Mid-winter dabbling duck population objectives for U.S. Joint Ventures are presented in Table 1. Fifty-four percent of the total mid-winter dabbling duck objective is assigned to Joint Ventures that overlap with U.S. rice-growing regions. These three Joint Ventures and the habitats they provide are particularly important for northern pintail, collectively accounting for 70% of the species' continental mid-winter objective. Although these population objectives provide a direct connection to the NAWMP they are specific to early January and do not account for temporal variation in wintering waterfowl abundance. Because our model runs span several months, period-specific population objectives that are connected to the NAWMP goal were needed. One method for generating period specific population objectives is to use periodic waterfowl surveys to characterize migration chronology within a Joint Venture. Many state and federal natural resource agencies conduct monthly or semi-monthly surveys during fall and winter to monitor trends in waterfowl abundance and distribution. Joint Ventures can use these data to calculate average period-specific migration chronologies across a range of years and then express these values as a percentage of the mid-winter population objective.

Table 1. Mid-Winter population goals derived from the NAWMP for dabbling duck species that occur in U.S. Joint Ventures where rice is produced vs. U.S. Joint Ventures where no rice is produced.

| Dabbling Duck Species | CVJV[a] | GCJV[a] | LMVJV[a] | Rice JV's Total[b] | "Other" U.S. JV's[c] | Rice JV's %[d] |
|---|---|---|---|---|---|---|
| Mallard | 709,391 | 891,623 | 3,347,409 | 4,948,423 | 7,986,084 | 38.3 |
| Pintail | 2,480,719 | 1,797,285 | 901,516 | 5,179,520 | 2,138,419 | 70.1 |
| Mottled Duck | 0 | 470,504 | 47,224 | 517,728 | 41,356 | 92.6 |
| Black Duck | 0 | 564 | 47,616 | 48,180 | 1,590,809 | 2.9 |
| Gadwall | 109,207 | 1,214,830 | 570,655 | 1,894,692 | 410,887 | 82.2 |
| Wigeon | 1,151,017 | 695,778 | 333,637 | 2,180,432 | 1,560,665 | 58.3 |
| Green-Winged Teal | 492,566 | 1,414,918 | 464,001 | 2,371,485 | 807,529 | 74.6 |
| Blue-Winged Teal | 0 | 218,500 | 0 | 218,500 | 0 | 100.0 |
| Cinnamon Teal | 2,330 | 0 | 0 | 2,330 | 0 | 100.0 |
| Shoveler | 601,335 | 350,696 | 175,367 | 1,401,270 | 409,221 | 77.4 |
| Wood Ducks | 124,424 | 354,448 | 1,961,936 | 2,440,808 | 2,806,432 | 46.5 |
| Whistling Ducks | 0 | 3,400 | 0 | 3,400 | 1,600 | 68.0 |
| Total Dabblers | 5,670,989 | 7,412,546 | 7,849,362 | 20,932,897 | 17,753,002 | 54.1 |

[a] Joint Ventures where rice is produced

[b] Total mid-winter population goals for rice producing Joint Ventures

[c] Combined mid-winter population goals for U.S. Joint Ventures where no rice production occurs. These goals include portions of this U.S. that are not contained within a Joint Venture boundary.

[d] Percent of total mid-winter population goal (rice producing and non-rice producing Joint Ventures combined) that occur in rice producing Joint Ventures.

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The mid-winter objective is then multiplied by each of these percentages to generate period-specific population abundance objectives that maintain a connection to the NAWMP (Petrie et al. 2011). We used this method to generate period specific population objectives for the CVJV where migration was determined from bi-monthly surveys of waterfowl in the Central Valley between September and March (Fleskes et al. 2000; Table A-1). However, slight variation exists in how Joint

Ventures have extrapolated mid-winter population objectives to period-specific population objectives.

Reinecke and Loesch (1996) did not use migration chronology to establish period-specific population objectives for the LMVJV. Instead, they assumed a 110 day average wintering period (mid- November to mid-February) and multiplied this by their mid-winter population objective to calculate duck energy day (DED) objectives for the LMVJV. A DED is defined as the amount of dietary energy needed to support an average sized duck for one day. Thus, a single duck residing in the LMVJV for 110 days is equal to 110 DED's. The current dabbling duck objective for the LMVJV is 362,120,220 DED's.

Although the LMVJV's DED objective was stepped down from the NAWMP we needed to convert it to period-specific population objectives. Beginning in 2008, a network of observers was established in the Mississippi Flyway to rank the progress of mallard migration from fall through early spring. Observers are instructed to revise their rankings at the end of each year to scale all values to a single "10", which represents the peak of mallard migration for that year. We used the average of migration ranks from waterfowl managers in the LMVJV from 2010 to 2012 to construct a migration chronology curve for mallards that was applied to all dabbling duck species (Figure A-1). We used ranks from 2010 to 2012 because observations from these years extended into March.

To establish period-specific population objectives for the LMVJV, we divided its DED objective by twelve, which equaled the number of semi-monthly periods between October 1 and March 31. This yielded an average objective of 30,176,685 DEDs that was initially applied to all twelve time periods. This average objective was then adjusted for each time period to reflect migration ranks. For example, if the migration rank of a time period was twice the average rank then the DED objective for that time interval equaled 60,353,370 or 30,176,685 × 2. This DED objective was then divided by the number of days in an interval to yield an actual population objective. A fifteen day time interval with a DED objective of 60,353,370 translates into an average daily population objective of 4,023,558 birds for that time interval (60,353,370/15). Repeating this process for all time periods yields the LMVJV's original DED objective (Table A-2).

The GCJV used methods similar to that of Reinecke and Loesch (1996) to calculate mid-winter population objectives tied to the NAWMP and used semi-monthly migration surveys between September and March to establish period-specific population objectives (Table A-3). Consequently, we adopted without modification the GCJV period-specific population objectives as established in GCJV implementation plans (e.g., Esslinger and Wilson 2001). Our analyses for the CVJV and LMVJV were "Joint Venture wide" meaning we did not separate these Joint Ventures into geographically distinct areas when evaluating the importance of rice to waterfowl. However, conservation planning in the GCJV occurs among smaller geographic subdivisions, termed Initiative Areas, based on shared geomorphology, wildlife and habitat communities, resource concerns, and a combination of other geopolitical considerations to enhance the efficiency and strategy of conservation priorities. Rice production along the Gulf Coast is concentrated in two of the GCJV's five initiative areas – the Texas Mid-Coast (TXMC) and Chenier Plain Initiative Areas, with the latter divided into the Texas Chenier Plain (TXCP), and the Louisiana Chenier Plain (LACP). Rice production in these initiative areas faces different challenges, and these area-specific analyses were necessary to fully understand their implications for waterfowl.

Duck population objectives for the TXMC, TXCP, and LACP are presented in Tables A-4 through A-6. Population objectives within a GCJV initiative area are divided among different habitat types based on an understanding of species-habitat associations observed for waterfowl within the GCJV region. In rice producing areas these population objectives are distributed among agricultural and coastal marsh habitats. Diving duck population objectives for coastal marsh habitats are also included in Tables A-4 through A-6. Diving ducks and dabbling ducks overlap in their use of some coastal marsh foods, making it necessary to account for the effects of diving duck food consumption when simultaneously modelling agricultural and coastal marsh habitats.

Wood Ducks. -- Although the CVJV and GCJV have established population objectives for wood ducks, we did not include this species when evaluating the importance of rice to waterfowl in these Joint Ventures. Wood ducks make up less than 2% of the CVJV and GCJV dabbling duck objective and rice is believed to be a minor component of their diet. In contrast, wood ducks represent a significant fraction of all duck species present in the LMVJV. Wood ducks in the LMVJV are assumed to meet most of their food energy needs from forested wetlands, which is also an important foraging habitat for key species like mallards. Many of the model simulations in this report include multiple foraging habitats used by dabbling ducks. Because wood ducks may consume a large fraction of the food produced in forested wetlands in the LMVJV, it was necessary to account for these foraging effects by establishing population objectives for this species.

The LMVJV has established a wood duck objective of 123,527,000 DED's that is separate from the Joint Venture's DED objective for dabbling ducks. We used the same process described for other dabbling duck species in the LMVJV to develop period-specific population objectives for wood ducks that summed to the Joint Venture's original DED objective for this species (Table A-7).

Geese.-- Although goose population objectives have also been stepped down from the NAWMP, Joint Ventures have been advised to use recent goose counts when establishing population objectives because of large-scale changes in goose distribution (M. Koneff personal communication). Goose population objectives for the Central Valley were based on goose counts between September and March and were adopted from the CVJV Implementation Plan (2006). The CVJV established separate population objectives for white geese and dark geese because of differences in habitat use and we maintained that distinction here. White geese include lesser snow geese and Ross's geese. The CVJV also included tundra swans in the white goose foraging guild because of similarities in habitat use. Dark geese included white-fronted geese and Canada geese (Table A-8).

Goose population objectives for the LMVJV were derived from mid-winter surveys of geese within the LMVJV's boundaries and were based on a five year average of goose counts between 2009 and 2013. Over 90% of geese observed during the mid-winter survey are snow geese and we combined the mid-winter estimate of goose numbers with information on migration chronology for snow geese in AR, MS, and LA (ebird; Figure A-2) to generate period-specific population objectives using the methods of Petrie et al. 2011 (Table A-9).

Species-specific, mid-winter population objectives for geese in the GCJV region were based on estimates of goose abundance observed from December aerial surveys in coastal Louisiana and

Texas.  The GCJV used data from 1982-88 to establish goose "objectives," but also used data from more contemporary periods (2005-09) to estimate "expected" numbers of geese, thereby accounting for continental population increases in certain goose species and their impact as competitive foragers with ducks for certain food resources within the GCJV region (Esslinger and Wilson 2001; GCJV, unpublished data).  Following the guidance of the GCJV, we selected and modeled the higher of these two values ("objective" vs. "expected") to account for goose population energy demands in a manner consistent with GCJV conservation planning (Table A-10).

*Daily energy requirement of a single bird within a foraging guild.*—Joint Ventures typically estimate the daily energy requirements of ducks and geese by multiplying the resting metabolic rate (RMR) of an "average" bird by a factor of three to account for the energy costs of free living.  We used the following equation from Miller and Eadie (2006) to calculate the RMR of dabbling ducks and geese and multiplied RMR by a factor of three to estimate the daily energy requirement of an average bird in each of these foraging guilds:

$$\text{RMR (kJ/day)} = 433 * (\text{Dabbling duck body mass in kg})^{0.785}$$

$$\text{RMR (kJ/day)} = 419 * (\text{Goose body mass in kg})^{0.719}$$

Body mass was calculated as the weighted mean for all species in a foraging guild assuming equal sex ratios for all species.  For the CVJV and LMVJV we assumed that species composition of the dabbling duck guild remained similar over time and the daily energy requirement of dabbling ducks did not vary among time periods.  Dabbling ducks in the CVJV require 274 kcal of food energy per day, while dabbling ducks in the LMVJV require 294 kcal per day.  Changes in species composition by time period have been determined for dabbling ducks in the GCJV.  As a result, we calculated time-specific daily energy requirements for dabbling ducks in this Joint Venture (Table A-11).

Daily energy needs for white geese in the CVJV were estimated by calculating a weighted body mass for lesser snow and Ross's geese.  Lesser snow geese make up 60% of white geese in the Central Valley, while Ross's geese account for the remainder (CVJV 2006).  Body mass estimates for both species were available from November through February and this information was used to estimate daily energy needs in those months.  These energy needs were then applied to the appropriate 15 day time period. No time specific body mass estimates were available for swans. Instead, a single body mass reported by Bellrose (1980) was used to calculate a daily energy need of 1106 kcal/day. This estimate was applied to all time periods. The make-up of white goose populations varied by time period. As a result, daily energy requirements for white geese were based on the relative abundance of snow/Ross's geese and swans in each time period (Table A-12).

Dark geese in the CVJV include both white-fronted geese and Canada geese. Body mass estimates for white-fronted geese were available on a monthly basis and this information was used to estimate daily energy requirements in that month. These energy needs were then applied to the appropriate 15 or 16 day intervals. Body mass estimates for Canada geese were available for two time periods; August to November and December through March. The make-up of dark goose populations varied by time interval. As a result, daily energy requirements for dark geese in the CVJV were based on the relative abundance of white-fronted geese and Canada geese in each time interval (Table A-13).

Daily energy requirements for each of the four goose species in the GCJV were also calculated using body mass, however, body mass was not varied through time. Thus, our estimates of daily energy requirements for each species were fixed across all time periods. Goose species in the GCJV are assumed to use the same habitats and all four species were modeled as a single goose population. However, the relative abundance of these species varies over time and the daily energy requirements of this combined goose population were based on the relative abundance of each species in each time period (Table A-14). Finally, the energy requirements of geese in the LMVJV are based solely on lesser snow geese and assume a fixed daily energy requirement of 618 kcal/day for all time periods.

*Acreage of each habitat for each time period.* -- Although this report is focused on rice we included all major dabbling duck habitats in the CVJV, LMVJV, and GCJV when evaluating the importance of rice to dabbling ducks. Our dabbling duck habitat estimates included the acreage of each habitat type in a Joint Venture, as well as the availability of these habitats. We defined availability as the ability of waterfowl to access the food resources produced in a habitat, which can vary with flooding conditions or timing of agricultural harvest.

Virtually all the foraging habitats that we assumed available to dabbling ducks are flooded. For example, harvested flooded rice fields were assumed to be available to dabbling ducks but dry harvested ricefields were not. In contrast, geese often exploit agricultural habitats regardless if these habitats are flooded. To properly model the competitive effects of geese on dabbling duck food sources, it was necessary to estimate goose foraging habitats even if these habitats receive little if any use by dabbling ducks.

CVJV.--Dabbling ducks in the Central Valley rely on the following habitat types; 1) flooded harvested rice fields, 2) managed seasonal wetlands, and 3) flooded and unflooded harvested corn fields (CVJV 2006). The amount of rice planted in the Central Valley between 2008 and 2012 averaged 557,200 acres per year, and we used this five year to average to evaluate the food resources provided by rice. However, post-harvest treatment of rice strongly influences the availability of food resources in these habitats. Virtually all the rice produced in the Central Valley occurs in the Sacramento Valley. While 12,000 acres of rice is grown in the San Joaquin Valley, deep plowing of harvested rice fields makes most of the food in these 12,000 acres unavailable to waterfowl (CVJV 2006).

An estimated 56% of all harvested ricefields in the Sacramento Valley are now winter- flooded, which equals just over 305,000 acres (K. Petrik). Of the 240,000 acres of ricefields that are not winter- flooded, the CVJV assumes that 25% of these acres are deep plowed and provide no waterfowl food resources (CVJV 2006). This leaves about 180,000 acres of harvested rice fields that are not purposely flooded or deep plowed following harvest (Table A-15). Dark geese are assumed to forage in both flooded and dry rice fields, while white geese mostly forage in unflooded rice (CVJV 2006).

The availability of rice habitat to waterfowl in the Central Valley is a function of harvest date and the timing and duration of winter-flooding. Rice harvest in the Central Valley begins in mid-September and is largely complete by late October (CVJV 2006). Winter flooding of harvested rice fields begins in early October with most fields flooded by early to late December. The 2006 CVJV implementation plan assumed that landowners began draining rice fields during the first half of February with most fields dry by early March (Figure A-3).

In addition to rice, there are an estimated 197,232 acres of managed seasonal wetlands and nearly 80,000 acres of harvested cornfields available to waterfowl in the Central Valley (Table A-15). Dark geese are assumed to forage in managed wetlands and corn, while white geese forage in corn but not managed wetlands (CVJV 2006). Flooding of managed seasonal wetlands begins in late August and early September with nearly all wetlands flooded by late November. Wetlands are assumed to be continuously flooded through March (Figure A-4). The availability of waste corn is largely a function of harvest dates which are similar to that for rice (CVJV 2006).

LMVJV.--Dabbling ducks in the LMVJV rely on the following habitats; 1) flooded harvested rice fields, 2) forested wetlands, 3) managed seasonal wetlands, 4)flooded harvested row crops (predominately soybeans), and 5) flooded unharvested crops that include corn, soybeans, millet, sorghum and rice (Table A-16). The amount of rice planted in the LMVJV between 2008 and 2012 averaged 1,850, 748 acres (USDA National Agricultural Statistics Service Cropland Data Layer 2012). An estimated 388,000 acres of harvested ricefields are now winter flooded in the LMVJV, or about 21% of the planted rice base. This leaves nearly 1.47 million acres of harvested rice that are not purposely flooded. Winter flooding of rice in the LMVJV begins in mid to late October with most fields flooded by mid-December. By late February or early March most winter flooded ricefields have been drained (Figure A-5).

Managed seasonal wetlands in the LMVJV total nearly 88,000 acres, while there are nearly 1.38 million acres of forested wetlands. Harvested row crops that are purposely flooded in the LMVJV equal nearly 700,000 acres, while just less than 9,000 acres of unharvested crops are flooded. Flooding of managed seasonal wetlands and forested wetlands begins in early October with most of these wetlands flooded by late December or early January (Figures A-6 & A-7). Most harvested crops are flooded beginning in December with most being drained by mid-February (Figure A-8). In contrast, flooding of unharvested crops usually begins in October with most of these habitats flooded by late December (Figure A-9).

The LMVJV assumes that geese meet 25% of their food energy requirements from flooded habitats, excluding forested wetlands. We adopted this assumption when modelling the competitive effects of geese on dabbling duck food sources and in determining the amount of food energy provided by rice to dabbling ducks in the LMVJV.

GCJV. -- Dabbling ducks in the GCJV rely on the following habitats; 1) flooded harvested rice fields, 2) flooded unharvested rice fields, 3) flooded idled rice lands, 4) flooded harvested soybean fields, 5) coastal marsh, and 6) forested wetlands. Ricelands in the CVJV and LMVJV are usually planted to rice each year and only one crop of rice is produced. In contrast, ricelands in the GCJV are cultivated on a rotational basis with a percentage of fields left idle or used to grow alternate crops when not in rice production. In addition, the longer growing season in the GCJV makes it possible to grow a second (i.e., ratoon) rice crop in the same season after the first crop is harvested.

Although rice is grown on a rotational basis in each of the GCJV's rice producing initiative areas, the length of time ricelands are idled or used to grow alternate crops differs. In the LACP most growers have adopted a 2-year rotation where rice is grown in Year 1 and the land is idled or used to grow an alternate crop in Year 2. After Year 2 the land is returned to rice. The amount of land planted to rice in the LACP between 2008 and 2011 averaged 297,650 acres. However, the actual amount of land used for rice production in the LACP is estimated at 595,300 acres. We refer to this larger figure as the "rice base," which equals the acres planted multiplied by rotation length in years. On average, 75% of lands not in rice production in the LACP are idled, while 25% are planted to an alternate crop (GCJV unpublished data; Table A-17).

The amount of land planted to rice in the TXCP between 2008 and 2011 averaged 31,725 acres. Rice in the TXCP is grown on approximately a three year rotation, which results in a current rice base of just over 95,000 acres. Ninety five percent of ricelands in the TXCP that are not in production are idled with only 5% planted to alternative crops (GCJV, unpublished data). Planted rice in the TXMC averaged 142,900 acres between 2008 and 2011. Growers in the TXMC vary between a two and three year rotation period with an estimated rice base of nearly 372,000 acres. All TXMC ricelands that are not in production are believed to be idled with few if any acres devoted to alternate crops ((GCJV, unpublished data; Table A-17).

Ricelands in the GCJV can be divided among four habitat categories; 1) fields that are harvested in July or August that are not ratooned, 2) fields that are harvested in July or August that are ratooned with second crop rice harvested in early November, 3) fields that are harvested in July or August that are ratooned with second crop rice left standing (unharvested) and 4) idled ricelands (Table A-18). We used satellite imagery from three different periods during fall – winter 2010-11 and 2011-12, having approximate midpoints of September 21, December 7 and February 20, to quantify the total amount of flooded habitat within agricultural landscapes of the three rice producing Initiative Areas. We intersected the classified water with the USDA National Agricultural Statistics Service Cropland Data Layer (2010, 2011) of the corresponding years to quantify the abundance of individual agricultural-based habitats. We averaged the habitat-specific acreages across the two years examined and extrapolated between the approximate midpoint dates of the analyzed imagery to generate period-specific estimates of flooded riceland habitat.

Although we were able to distinguish between lands in rice production and lands that were being idled, we could not distinguish between fields that had been ratooned and those that had not; nor was it possible to distinguish between ratooned fields that had been harvested vs. those that were unharvested. To address this uncertainty we developed a flooding curve that combined all three of these rice habitats. However, these habitats differ in terms of food resources (e.g. the amount of rice in unharvested ratoon fields is significantly higher than in harvested ratoon fields). To account for these differences we assumed that our estimates of flooded rice reflected the relative abundance of these habitats through time (i.e., flooded in proportion to their availability). For example, sixty percent of all planted riceland in the TXMC is classified as harvested ratoon from November onward; we therefore assumed that 60% of all flooded rice from November onward was harvested ratoon as well.

Figures A-10 through A-13 depict the temporal availability of flooded harvested rice fields and flooded idled rice lands for each of the GCJV's rice producing initiative areas and the GCJV as a whole. Flooding of harvested rice fields and idled rice lands begins in late August, which is at least partly driven by flooding/irrigation of the ratoon crop, and peaks in late February. Peak flooding estimates of harvested rice fields range from 15,349 acres in the TXMC to nearly 148,000 acres in the LACP. Peak flooding estimates of idled rice lands range from 25,307 acres in the TXCP to 105,318 acres in the LACP (Table A-19).

All foraging habitats available to dabbling ducks in the GCJV's initiative areas, including non rice producing areas, are presented in Table A-20**.** Although geese forage in flooded rice fields and flooded idled lands, they also make use of harvested rice fields (ratooned and non-ratooned) and unharvested ratoon fields that are not flooded. These habitats are not included in Table A-20 but were included in GCJV model simulations involving geese.

*Food Biomass.*--Ricelands provide a variety of foods for wintering and migrating waterfowl including rice seeds, moist soil seeds, invertebrates, and green vegetation (Eadie et al. 2008). Food biomass estimates for ricelands and other foraging habitats were adopted from Joint Venture plans or from recently published studies. Waterfowl typically abandon feeding in habitats before all food is exhausted because at some point the costs of continuing to forage on a diminishing resource exceeds the energy gained. This value is called the giving-up-density or foraging threshold (Nolet et al. 2006), and habitat specific foraging thresholds were applied to all food biomass estimates.

CVJV.--Fleskes et al (2012) recently estimated waste rice seed in conventionally harvested and stripper-head harvested rice fields in the Central Valley. Conventionally harvested fields averaged 157kg/acre of waste rice, while stripper-headed fields averaged 99 kg/acre. Because about 18% of all rice fields in the Central Valley are now stripper-head harvested (Fleskes et al. 2012), we adopted a weighted estimate of 147 kg/acre waste rice. The CVJV assumes that 15% of all waste rice is consumed by non-waterfowl species, which reduced our estimate of waste rice to 125 kg/acre. However, the CVJV also assumes that harvested ricefields provide 11 kg/acre of moist soil seeds which results in a total seed biomass of 136 kg /acre. Lastly, we applied the CVJV's waterfowl foraging threshold of 13 kg/acre to generate a modeled seed biomass of 123 kg/acre. Food biomass estimates and foraging thresholds for the Central Valley's other major waterfowl habitats were adopted from the CVJV's implementation plan (Table A-21; CVJV 2006).

LMVJV. -- Rice harvest in the Central Valley generally coincides with the arrival of large numbers of waterfowl. In contrast most rice harvest in the MAV occurs in August and September, which is well in advance of fall migration. The loss of waste rice to germination, decomposition, and consumption by other waterfowl species after harvest and before waterfowl arrive appears to be substantial (Eadie et al. 2008). Manley et al. (2004) documented a 79-99% reduction in waste rice between harvest and early winter, while similar studies have estimated losses between 71% and 78% (Stafford et al. 2006, Kross et al. 2008). The LMVJV assumes that harvested rice fields now provide 32 kg/acre of waste rice by the time large numbers of waterfowl begin arriving in the MAV. Manley (1999) estimated 2 kg/acre of moist soil seeds in harvested rice fields in the MAV, and we combined this food source with waste rice for a total seed biomass of 34 kg/acre. The LMVJV's 20kg/acre foraging threshold was subtracted from this number to yield a modeled seed biomass of 14 kg/acre. Food biomass estimates for other major habitats in the MAV were obtained from the LMVJV's Waterfowl Working Group (Table A-22; Reinecke and Kaminski 2013).

GCJV.--The diversity of riceland habitats in the GCJV results in a wide range of food biomass values both within and among Joint Venture initiative areas where rice is grown (Table A-23). Waste rice estimates for harvested ratoon fields are generally higher than for harvested fields that are not ratooned, while ratooned fields that are not harvested provide substantially more food biomass than any category of riceland habitat. The amount of moist-soil seeds present in harvested and unharvested rice fields appears to be significantly higher than in the CVJV and LMVJV, especially for unharvested ratooned fields. The GCJV assumes a foraging threshold of 20kg/acre for all rice habitats including idled rice lands, as well as for all non-rice habitats.

While harvested first crop and ratoon crop rice in the GCJV provide abundant rice and natural seeds for waterfowl when flooded during winter, idle ricelands have similar potential to serve as high quality foraging habitat because they are readily established by annual, seed-producing grasses and sedges during the summer(s) when idled. Recent research by Marty (2013) indicates that seed biomass within idled rice fields equals, and in some cases may exceed, that of food resources in harvested rice fields and intensively managed moist-soil wetlands. Because of the conventional rotational systems employed by rice producers in coastal Texas and Louisiana, a substantial portion of the total rice base within this region serves as potential habitat for wintering waterfowl, and when flooded during winter provides access to high quality food resources that rival that found in managed wetlands.  Moist soil seeds account for virtually all the dabbling duck foods found in idled rice lands.  However in the absence of foraging, the abundance of moist soil seeds in idled lands increases from late summer to early fall.  As a result, different food biomass values were assigned to lands flooded prior to November (early idle) vs. those lands flooded after November (late idle). Food biomass estimates for coastal marsh, forested wetlands, and soybean fields are presented in Table A-24.  In general, these habitats provide less food per acre than do ricelands.

*Nutritional Quality and Decomposition of Foods.*--The carrying capacity of waterfowl habitat is strongly dependent on food biomass.  However, the energy or calories provided by these foods also influences carrying capacity.  Metabolizable energy estimates for all foods included in model simulations were obtained from Joint Venture plans or from the published literature (Table A-25). Finally, both natural and agricultural foods decompose under flooded conditions and deterioration of these foods can significantly reduce waterfowl energy supplies (Naylor et al. 2002, Nelms and Twendt 1996).  As a result, we included estimated food decomposition rates in TRUEMET for all model simulations.

*Habitat used by Foraging Guilds:* Within the TRUEMET model we made explicit assumptions about the habitats used and foods consumed by each waterfowl guild to meet their daily energy requirements.  Although many of these assumptions have already been described, Tables A-26 to A-28 provides a summary of these assumptions for the CVJV, LMVJV, and GCJV, respectively.

<u>Economic Contribution of Ricefields</u>

Winter-flooded ricefields and managed seasonal wetlands both provide shallowly flooded habitat preferred by dabbling ducks and often provide similar amounts of food energy.  We estimated the capital cost of replacing rice habitat with seasonal wetlands in each Joint Venture using the following information; 1) the current amount of flooded rice habitat in a Joint Venture, 2) the amount of food energy (kg/acre) provided by rice compared to managed seasonal wetlands, and 3) the cost per acre of restoring managed seasonal wetlands.

The amount of flooded rice habitat in each Joint Venture was taken from Tables A-15, A-16, and A-20 in Appendix I.  To determine the amount of food energy provided by rice relative to seasonal wetlands, we multiplied the food biomass in each habitat type by its corresponding TME value. For example, harvested ricefields in the CVJV average 122.7 kg/acre of food with a corresponding TME value of 3.0 kcal/g (Table 2). This equals 368,100 kcals of food energy per acre (122.7 kg/acre *1000 g/kg * 3.0 kcal/g). Managed seasonal wetlands in the CVJV average 242.2 kg/acre of food with a corresponding TME value of 2.5 kcal / g. This equates to 605,000 kcal/acre of food energy (Table 2). Thus, food energy provided by rice habitat in the CVJV equates to approximately sixty-one percent of that provided by seasonally managed wetlands on a per acre basis (368,100 / 605,000). There are an estimated 305,227 acres of winter-flooded rice in the CVJV. Replacing these rice habitats would require 186,188 acres of managed seasonal wetlands (305,227 * 0.61; Table 2).

The capital costs of restoring managed seasonal wetlands include the following; 1) the cost of land purchase, 2) vendor costs which include normal restoration activities like levee construction and the installation of water control structures, and 3) staff costs associated with a restoration project (e.g. project design, permitting, construction management). These cost estimates were obtained from Ducks Unlimited and/or U.S. Fish and Wildlife Service staff working in each Joint Venture region.

Table 2. Acres of managed seasonal wetlands that would have to be restored to replace the food energy currently provided by flooded rice habitats.

| Joint Venture | Rice Food Biomass (kg/acre) | Rice TME (kcal/g) | Rice (kcal/acre) | MSW Food Biomass (kg/acre) | MSW TME (kcal/g) | MSW (kcal/acre) | Rice Replacement (acres of MSW) |
|---|---|---|---|---|---|---|---|
| CVJV | 122.7 | 3.0 | 368,100 | 242.2 | 2.5 | 605,100 | 186,188 |
| GCJV | 137.2 | 2.64 | 362,208 | 187.9[b] | 2.5 | 469,750 | 266,019 |
| LMVJV | 13.8 | 3.0 | 41,400 | 187.9 | 2.47 | 464,113 | 34,613 |
| LMVJV[a] | 160.0 | 3.0 | 480,000 | 187.9 | 2.47 | 464,113 | 401,311 |

MSW – Managed Seasonal Wetlands

Rice Replacement – Acres of managed seasonal wetlands that would have to be restored to replace the food energy currently provided by flooded rice habitats. Calculated as: Existing acres of flooded rice habitat * (Rice kcal/acre /MSW kcal/acre). Existing acres of flooded rice habitat in each Joint Venture can be found in Tables A-15, A-16, and A-20.

[a] Assumes that winter-flooded ricefields in the LMVJV are ratooned and harvested.

[b] Based on food biomass estimates in managed seasonal wetlands in the LMVJV.

Although the capital costs of replacing rice habitat with managed wetlands are likely to be formidable, long-term costs must also be considered. Managed wetlands incur annual costs that may include levee maintenance, replacement or repair of water control structures and water conveyance systems, disking or fire to set back plant succession, water costs, and staff costs associated with managing these wetlands. These annual costs are currently borne by rice producers. As a result, we also estimated the annual operation and management costs (O & M costs) associated with replacing rice habitat with managed seasonal wetlands.

Finally, we conducted an additional costs analysis for the LMVJV were we assumed that winter-flooded ricefields had been ratooned. Our intent was to demonstrate how changes in agricultural practices that benefit waterfowl can produce significant cost savings to the waterfowl management community.

**Results**

Waterfowl population energy demand and food energy supplies can vary widely over time. Figure 8 is a "hypothetical" TRUEMET output that reasonably represents many wintering areas, including those that coincide with major rice growing areas. Population energy demand increases from early fall through late winter as birds reach their terminal wintering areas, then begins to decline as birds begin spring migration. Food energy supplies often increase dramatically in early and late fall as wetlands and agricultural habitats are flooded in anticipation of the hunting season. This flooding pulse often creates a large surplus of food that pre-dates the arrival of most birds. This intentional flooding is largely complete by early winter, after which food supplies begin to decline as food consumption exceeds any new habitat being added to the landscape. Food supplies in late winter and early spring may be especially important for birds that are acquiring the fat reserves necessary for spring migration, and ultimately reproduction. As a result, we paid special attention to this late winter-early spring period when interpreting TRUEMET results for each Joint Venture.

Although our actual model scenarios varied widely among Joint Ventures, we followed the same general approach for each. We began by modelling “current conditions”. These scenarios included all existing habitats and were intended to describe the current relationship between food energy demand and food energy supply within a Joint Venture. We then modeled scenarios where rice acreage or the amount of food provided by rice habitats was varied to determine how this influenced population energy supply. The basis for many of these scenarios can be found in the section that describes each rice growing region

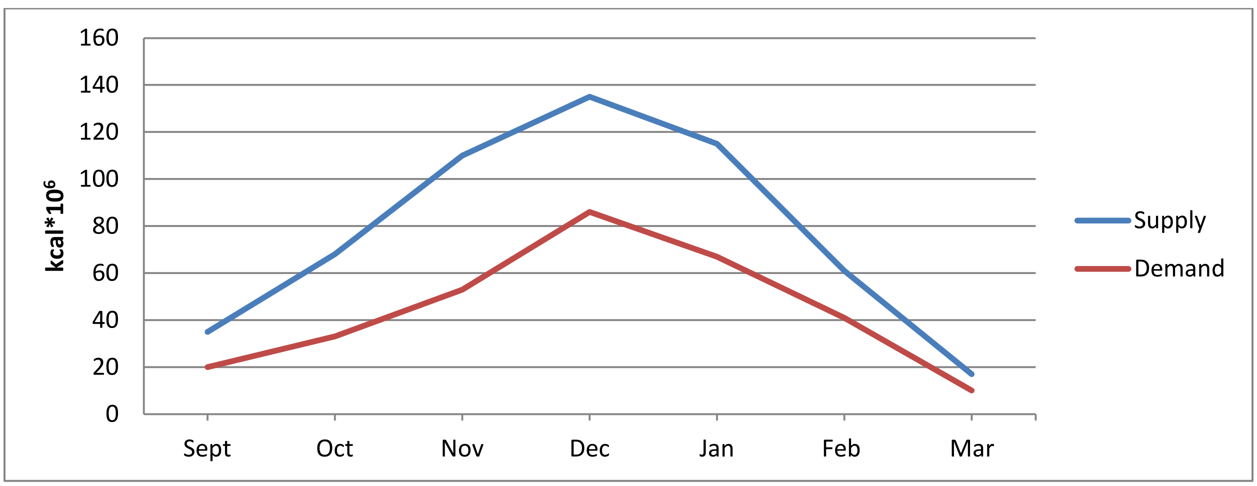


Figure 8. Hypothetical TRUEMET output.

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Prior to reporting TRUEMET results we estimated three metrics that were common to all Joint Ventures:

Rice Potential: The total energy demand of dabbling ducks and geese across all time periods compared to the food energy provided by rice if post harvest practices made all waste rice available.

Foraging Base: The percent of the total foraging base (acres) attributed to rice. For dabbling ducks this includes winter-flooded rice fields. For geese it can include both flooded and unflooded fields.

Fraction of Total Food Energy: The fraction of total waterfowl food energy provided by rice.

Central Valley Joint Venture

*Common Metrics*

Rice Potential.--Population objectives for dabbling ducks and geese in the CVJV from August through March equal a combined food energy demand of $2631.2 * 10^8$ kcals. The amount of rice planted in the Central Valley during the past five years has averaged 557,200 acres. We assume that rice fields provide 122.7 kg/acre of waste rice and moist-soil seeds immediately after harvest (Table A-21), and the TME value of these foods averages 3.0 kcal/g (Table A-25). If post-harvest practices allowed waterfowl to utilize all these foods, ricefields would provide $2006.4 * 10^8$ kcals or 76% of the total food energy needs of dabbling ducks and geese in the CVJV.

Rice Foraging Base.--Winter-flooded ricefields total 305,000 acres and provide 53% of the dabbling duck foraging base in the Central Valley. Flooded and unflooded ricefields provide 64% and 86% of the Dark and White goose foraging base respectively (Table A-15).

Fraction of Total Food Energy Provided by Rice.--Winter-flooded ricefields provide 44% of all food energy available to dabbling ducks in flooded habitats in the CVJV (Figure 9). Flooded and unflooded ricefields provide 49% of all food energy available to Dark geese , and 73% of all food energy available to White geese.

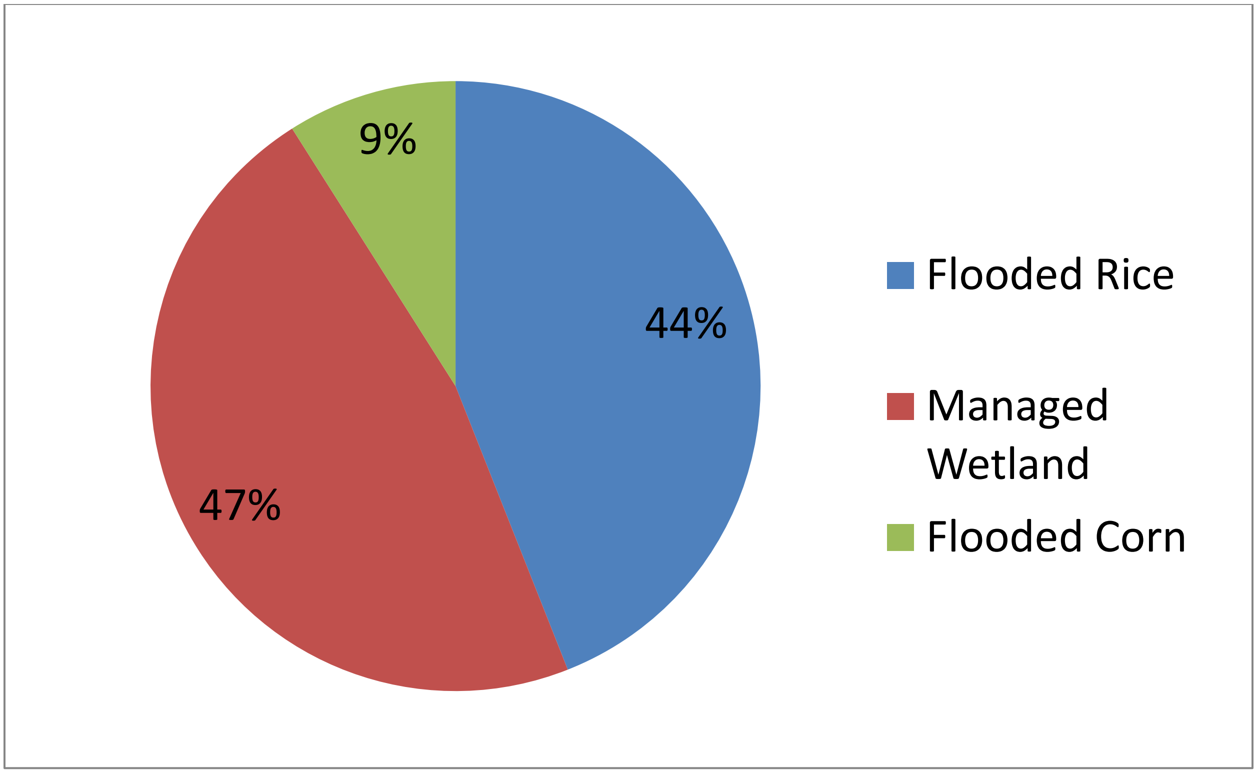


Figure 9. Fraction of dabbling duck food energy in the CVJV attributed to rice and other habitat types.

*TRUEMET Results*

We conducted nine scenarios for the Central Valley (Table 3). Scenario 1 represents our understanding of current habitat conditions in the CVJV, and assumes that rice production and the amount of winter-flooded rice is unaffected by water issues in California relating to drought or the needs of ESA fish. Scenario 2 represents the unlikely event that rice is no longer produced in the Central Valley.

Table 3. Habitat acres used in CVJV TRUEMET scenarios.

| Scenario | Planted Rice[a] | Winter-Flooded Rice[b] | Dry Rice[c] | Managed Wetlands | Harvested Corn |
|---|---|---|---|---|---|
| #1 | 545,049 | 305,227 | 179,866 | 197,232 | 78,796 |
| #2 | 0 | 0 | 0 | 197,232 | 78,796 |
| #3 | 545,049 | 152,614 | 332,480 | 197,232 | 78,796 |
| #4 | 545,049 | 0 | 485,094 | 197,232 | 78,796 |
| #5 | 545,049 | 152,614 | 179,866 | 197,232 | 78,796 |
| #6 | 545,049 | 0 | 179,866 | 197,232 | 78,796 |
| #7 | 408,787 | 0 | 134,900 | 197,232 | 78,796 |
| #8 | 272,525 | 0 | 89,933 | 197,232 | 78,796 |
| #9 | 408,787 | 0 | 134,900 | 147,924 | 78,796 |

[a] Excludes all rice grown in the San Joaquin Valley as the CVJV assumes that these fields provide no waterfowl food resources.

[b] Harvested ricefields that are purposely flooded for straw decomposition.

[c] Harvested ricefields that are not purposely flooded for straw decomposition, but which provide food resources consistent with CVJV assumptions (i.e. not deep plowed).

Because the impact of reduced water supplies likely falls between these two extremes, we modeled several scenarios where rice production and winter-flooding are increasingly affected by water shortages. Although modeling a decline in planted rice is fairly straightforward, forecasting the effects of less winter flooding includes a great deal more uncertainty. Much of this uncertainty involves rice growers that have traditionally winter-flooded their fields to decompose straw, and how they may react in the absence of reliable and/or affordable water supplies. If many of these growers adopt post harvest practices that essentially "bury" much of the waste rice, the loss of winter flooding is further compounded by a decline in harvested rice fields that provide significant food resources. The CVJV now assumes that 25% of all rice fields are “deep plowed” and provide no waterfowl food resources. However, this percentage may increase as more producers rely on deep plowing to decompose rice straw in the face of less water. Because declines in winter-flooding and increases in deep plowing may work in tandem, many of our model scenarios simultaneously examine the effects of less winter-flooding and more deep plowing. Finally, the CVJV assumes that dabbling ducks do not generally forage in harvested ricefields that remain dry (Table A-26). However, ricefields not purposely flooded for straw decomposition may be temporarily flooded by rainfall and provide short term foraging opportunities for dabbling ducks. Although we didn’t consider such events in our modelling, the potential for such events to increase food supplies for dabbling ducks will be strongly dependent on post-harvest practices that influence waste rice supplies.

Scenario 1.-- Current habitat conditions in the Central Valley.

This scenario modeled dabbling duck and goose energy supplies under current habitat conditions in the Central Valley.

Outcome.--Existing habitats in the Central Valley are sufficient to meet dabbling duck energy needs in all time periods except late March (Figure 10). Goose energy needs are currently met in all time periods (Figure s 11 & 12).

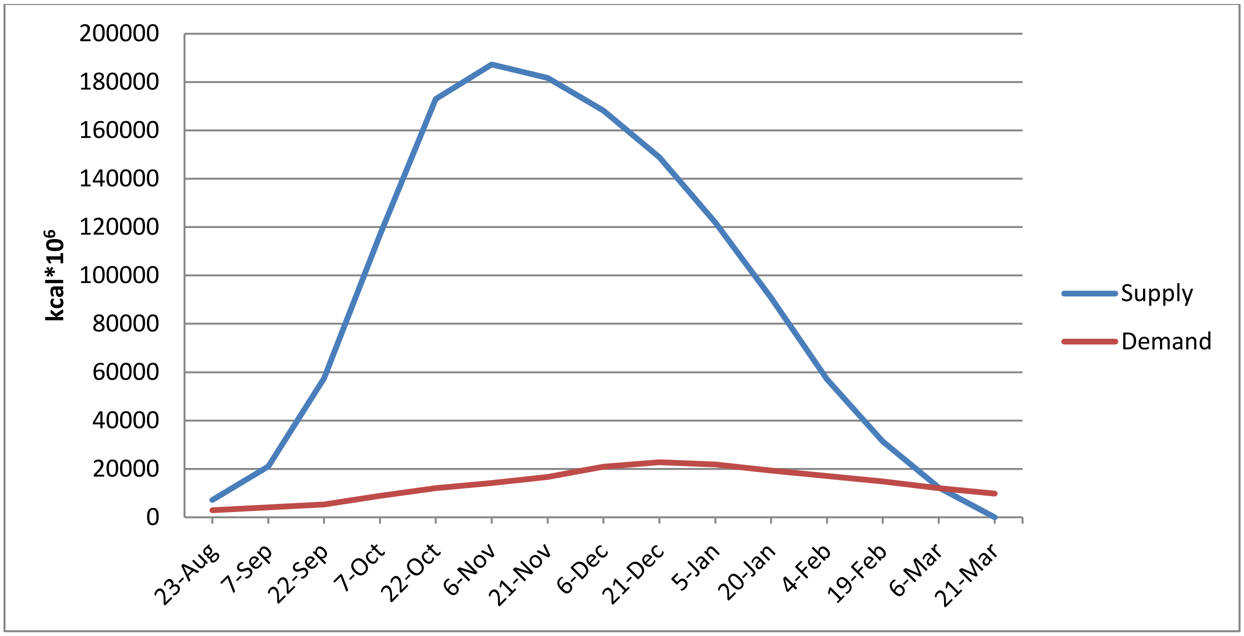


Figure 10. Scenario 1 results for dabbling ducks in the CVJV.

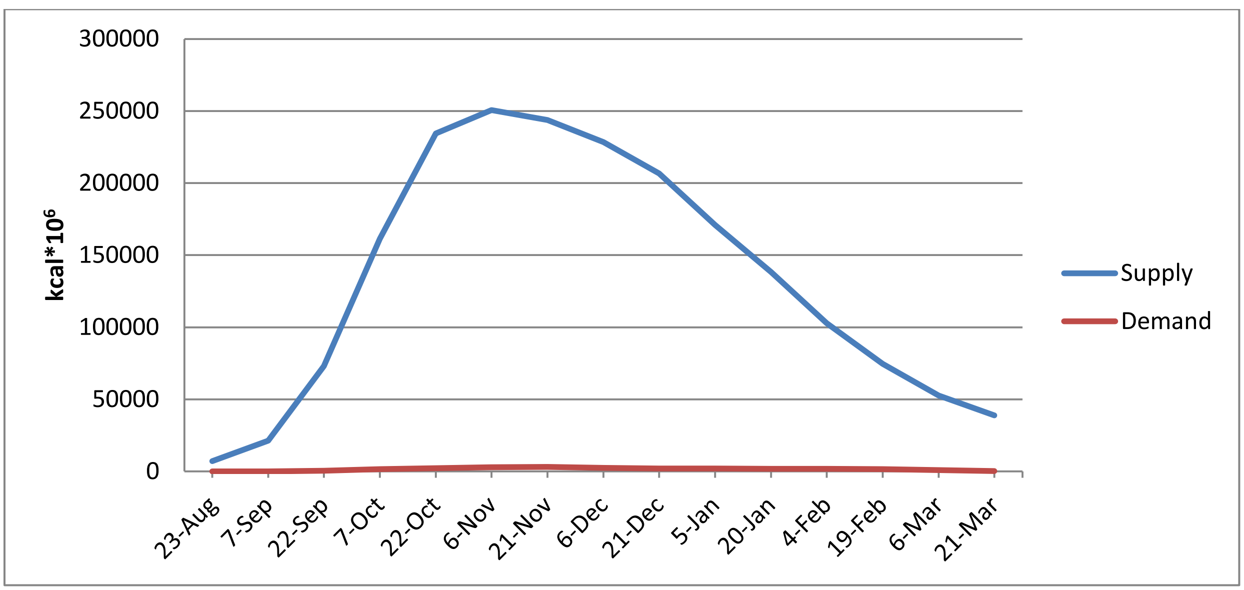


Figure 11. Scenario 1 results for dark geese in the CVJV.

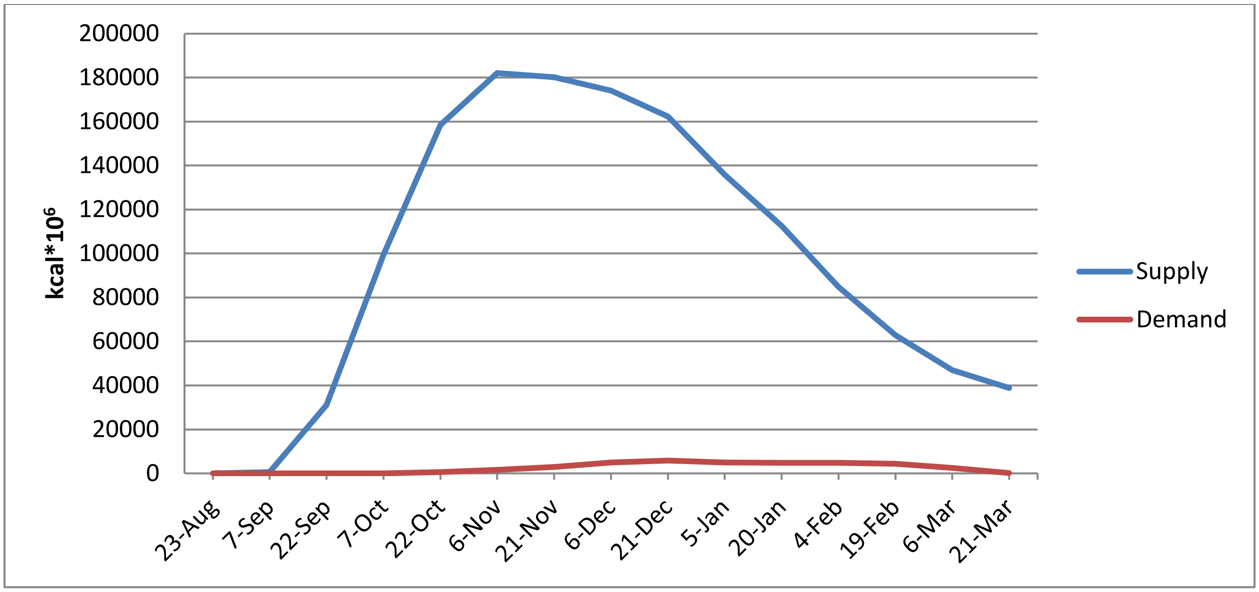


Figure 12. Scenario 1 results for white geese in the CVJV.

Scenario 2.--No rice produced in the Central Valley.

This scenario forecasted dabbling duck and goose energy supplies where no rice is produced in the Central Valley, and where the availability of other habitats remains unchanged from current conditions.

Outcome.--The loss of rice production in the Central Valley would result in dabbling duck food supplies falling below demand by early January (Figure 13). Goose energy needs would also be exhausted by early January if no rice were produced (Figures 14 & 15).

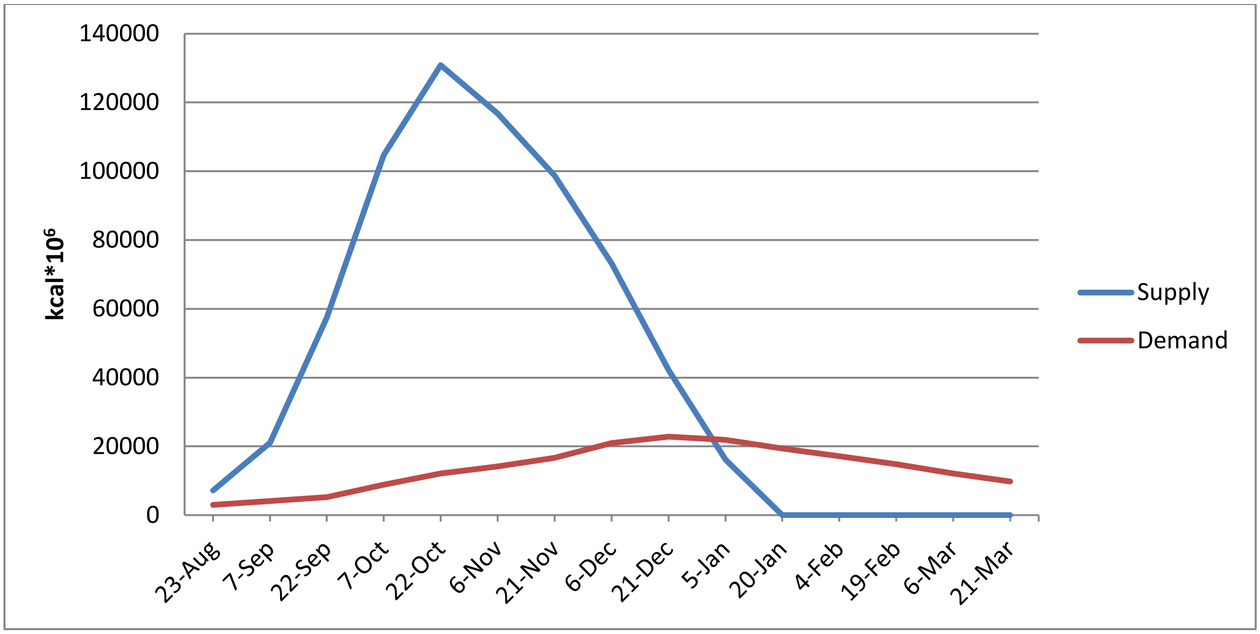


Figure 13. Scenario 2 results for dabbling ducks in the CVJV.

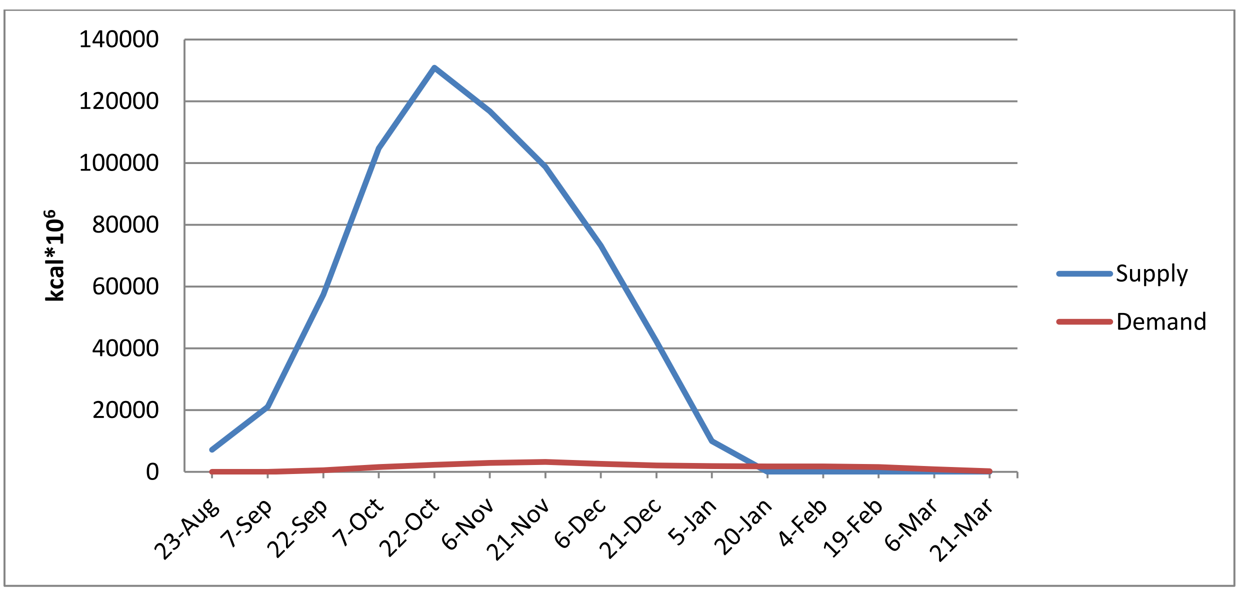


Figure 14. Scenario 2 results for dark geese in the CVJV.

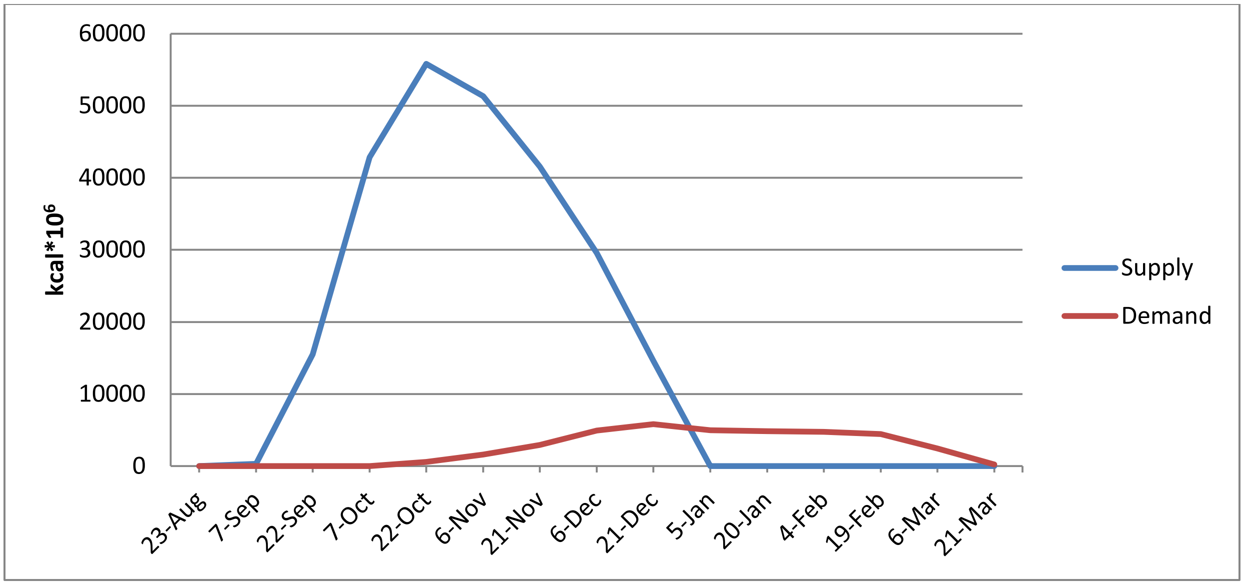


Figure 15. Scenario 2 results for white geese in the CVJV.

Scenario 3.--The amount of rice planted in the Central Valley remains unchanged; however, winter-flooded rice is reduced by 50% from current levels. Fields that were previously winter flooded are not deep plowed and still provide food resources.

Outcome.--Dabbling duck food supplies fall below demand by mid-February as a result of reductions in winter flooding (Figure 16). Harvested rice fields that are not flooded but which still provide food resources increase to over 330,000 acres (Table 3). As expected, food supplies for geese remain adequate in all time periods as geese are assumed to forage in harvested rice fields regardless if they are flooded. Although we assume that dabbling ducks do not forage in dry rice fields, rainfall may temporarily flood rice fields that are not purposely flooded for straw decomposition and thus increase dabbling duck food supplies.

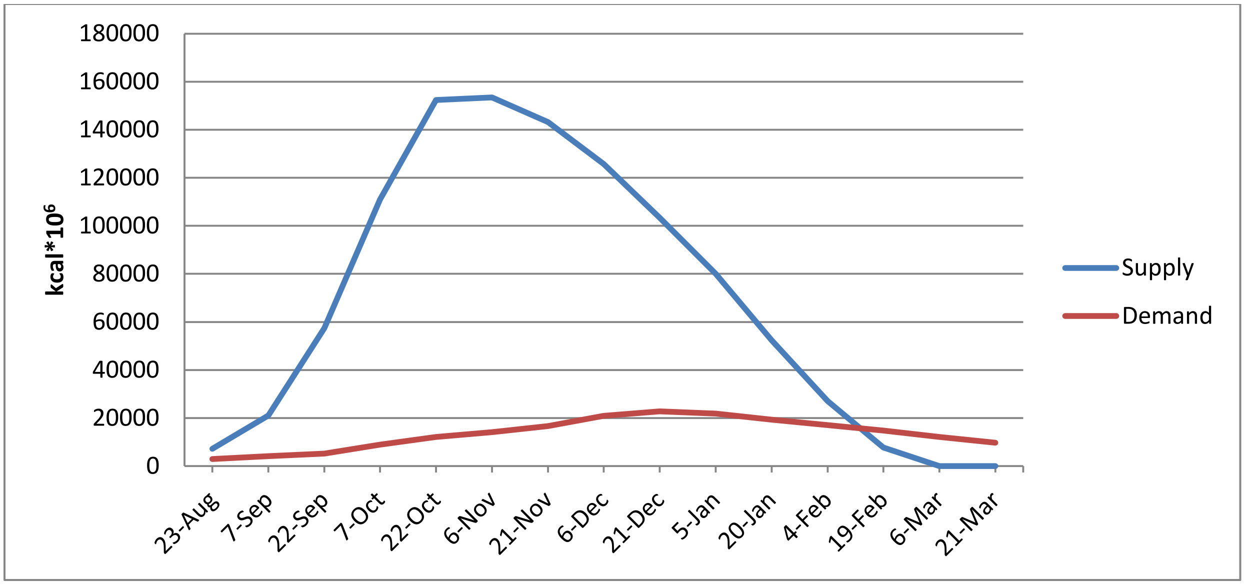


Figure 16. Scenario 3 results for dabbling ducks in the CVJV.

*Scenario 4.*--The amount of rice planted in the Central Valley remains unchanged; however, winter flooded rice is eliminated (i.e. no fields are purposely flooded for straw decomposition). Fields that were formerly winter flooded are not deep plowed and still provide food resources.

*Outcome.*--Dabbling duck food supplies fall below demand by mid-January in the absence of any winter flooding (Figure 17). Again, rainfall could increase dabbling duck food supplies by temporarily flooding some harvested rice fields.

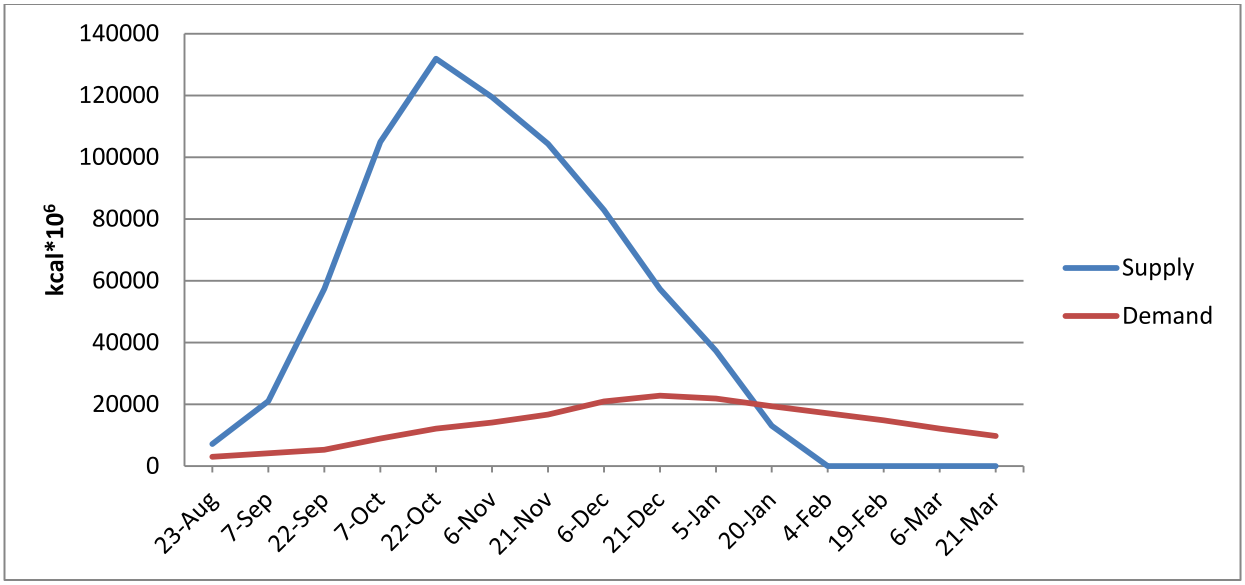


Figure 17. Scenario 4 results for dabbling ducks in the CVJV.

Scenario 5.--The amount of rice planted in the Central Valley remains unchanged; however, winter-flooded rice is reduced by 50% from current levels. In addition, all fields that were previously winter-flooded are now deep plowed and provide no food resources for ducks or geese.

Outcome.--Dabbling duck food supplies fall below demand by mid-February, similar to that observed for Scenario 3 (Figure 18). However, the total amount of rice habitat that provides food resources is reduced to 332,480 acres (Table 3), which may make it more difficult for rainfall to increase dabbling duck food supplies by temporarily flooding some fields. Despite a reduction in rice acres that provide food, goose energy needs continue to be met in all time periods (Figures 19 & 20).

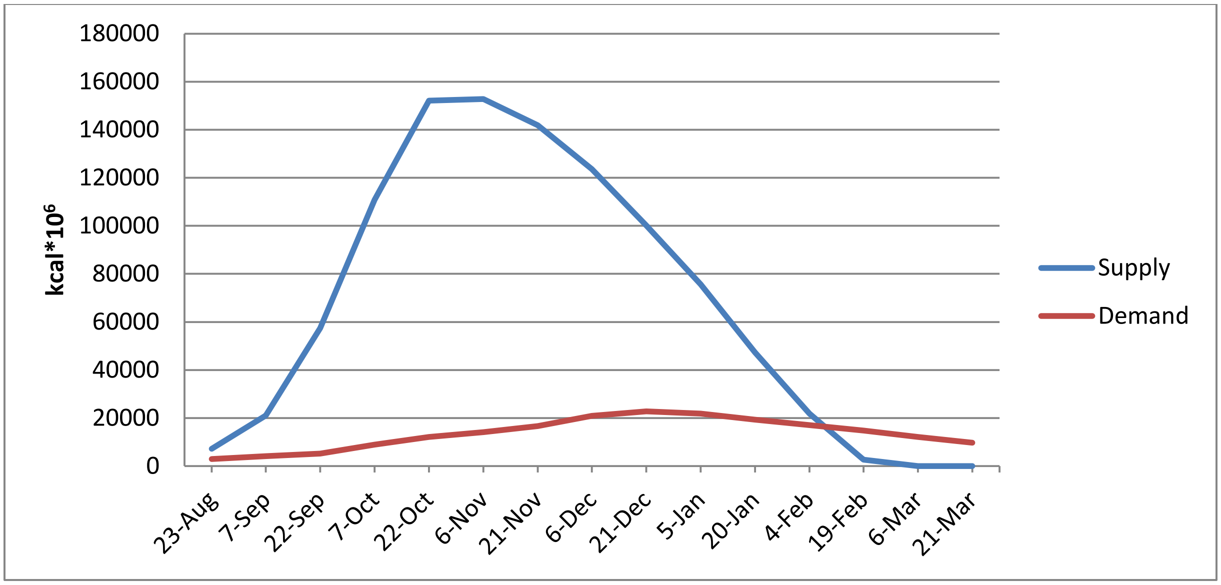


Figure 18. Scenario 5 results for dabbling ducks in the CVJV.

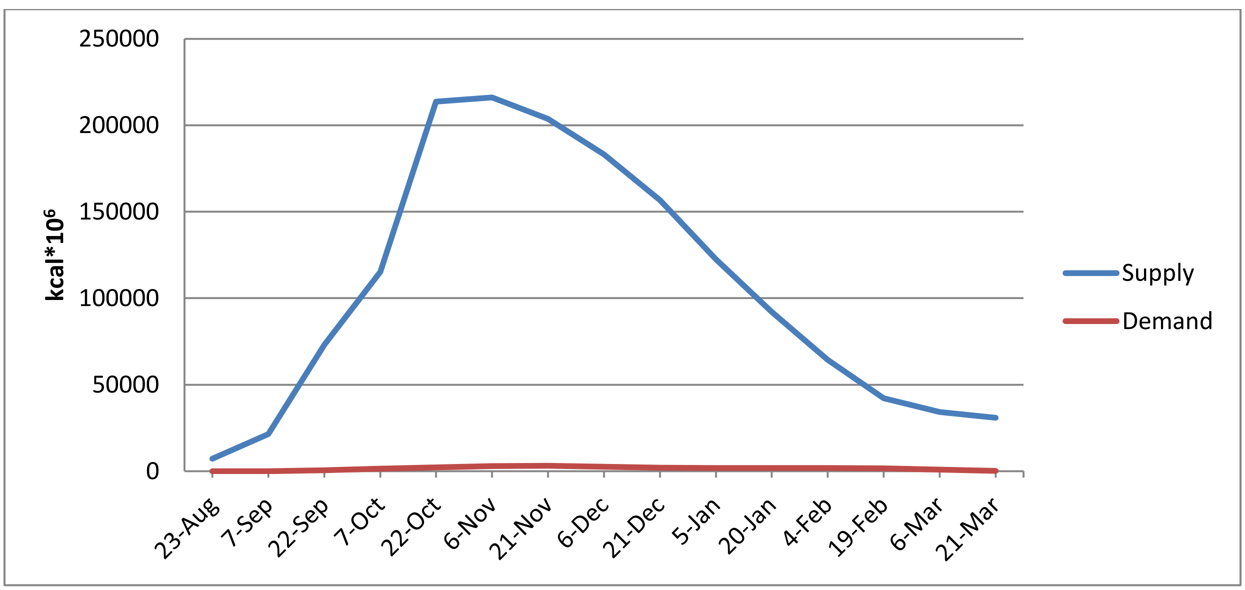


Figure 19. Scenario 5 results for dark geese in the CVJV.

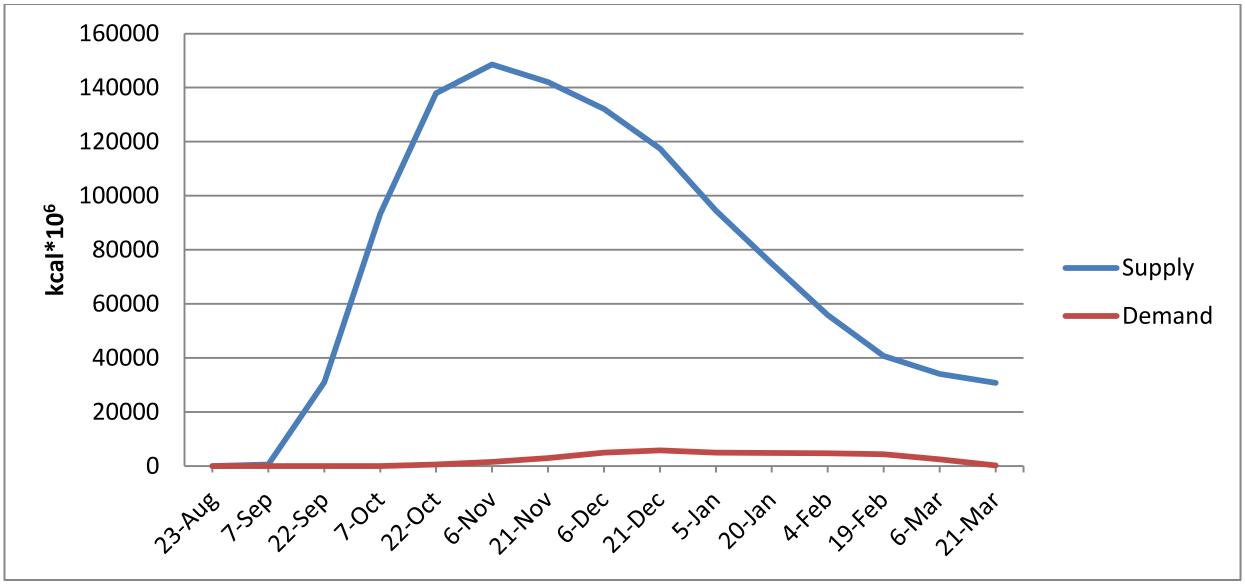


Figure 20. Scenario 5 results for white geese in the CVJV.

Scenario 6.--The amount of rice planted in the Central Valley remains unchanged; however, winter-flooded rice is eliminated. In addition, all fields that were previously winter-flooded are now deep plowed and provide no food resources for ducks or geese.

Outcome.--Dabbling duck food supplies fall below demand by early January (Figure 21), and the total amount of rice habitat that provides food resources falls below 180,000 acres (Table 3). The potential for rainfall to increase dabbling duck food supplies by temporarily flooding some fields is now greatly reduced as the majority of rice fields now have little or no food because of deep plowing. Moreover, goose foraging will be intensified on those rice fields that do provide food. Food resources continue to be adequate for geese, though the food surplus that existed under current condition s is significantly reduced (Figure 22 & 23).

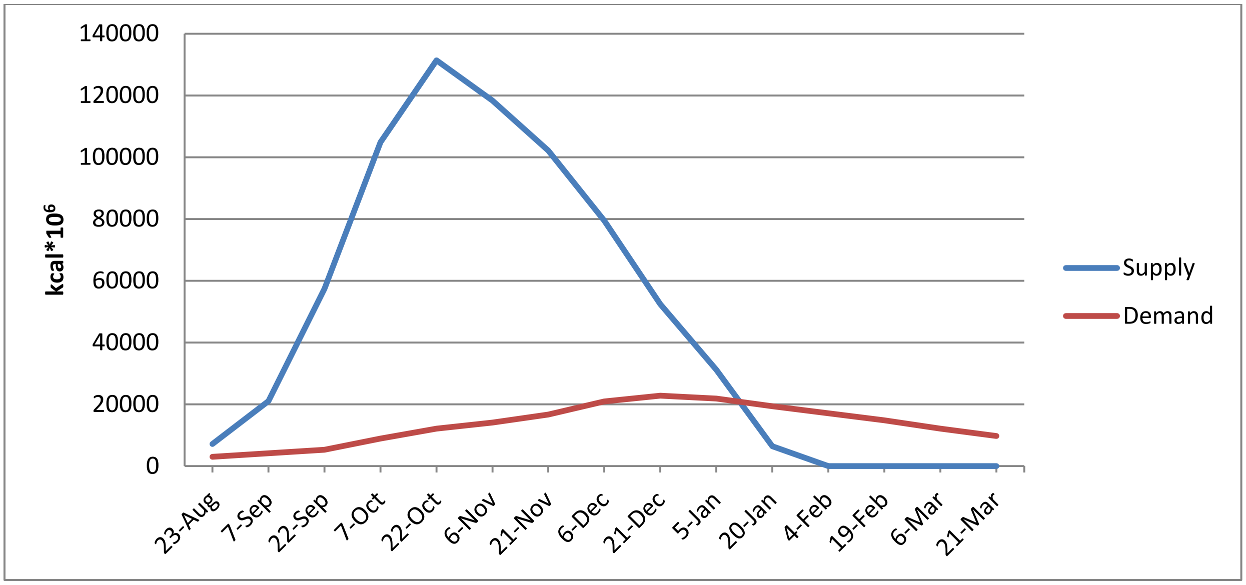


Figure 21. Scenario 6 results for dabbling ducks in the CVJV.

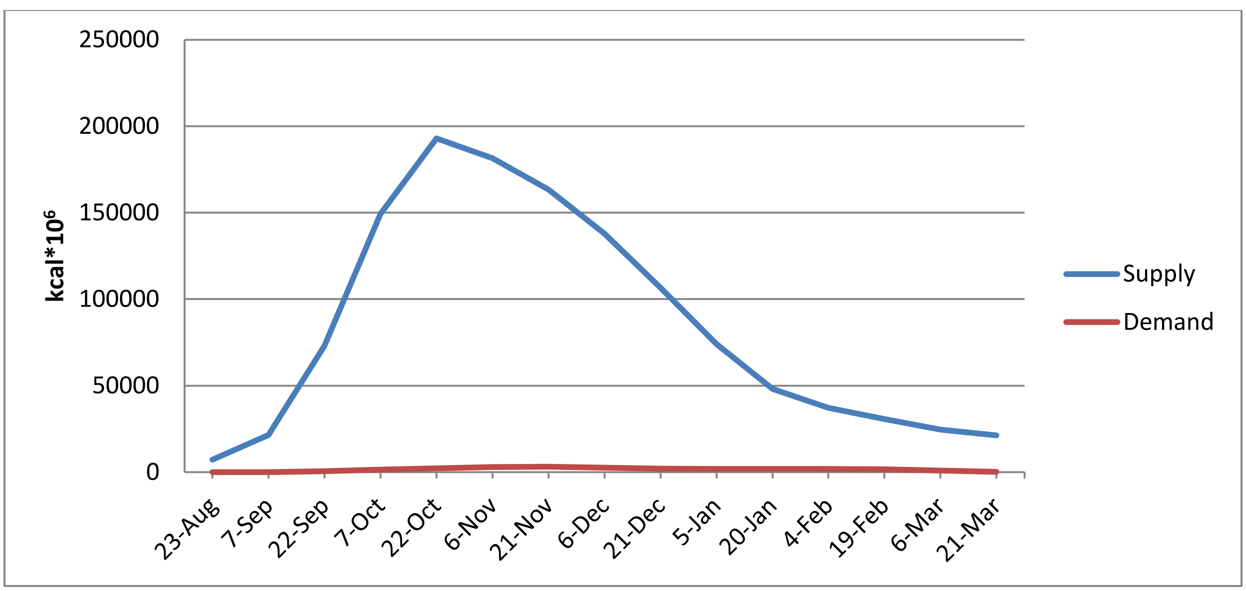


Figure 22. Scenario 6 results for dark geese in the CVJV.

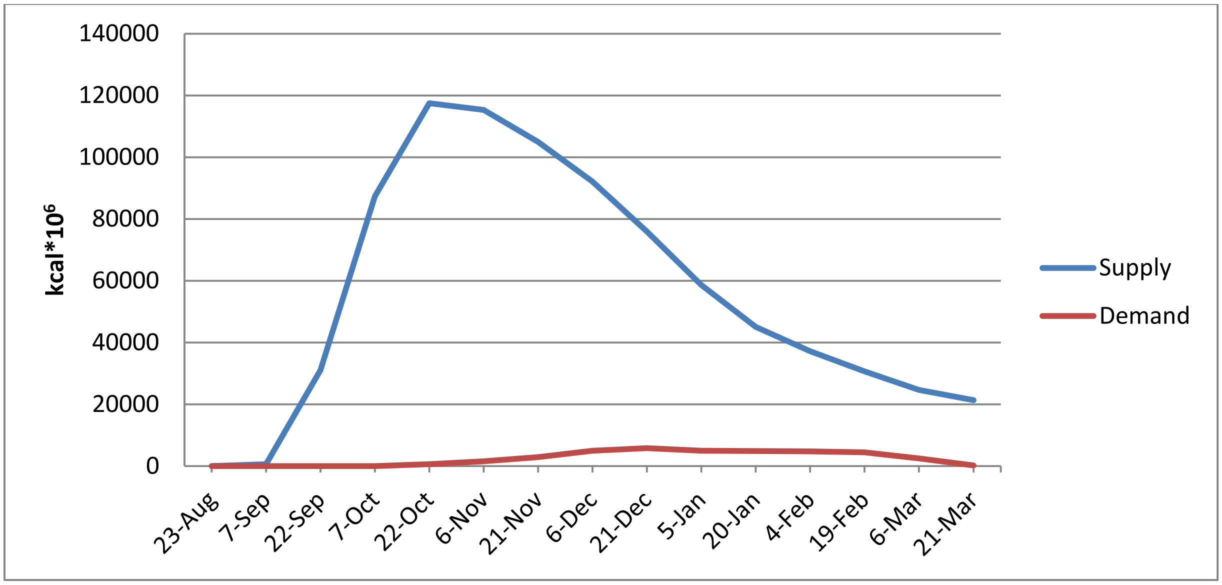


Figure 23. Scenario 6 results for white geese in the CVJV.

Scenario 7.--The amount of planted rice in the Central Valley is reduced by 25% and winter flooding is eliminated. In addition, all fields that were previously winter-flooded are now deep plowed and provide no food resources for ducks or geese.

Outcome.--Dabbling duck food supplies fall below demand by early January (Figure 24), and the total amount of rice habitat that provides food resources falls below 135,000 acres (Table 3). Goose food supplies are further reduced (Figures 25 & 26).

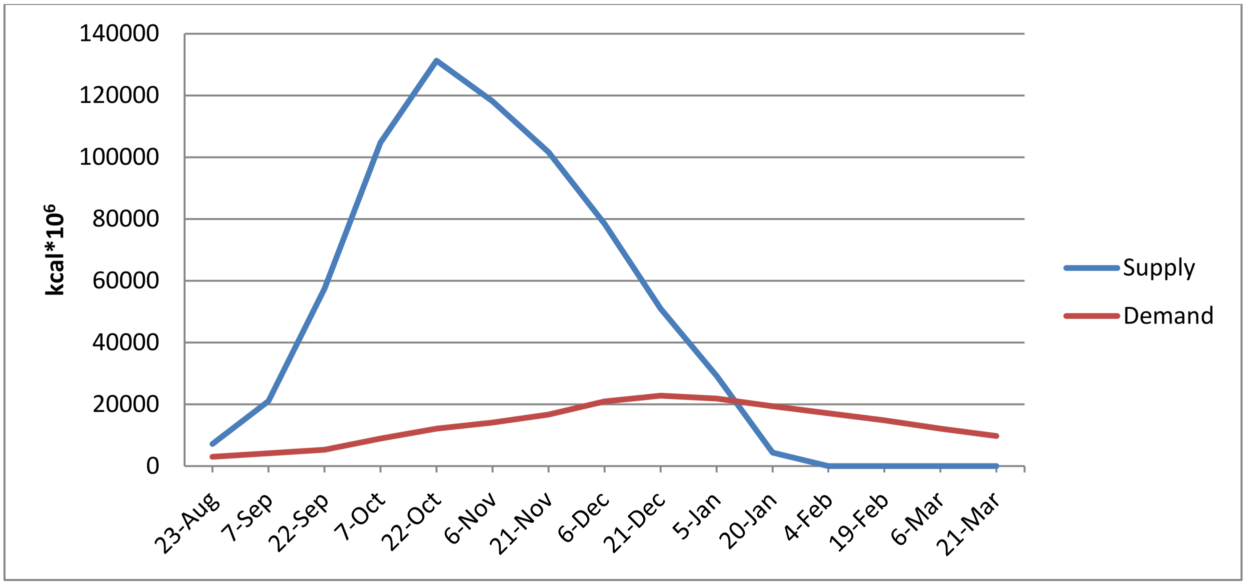


Figure 24. Scenario 7 results for dabbling ducks in the CVJV.

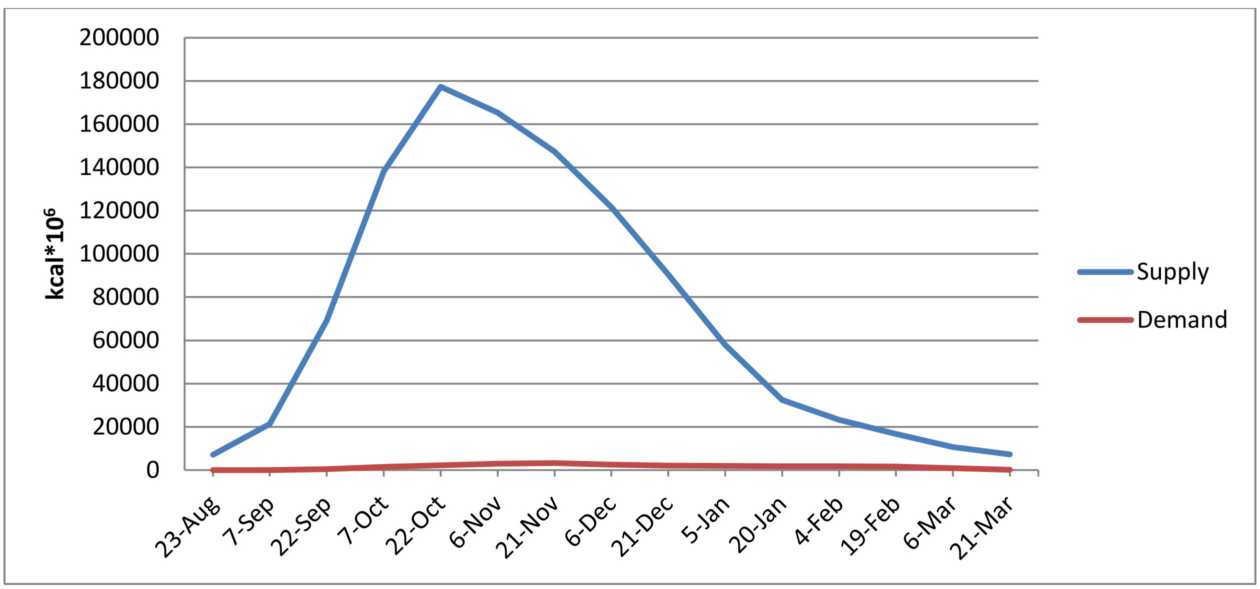


Figure 25. Scenario 7 results for dark geese in the CVJV.

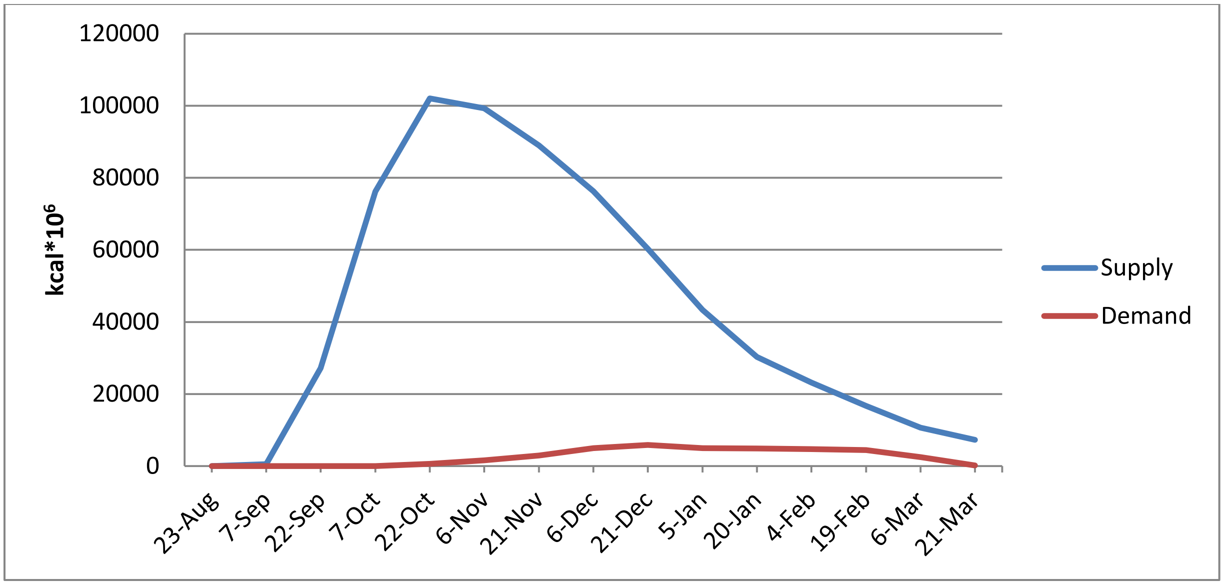


Figure 26. Scenario 7 results for white geese in the CVJV.

Scenario 8.--The amount of planted rice in the Central Valley is reduced by 50% and winter flooding is eliminated. In addition, all fields that were previously winter-flooded are now deep plowed and provide no food resources for ducks or geese.

Outcome.--Dabbling duck food supplies fall below demand by early January (Figure 27), and the total amount of rice that provides food resources declines below 90,000 acres (Table 3). Goose food supplies fall below demand by mid-February (Figures 28 & 29). Scenarios six through eight all assume no winter-flooding of harvested rice fields, and thus produce similar results for dabbling ducks. However, the opportunity for dabbling duck food supplies to be increased by rainfall progressively declines as less rice is planted and more acres are deep plowed.

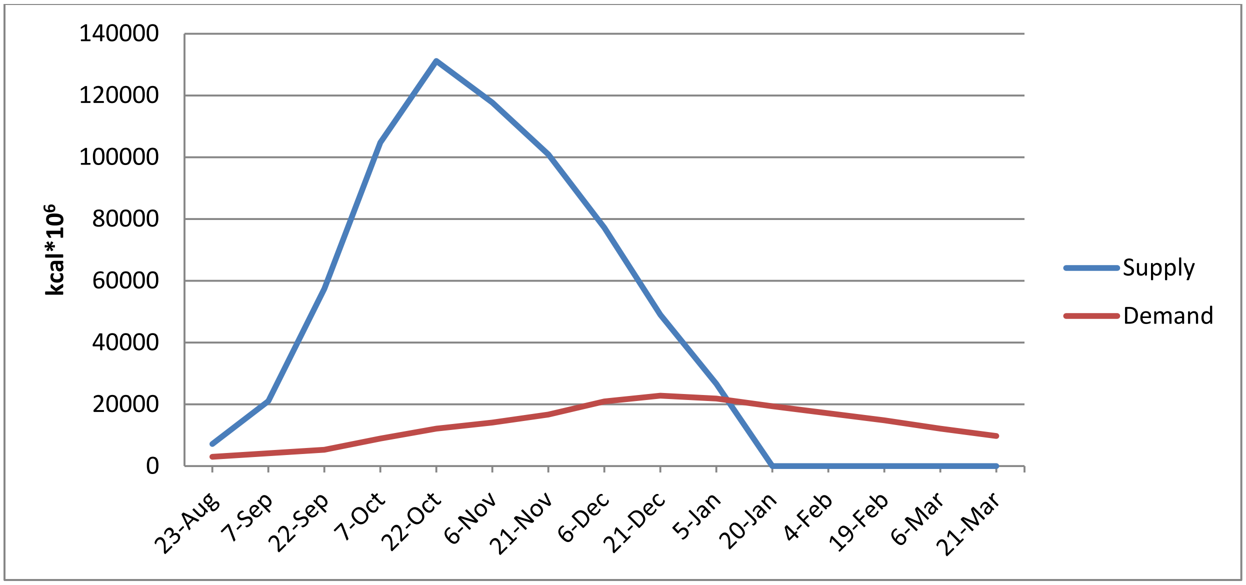


Figure 27. Scenario 8 results for dabbling ducks in the CVJV.

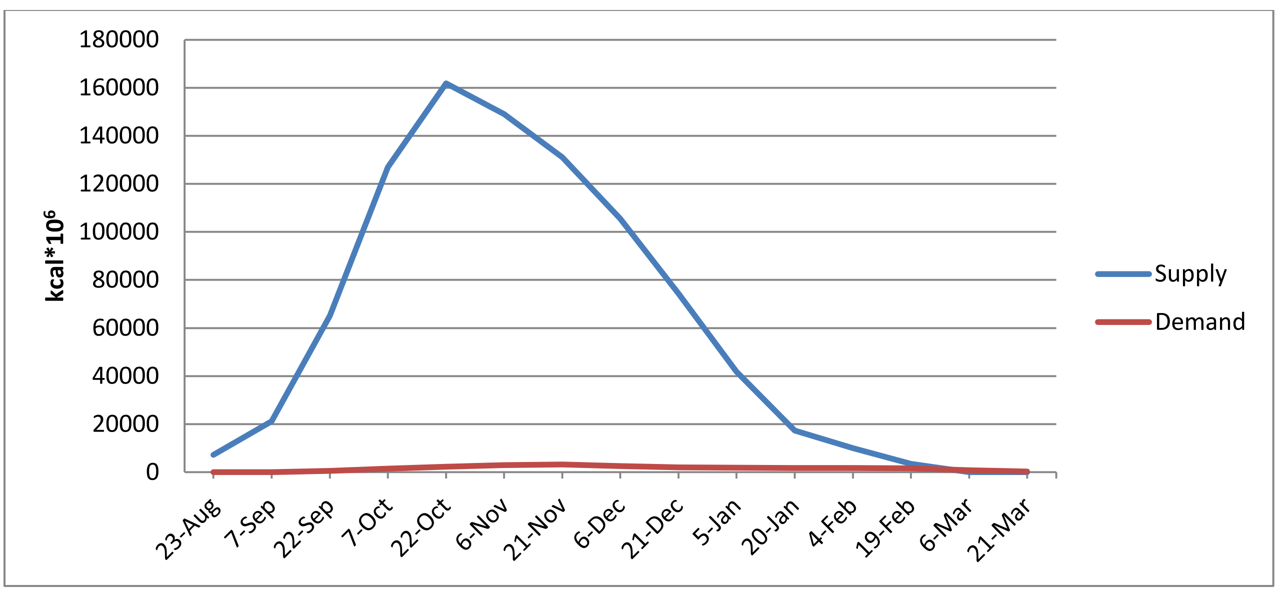


Figure 28. Scenario 8 results for dark geese in the CVJV.

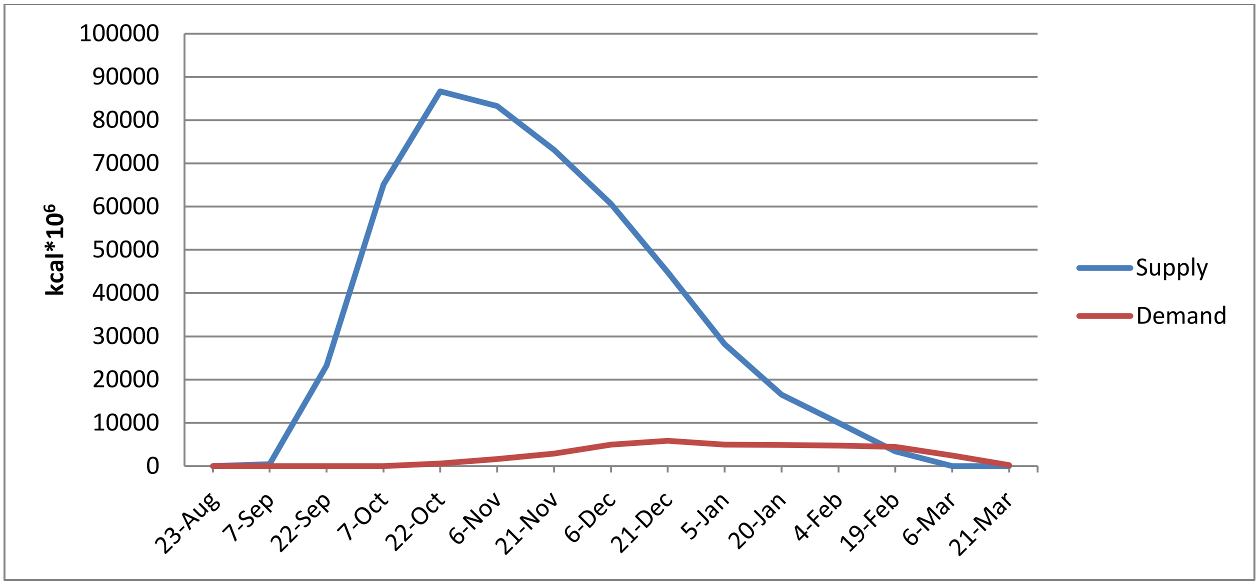


Figure 29. Scenario 8 results for white geese in the CVJV.

Scenario 9.--The amount of planted rice in the Central Valley is reduced by 25% and winter flooding is eliminated. In addition, all fields that were previously winter-flooded are now deep plowed and provide no food resources for ducks or geese. These conditions are identical to that described for Scenario 7. However, water shortages that curtail rice production and reduce winter flooding of harvested rice fields may also reduce managed seasonal wetlands in the Central Valley. As a result, managed wetlands were reduced by 25%.

Outcome.--Dabbling duck food supplies fall below demand by late December (Figure 30).

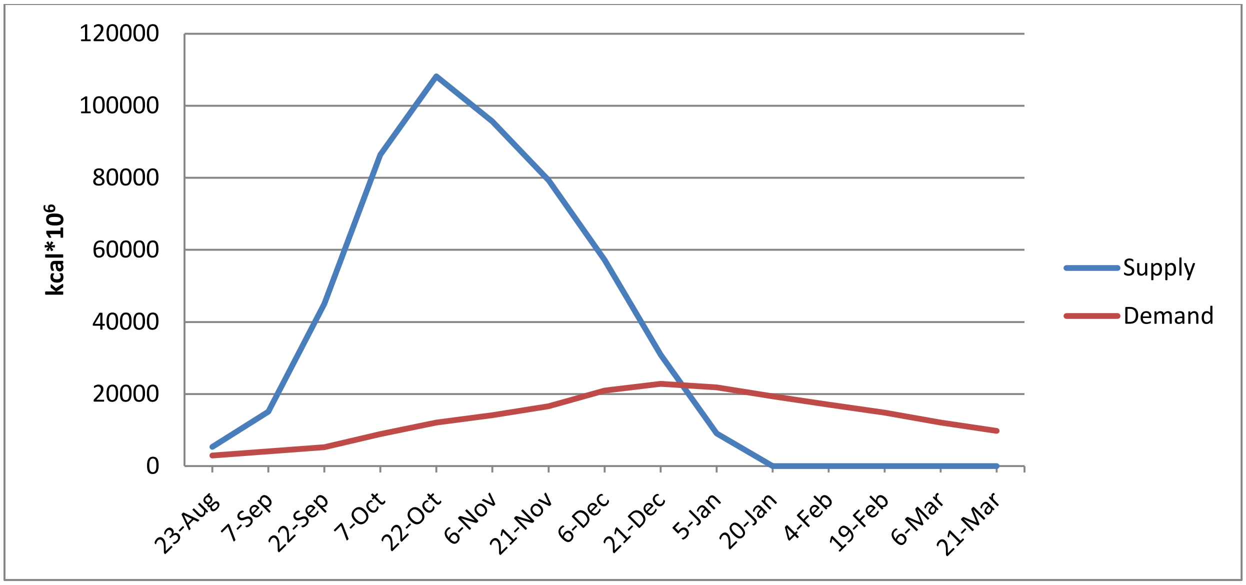


Figure 30. Scenario 9 results for dabbling ducks in the CVJV.

<u>Lower Mississippi Valley Joint Venture</u>

*Common Metrics*

Rice Potential.--Population objectives for dabbling ducks and geese in the LMVJV from October through March equal a combined food energy demand of 3,055.1 * $10^8$ kcals. The amount of rice planted in the LMVJV is estimated at 1,850,748 acres. We assume that rice fields provide 13.8 kg/acre of waste rice and moist-soil seeds (Table A-22), and the TME value of these foods averages 3.0 kcal/g (Table A-25). If post-harvest practices allowed waterfowl to utilize all these foods, ricefields would provide 766.2 * $10^8$ kcals or 25% of the total food energy needs of dabbling ducks and geese in the LMVJV.

Rice Foraging Base.--Winter-flooded ricefields total 388,000 acres and provide 15% of the dabbling duck foraging base in the LMVJV (Table A-16). We did not estimate the percent of the goose foraging base provided by rice as our estimate of goose habitats in the LMVJV are likely incomplete.

Fraction of Total Food Energy Provided by Rice.--Winter-flooded ricefields provide 11% of all food energy available to dabbling ducks in flooded habitats in the LMVJV ( Figure 31).

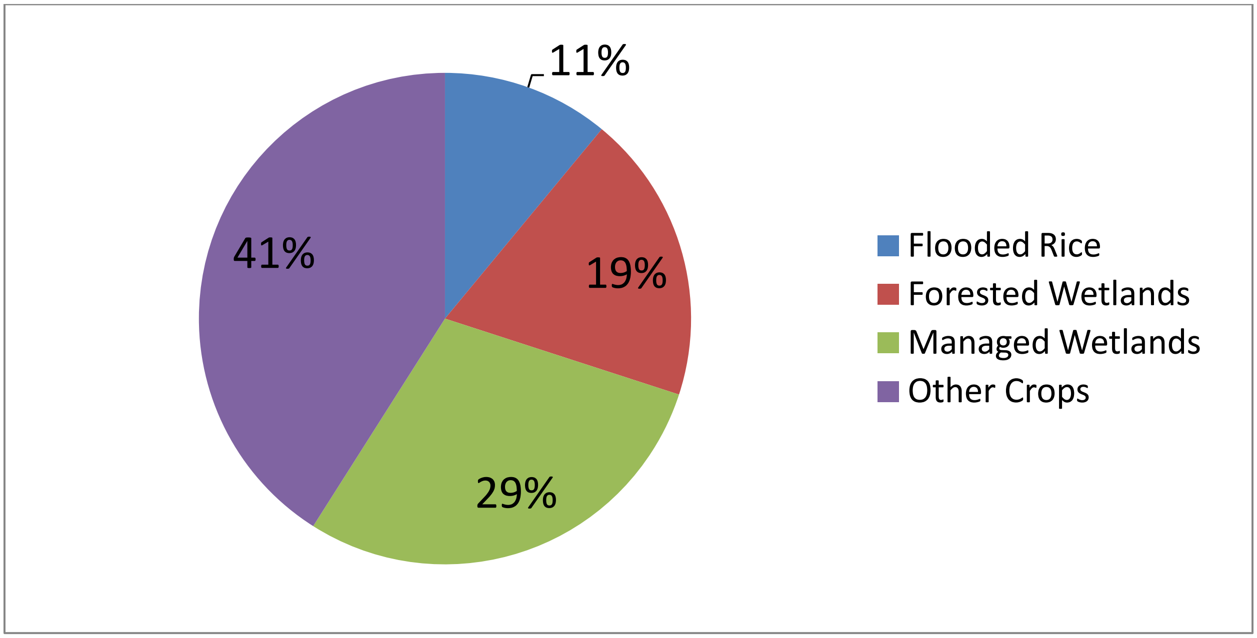


Figure 31. Fraction of dabbling duck food energy in the LMVJV attributed to rice and other habitat types.

*TRUEMET Results*

Approximately 388,000 acres of harvested ricefields are winter-flooded in the LMVJV, similar to that flooded in both the CVJV and GCJV. However, the amount of waste rice available to waterfowl in LMVJV rice fields appears to be substantially less compared to the other Joint Ventures. For example, harvested rice fields in the Central Valley and Gulf Coast provide just over 120 kg / acre of food. In contrast, harvested rice fields in the LMVJ provide only about 14 kg/acre of food or about twelve percent of that found in CVJV and GCJV.

Low food values associated LMJV rice habitats appear related to earlier maturing varieties of rice that allow fields to be harvested well in advance of waterfowl migration. As a result, most waste rice is lost to germination, decomposition, or consumption by non-waterfowl species. Many of our TRUEMET scenarios illustrate the declining food values provided by rice habitats in the LMVJV.

*However, with nearly two million acres of rice planted in the LMVJV the conservation opportunities provided by this rice base dwarf anything else.* Accordingly, we modeled the benefits of increasing the amount of food provided by rice fields with a special focus on ratooning (Table 4).

Table 4. Habitat acres used in LMVJV TRUEMET scenarios.

| Scenario | Flooded Rice (Harvested) | Dry Rice (Harvested) | Managed Wetlands | Forested Wetlands | Flooded Crops (Harvested) | Flooded Crops (Unharvested) |
|---|---|---|---|---|---|---|
| #1 | 388,028 | 1,462,720 | 87,943 | 1,379,447 | 698,458 | 8,795 |
| #2 | 0 | 1,850,748 | 87,943 | 1,379,447 | 698,458 | 8,795 |
| #3 | 388,028 | 1,462,720 | 0 | 0 | 0 | 0 |
| #4 | 388,028 | 1,462,720 | 87,943 | 1,379,447 | 698,458 | 8,795 |
| #5 | 388,028[a] | 1,462,720 | 87,943 | 1,379,447 | 698,458 | 8,795 |
| #6 | 388,028[a] | 1,462,720 | 0 | 0 | 0 | 0 |

[a] All winter-flooded rice acres have been ratooned with a corresponding food value of 160 kg/acre.

Scenario 1.--Current habitat conditions in the LMVJV

This scenario modeled dabbling duck food energy supplies under current habitat conditions in the LMVJV. Wood ducks were included in the dabbling duck foraging guild because they rely heavily on forested wetlands in the LMVJV.

Outcome.--Current habitat conditions in the LMVJV indicate that dabbling duck food supplies fall below population energy demand by early February (Figure 32). Our model results are strongly influenced by estimates of food production in forested wetlands, which are generally low compared to other foraging habitats (Table A-22). Forested wetlands account for over fifty percent of all habitats available to dabbling ducks in the LMVJV (Table A-16), and any model results for "current conditions" will be highly sensitive to food biomass estimates for this habitat type. In addition, the lack of dabbling duck food supplies in late winter and early spring is not solely the result of birds consuming all available foods. Many agricultural crops and forested wetlands that were flooded during the hunting season are being drained during the late winter – early spring period, and our model assumes these habitats are no longer available after being drained (see Figures A-5 through A-9). Finally, we may have excluded many unmanaged habitats that become available in late winter and early spring as a result of overbank flooding, and which may provide significant food resources.

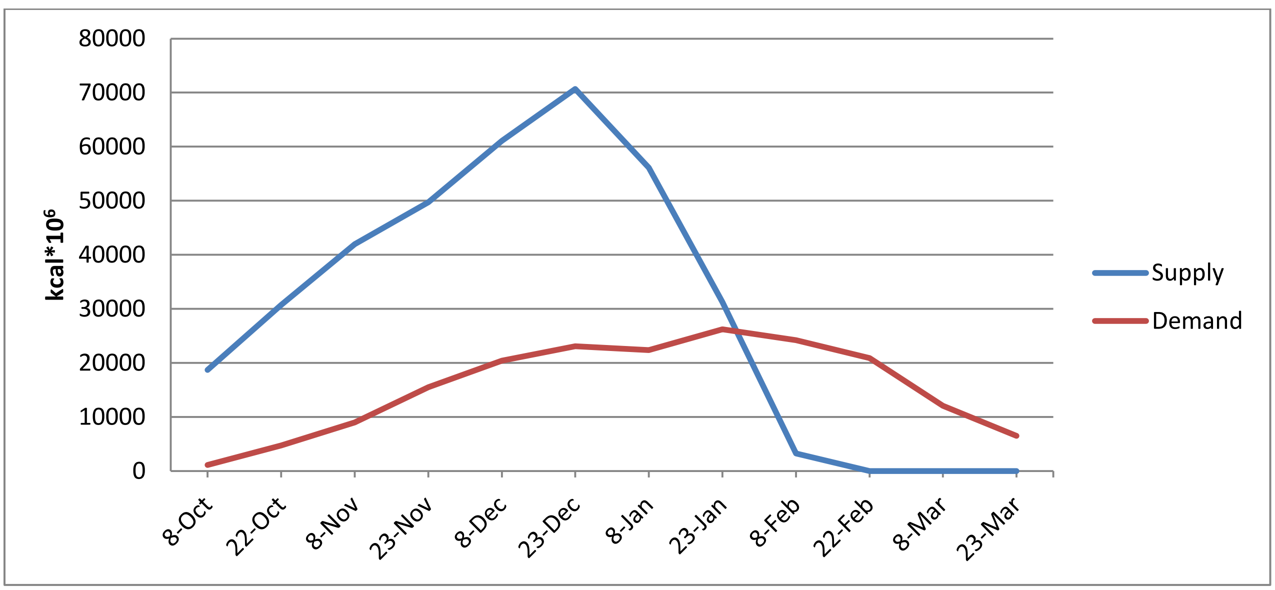


Figure 32. Scenario 1 results for dabbling ducks in the LMVJV.

Scenario 2.--No flooded rice habitat available in the LMVJV.

Outcome.--Dabbling duck food supplies fall below population energy demand by late January – early February (Figure 33). Although food surpluses for dabbling ducks in late fall and early winter are diminished compared to the "current conditions" scenario (Figure 32), there is little overall difference between the two scenarios despite the loss of nearly 400,000 acres of flooded rice habitat (Table 4). This result is entirely driven by the low food biomass assigned to rice.

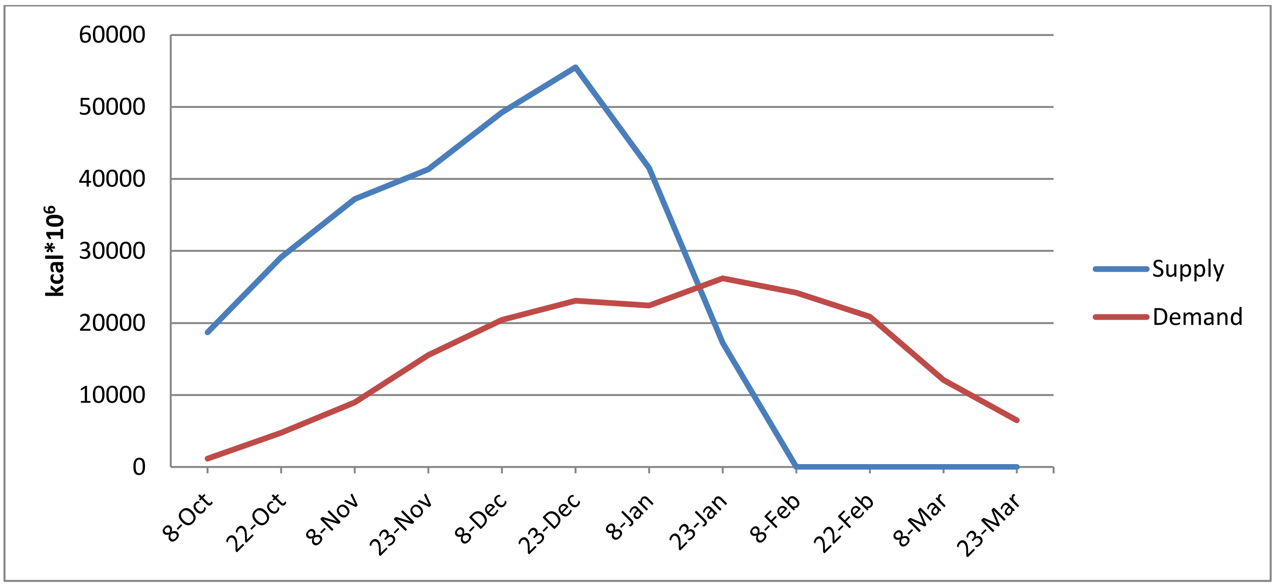


Figure 33. Scenario 2 results for dabbling ducks in the LMVJV.

Scenario 3.--Flooded rice habitat is the only habitat available dabbling ducks in the LMVJV. Wood ducks are excluded from the dabbling duck guild, though we continued to assume that geese meet twenty-five percent of their food energy needs from flooded habitats and would thus forage in these flooded rice fields.

Outcome.--The food resources provided by flooded rice fields alone are well below dabbling duck energy needs in all time periods, and no food resources are provided by this habitat after late December (Figure 34). The constant supply of food provided by rice from early November through late December reflects the continuous flooding of new fields throughout this period (Figure A-5). In essence, newly flooded fields are providing new food resources which are rapidly consumed. After flooding ceases the food provided by rice rapidly goes to zero.

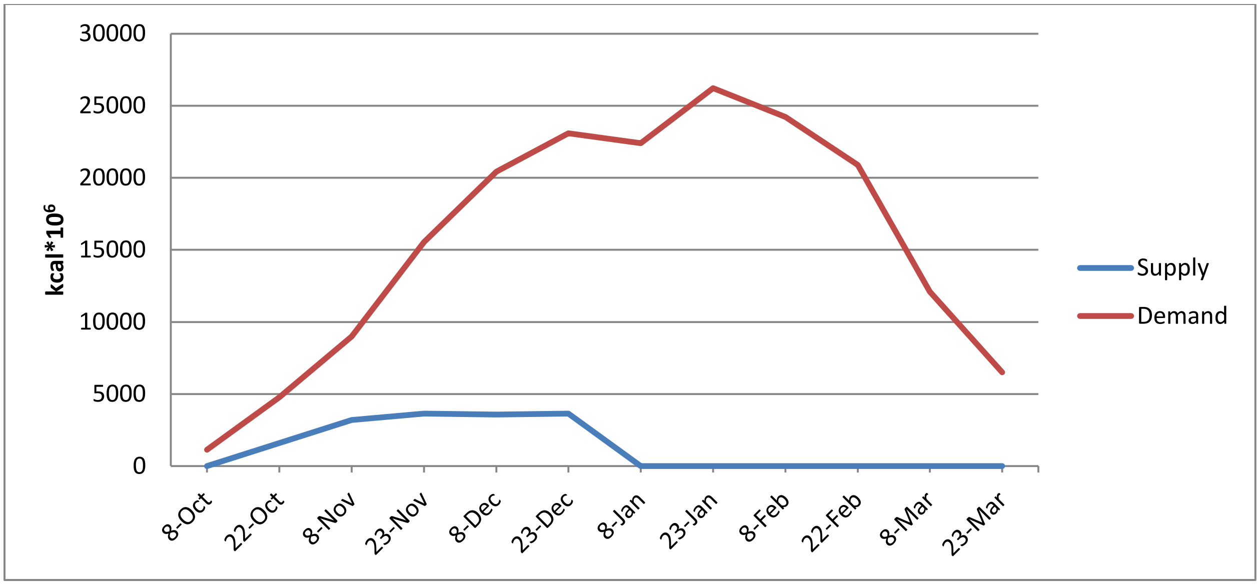


Figure 34. Scenario 3 results for dabbling ducks in the LMVJV.

Scenario 4.--The capacity of unflooded rice habitats to support LMVJV goose populations. The LMVJV assumes that geese meet twenty-five percent of their food energy needs from flooded habitats. In Scenario 3, we allowed seventy-five percent of the LMVJV goose population to forage exclusively on harvested rice fields that were not flooded. Harvested rice fields in the LMVJV that are not flooded total about 1.46 million acres (Table 4).

Outcome.--Geese exhaust food resources in unflooded rice fields by late December despite the abundance of this habitat type. (Figure 35). Again, these results are a function of the low food value assigned to harvested rice fields in the LMVJV.

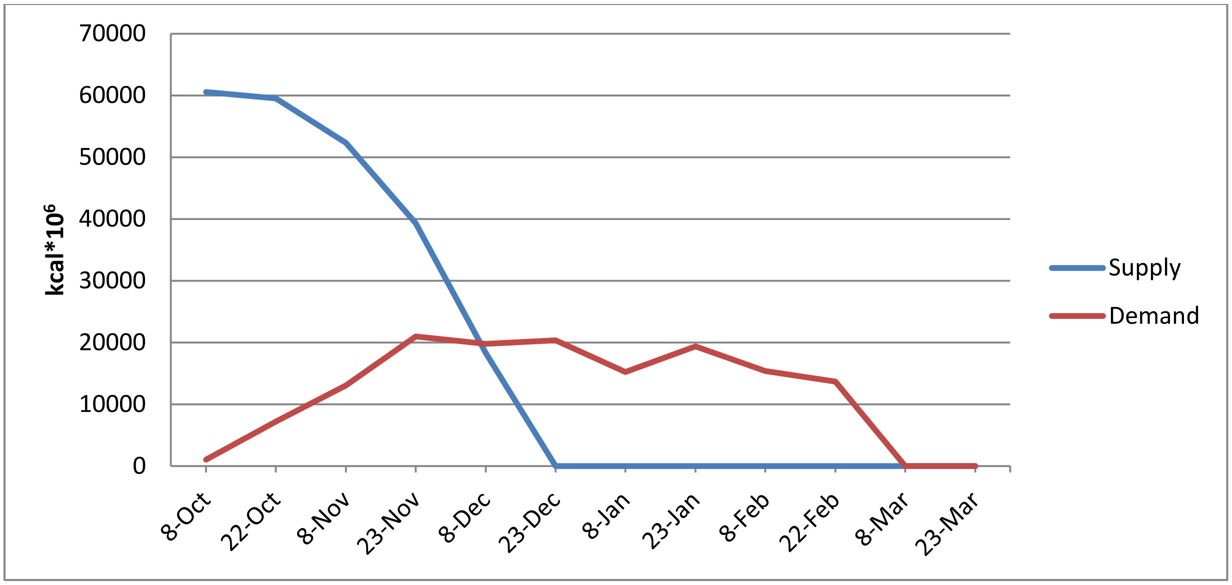


Figure 35. Scenario 4 results for geese in the LMVJV.

Scenario 5.--This scenario forecasts dabbling duck food energy supplies under current habitat conditions in the LMVJV but with ratooned rice present. We assumed that the amount of winter-flooded rice stays the same (388,000 acres), but that these fields have been ratooned and harvested prior to flooding. Harvested ratoon fields in the GCJV average about 160 kg/acre of food and we adopted that value here (Table 4). Because ratooned fields would be harvested much closer to the time that birds begin arriving in the LMVJV, the loss of waste rice to decomposition or germination would be greatly reduced.

Outcome.--Food resources for dabbling ducks are now adequate in all time periods except late March (Figure 36). The lack of food resources in March is largely driven by our assumption that many foraging habitats have been drained, including rice.

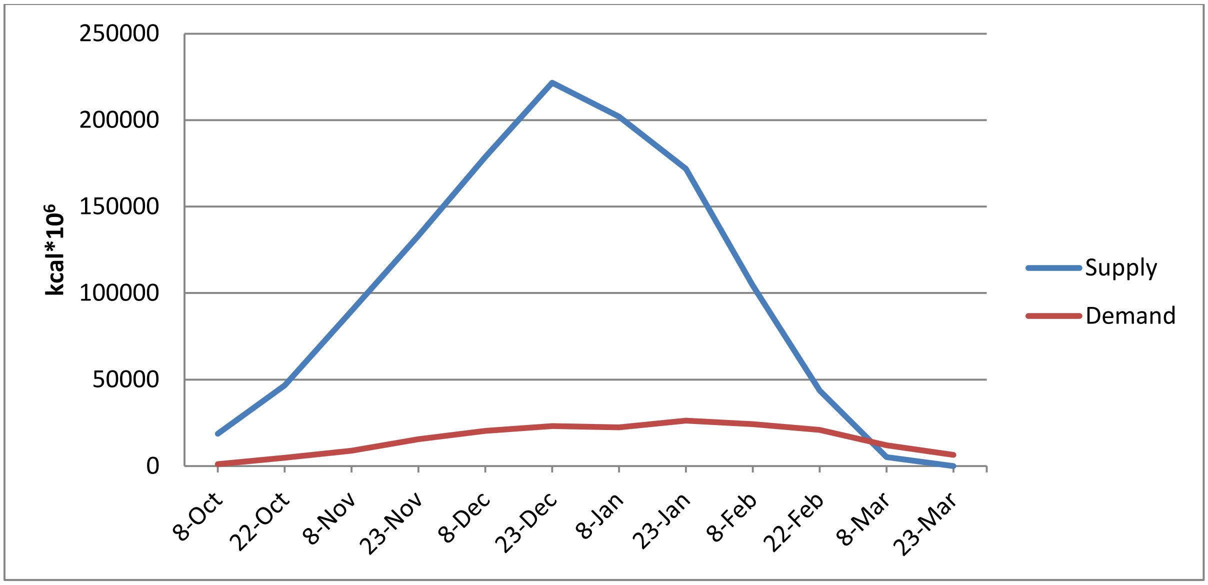


Figure 36. Scenario 5 results for dabbling ducks in the LMVJV.

Scenario 6.--This scenario is identical to scenario 3 (only flooded rice habitat available), however, all 388,000 acres of flooded rice have been ratooned and harvested (Table 4).

Outcome.--Ratooned ricefields alone can meet dabbling duck food energy requirements through late February (Figure 37). This result speaks to the tremendous potential of rice habitat in the LMVJV to meet waterfowl needs.

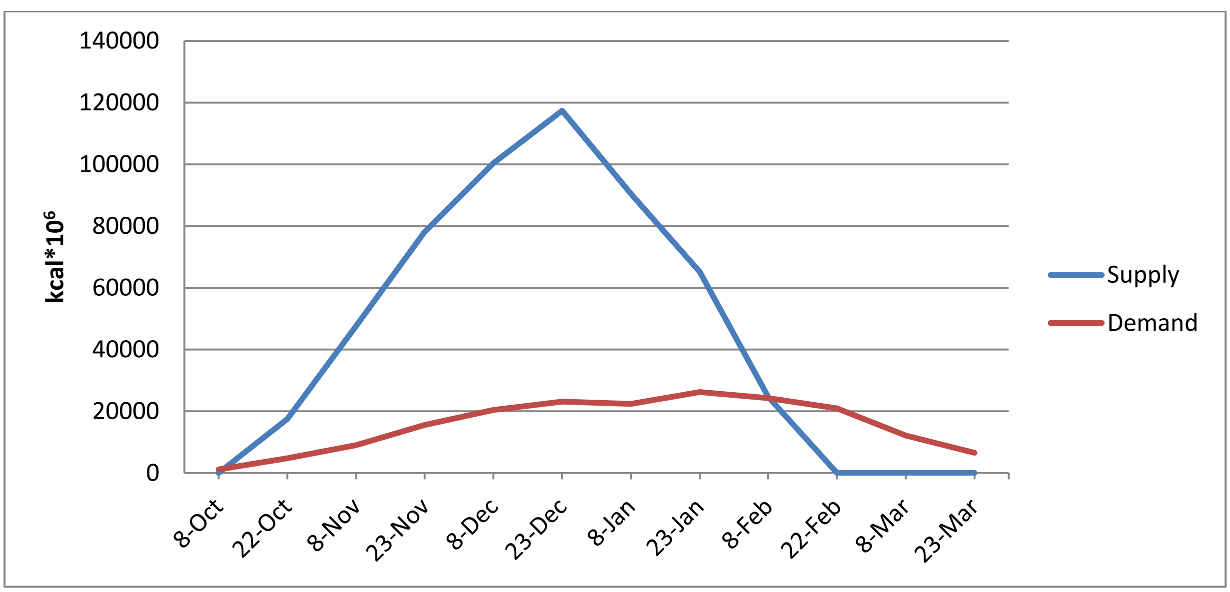


Figure 37. Scenario 6 results for dabbling ducks in the LMVJV.

Gulf Coast Joint Venture

*Common Metrics*

Rice Potential.--Population objectives for dabbling ducks and geese in the GCJV from August through March equal a combined food energy demand of 4745.3 * $10^8$ kcals. The Joint Venture's rice base totals over 1 million acres and consists primarily of planted rice and idled ricefields (Table A-17), which vary widely in the foods provided (Table A-23). If post-harvest practices allowed waterfowl to utilize all these foods, ricelands would provide 3857.0 * $10^8$ kcals or 81 % of the total food energy needs of dabbling ducks and geese in the GCJV.

Rice Foraging Base.--Total flooded ricelands during the years examined (i.e. fall/winter 2010-11 and 2011-12) total 345,000 acres and provide 7% of the dabbling duck foraging base in the GCJV (Table A-20).

Fraction of Total Food Energy Provided by Rice.--Flooded ricelands provided 42% of all food energy available to dabbling ducks in the GCJV (Figure 38). Although not calculated, ricelands are assumed to provide nearly all of the food energy available to geese in the GCJV.

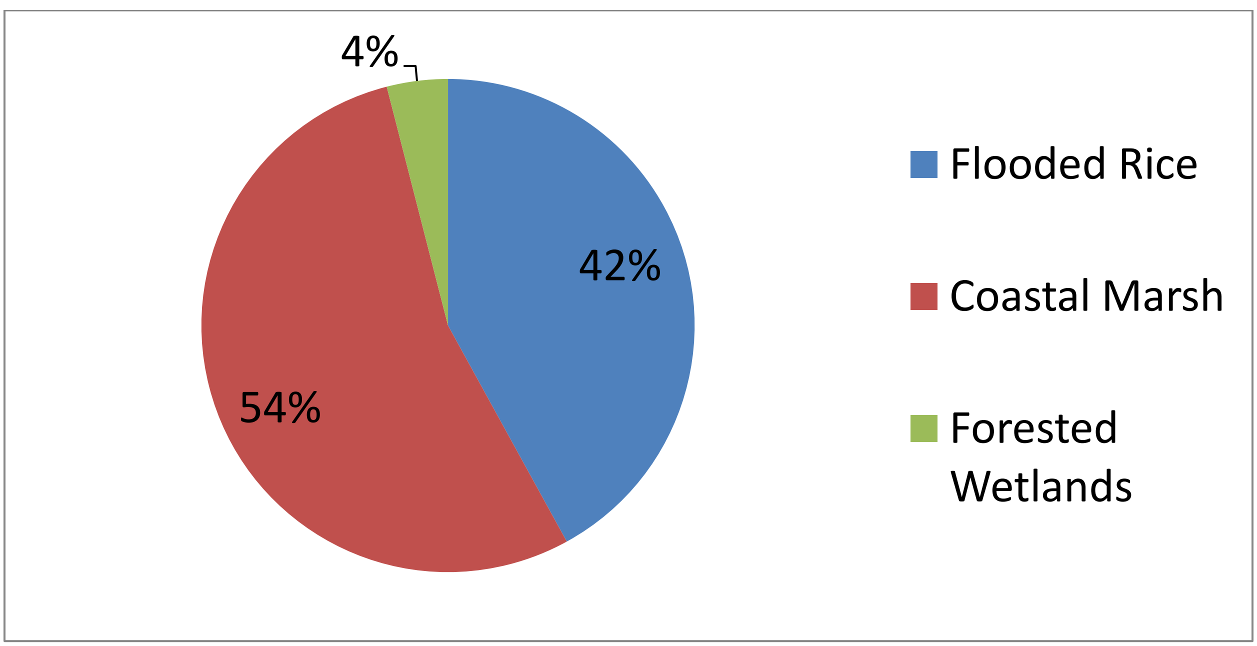


Figure 38. Fraction of dabbling duck food energy in the GCJV attributed to rice and other habitat types.

*TRUEMET Results*

Our model simulations for the CVJV and LMVJV did not separate these Joint Ventures into geographically distinct areas when evaluating the importance of rice to waterfowl. However, the GCJV is divided into five initiative areas that differ widely in terms of waterfowl habitats and conservation challenges. As a result we conducted separate model runs for each initiative area where rice is grown (TXMC, TXCP, and the LACP), and also conducted model runs where these three rice growing areas were combined. Finally, we analyzed the GCJV as a whole excluding the Laguna Madre Initiative Area where waterfowl habitat largely consists of sea grass beds and inland freshwater wetlands not directly associated with agriculture.

We ran the following four simulations for each initiative area or combinations of initiative areas: 1) current habitat conditions, 2) 25% reduction in riceland habitat, 3) 50% reduction in riceland habitat, and 4) elimination of all rice production (Tables 5 to 8). Virtually all the habitat available to waterfowl in the GCJV's rice growing initiative areas consists of ricelands and coastal marsh. Simulations 1 and 4 were also run for the GCJV as a whole. Because the GCJV has established waterfowl population objectives that are specific to these riceland and coastal marsh habitats (Tables A-4 through A-6), our evaluation of current conditions in the TXMC, TXCP, and LACP focused on populations assigned to riceland habitats. However, for scenarios where we eliminated all rice production we combined waterfowl population objectives for riceland and coastal marsh habitats and assumed that all birds were required to rely almost exclusively on coastal marsh. We did not present results for geese where rice was eliminated because we assumed that geese would largely abandon landscapes where rice is no longer grown.

Model simulations that reduced riceland habitat by 25% or 50% reflected our different foraging assumptions for ducks and geese. We assume that dabbling ducks only forage in riceland habitats that are flooded, while geese will forage in flooded and unflooded habitats (Table A-28). When reducing rice habitats within the model we reduced flooded and unflooded habitats by the same percentage. For example, a 25% reduction in riceland habitat was modeled as a 25% reduction in both flooded and unflooded habitats.

Texas Mid-Coast (TXMC)

Scenario 1.--Current habitat conditions in the TXMC.

This scenario modeled dabbling duck and goose food energy supplies under current habitat conditions in the TXMC.

Table 5. Habitat acres used in Texas Mid-Coast (TXMC) TRUEMET scenarios.

| Scenario | Flooded Ricelands | Flooded Soybeans | Coastal Marsh |
|---|---|---|---|
| #1 | 45,767 | 2,219 | 335,756 |
| #2 | 34,325 | 2,219 | 335,756 |
| #3 | 22,884 | 2,219 | 335,756 |
| #4 | 0 | 2,219 | 335,756 |

Outcome.--Existing habitats are insufficient to meet dabbling duck energy needs after mid-October (Figure 39), while goose energy needs are met in all time periods (Figure 40). The "spikes" in food energy supply seen on these graphs reflects agricultural practices and flooding patterns. For example, the increase in food energy supply that occurs in early November on both graphs coincides with the maturing and harvesting of ratooned rice. The mid-December increase in duck energy supplies results from a late season increase in flooded riceland habitats, especially idled rice fields (see Figure A-10). However, this increase is not large enough to meet duck energy needs. Insufficient food resources for dabbling ducks in the TXMC are of special concern given the long-term decline in planted rice acres and the more recent effects of drought on the Texas rice industry.

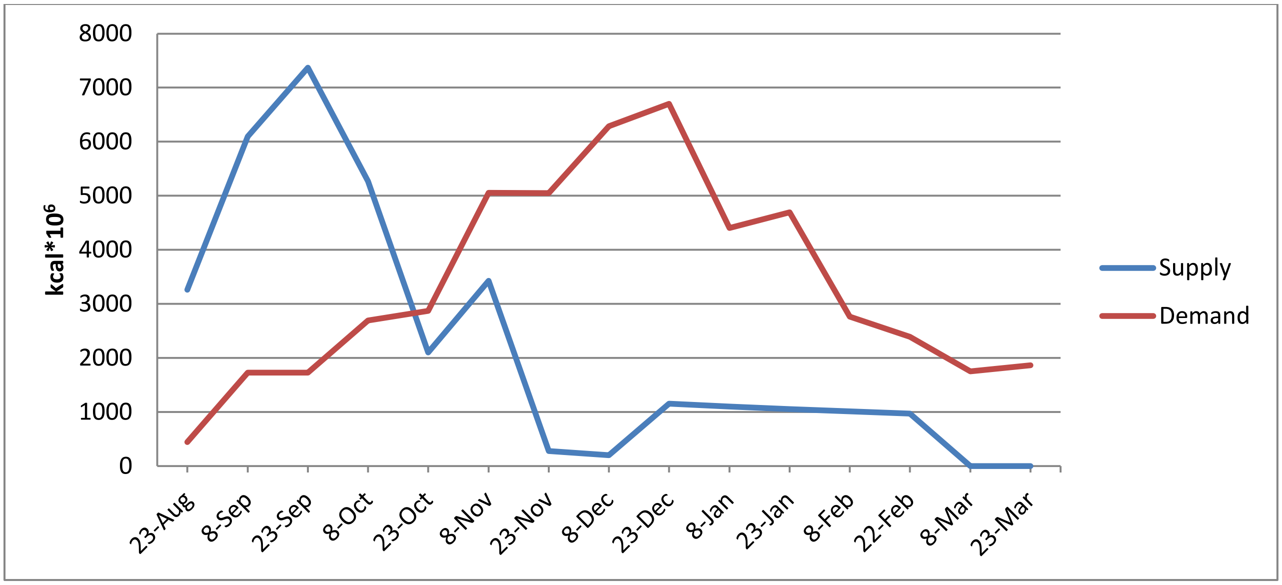


Figure 39. Scenario 1 results for dabbling ducks in the TXMC.

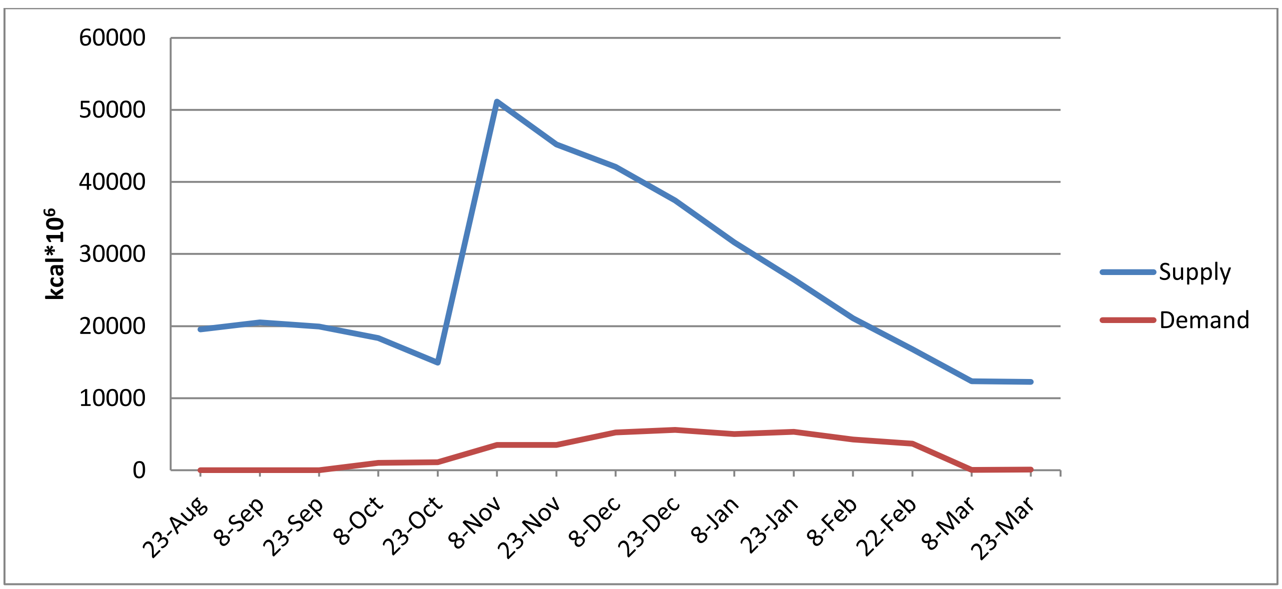


Figure 40. Scenario 1 results for geese in the TXMC.

Scenario 2.--Twenty five percent reduction in riceland habitats in the TXMC.

Outcome.--A 25% loss in riceland habitat further increases the food deficiency for dabbling ducks (Figure 41); however, food energy supplies for geese remain adequate in all time periods (Figure 42).

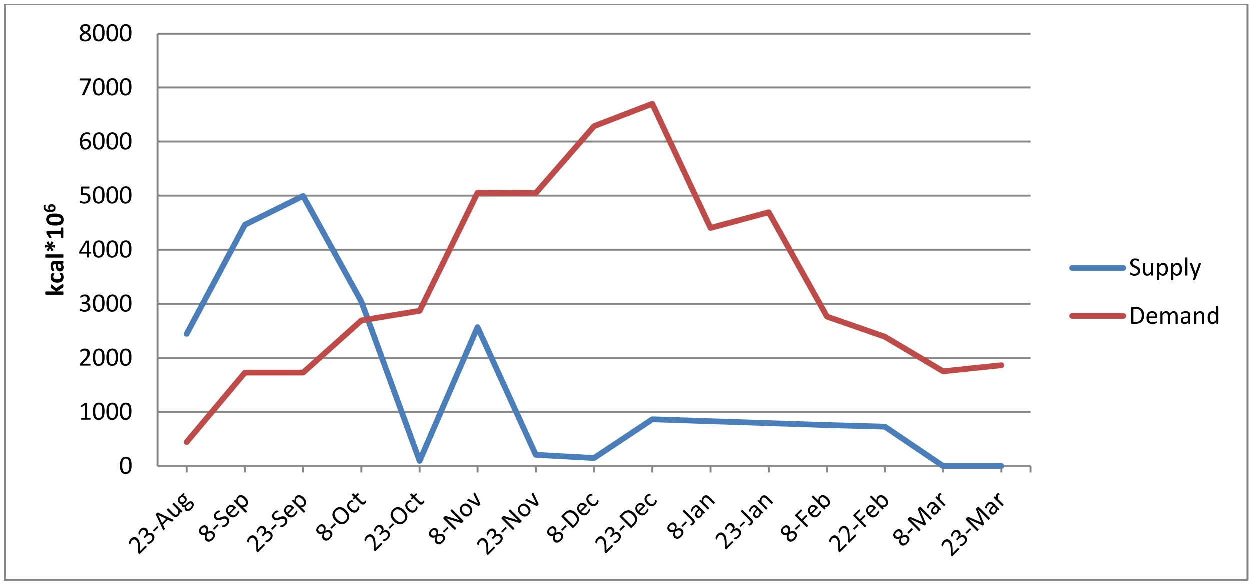


Figure 41. Scenario 2 results for dabbling ducks in the TXMC.

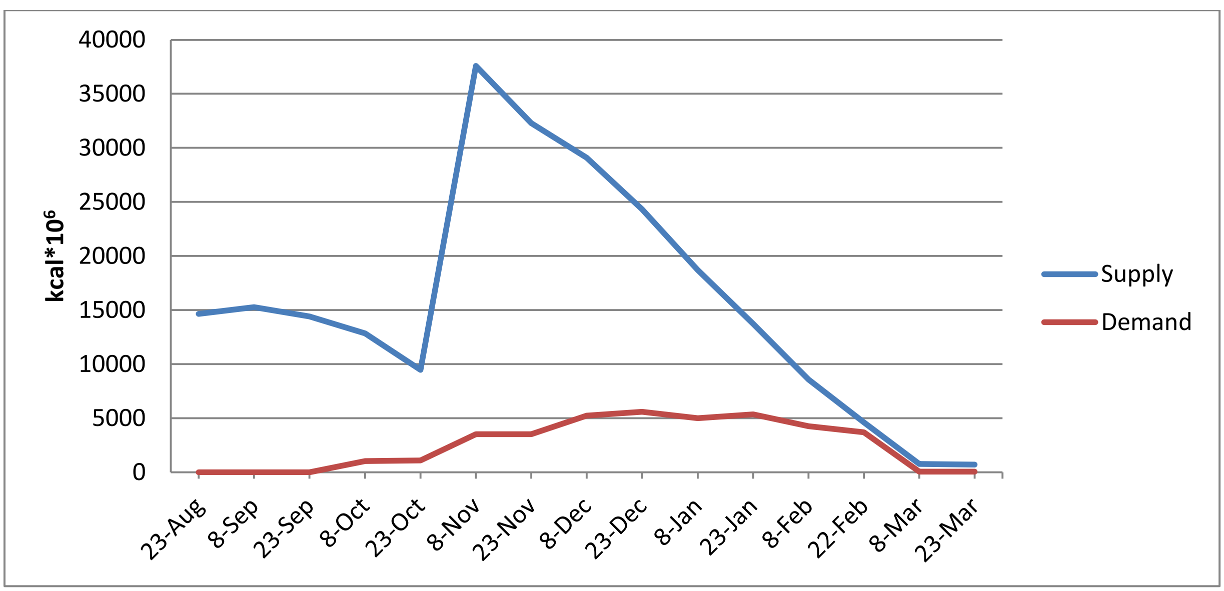


Figure 42. Scenario 2 results for geese in the TXMC.

Scenario 3.--Fifty percent reduction in riceland habitats in the TXMC.

Outcome.--A 50% loss in riceland habitat results in dabbling ducks food supplies falling below demand by late September, with large deficiencies in food supplies thereafter (Figure 43). Goose food supplies also become inadequate by mid-January (Figure 44).

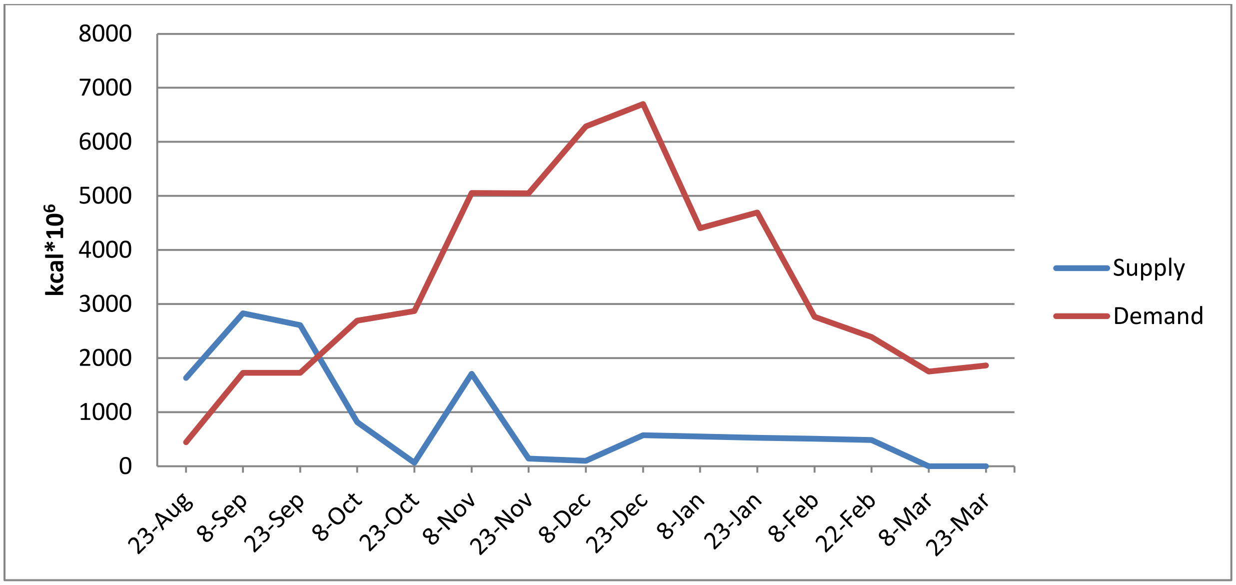


Figure 43. Scenario 3 results for dabbling ducks in the TXMC.

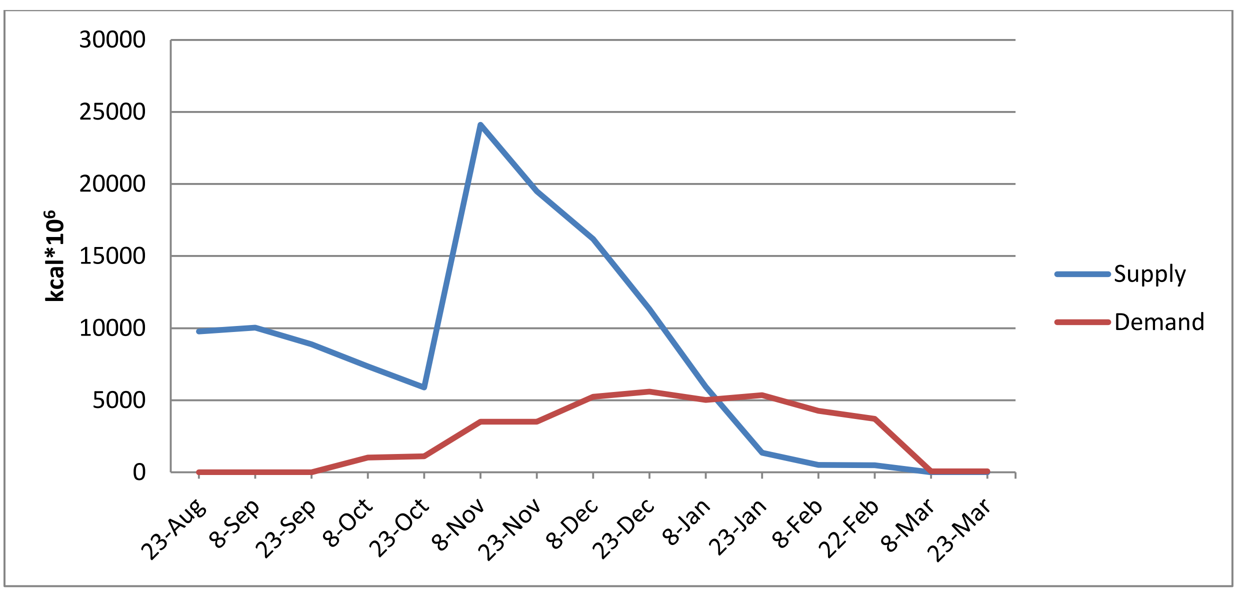


Figure 44. Scenario 3 results for geese in the TXMC.

Scenario 4.--All rice production is eliminated in the TXMC.

This scenario assumes that rice is no longer grown in the TXMC and that birds which relied on riceland habitats must now rely on coastal marsh.

Outcome.--Dabbling duck food supplies are exhausted by mid-November (Figure 45). Coastal marsh habitats in the TXMC are already assumed to support large numbers of dabbling and diving ducks (Table A-4). Shifting all ducks in the TXMC into coastal marsh puts a tremendous amount of foraging pressure on these coastal habitats, which is reflected in our results.

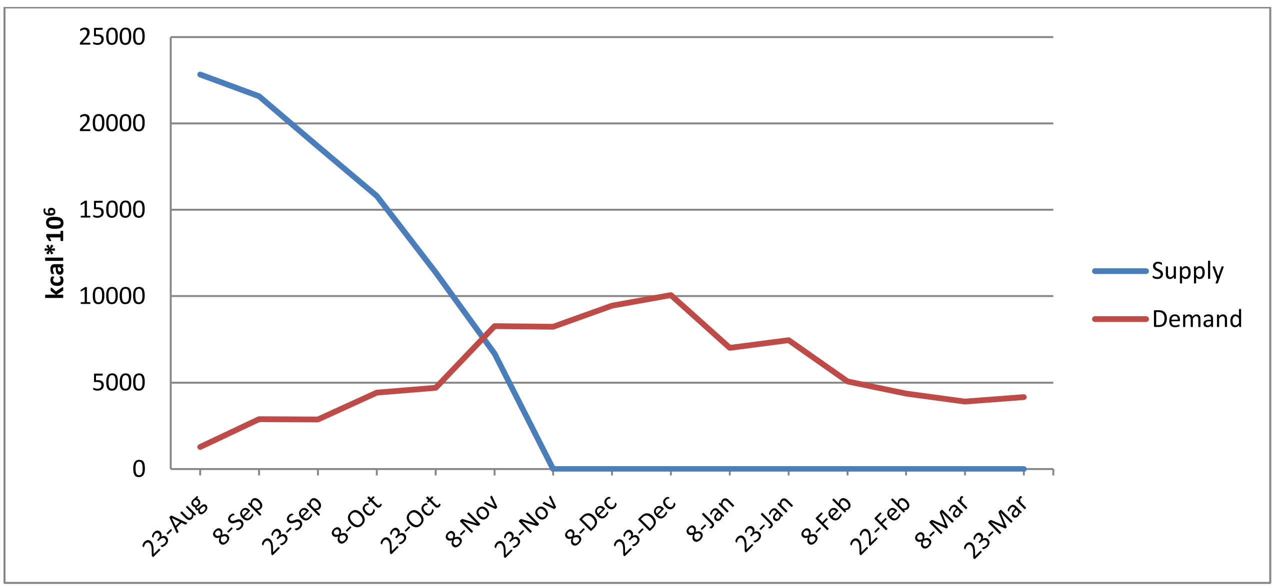


Figure 45. Scenario 4 results for dabbling ducks in the TXMC.

<u>Texas Chenier Plain (TXCP)</u>

Scenario 1.--Current habitat conditions in the TXCP

This scenario modeled dabbling duck and goose energy supplies under current habitat conditions in the TXCP.

Table 6. Habitat acres used in Texas Chenier Plain (TXCP) TRUEMET scenarios.

| Scenario | Flooded Ricelands | Flooded Soybeans | Coastal Marsh |
|---|---|---|---|
| #1 | 46,281 | 2,592 | 250,968 |
| #2 | 34,711 | 2,592 | 250,968 |
| #3 | 23,140 | 2,592 | 250,968 |
| #4 | 0 | 2,592 | 250,968 |

Outcome.--The ability of existing habitats to meet dabbling duck energy needs appears to vary from early fall through early spring (Figure 46). Food energy supplies are insufficient throughout much of September and October, and again in March. March deficiencies are at least partly driven by high food energy demand, which presumably results from a large influx of spring-migrating blue-winged teal that have wintered south of the GCJV. In contrast, food supplies are adequate or near adequate in much of November and from January through February. These periods of adequate food supplies correspond with the maturing and harvesting of ratooned rice crops, and the late season flooding of riceland habitats (Figure A-11). Food energy supplies for geese appear sufficient in all time periods (Figure 47).

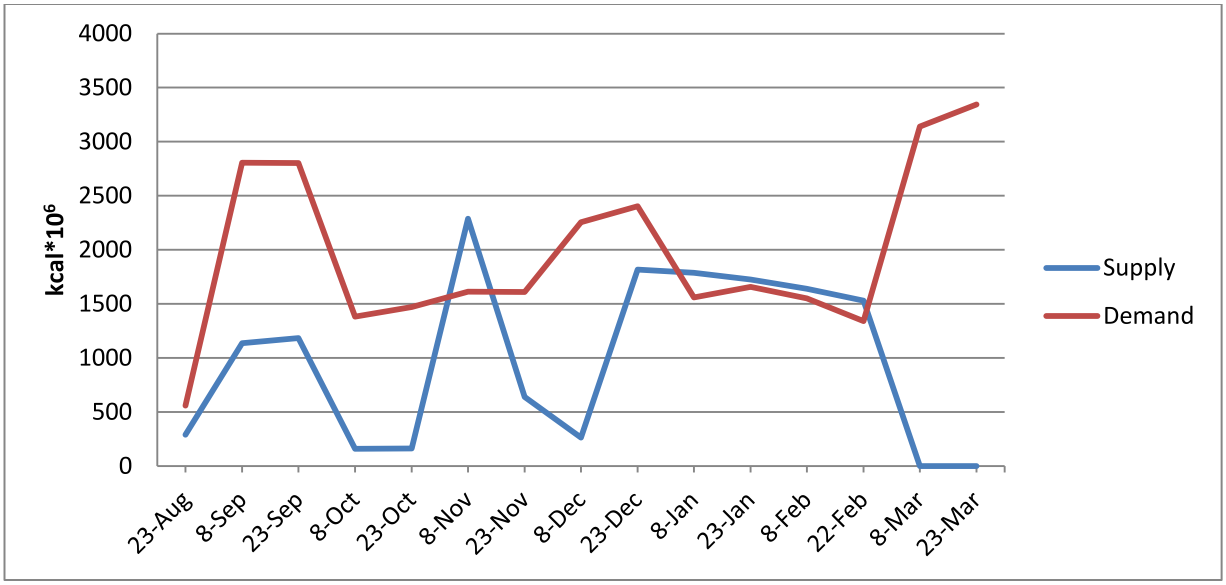


Figure 46. Scenario 1 results for dabbling ducks in the TXCP.

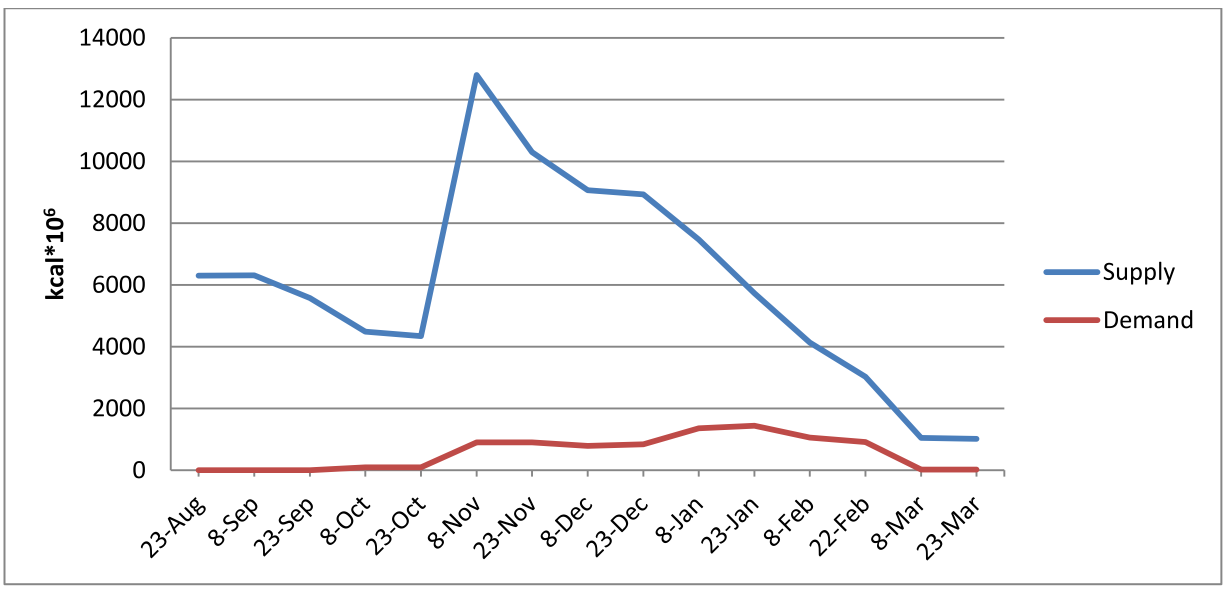


Figure 47. Scenario 1 results for geese in the TXCP.

Scenario 2.--Twenty five percent reduction in riceland habitats in the TXMC.

Outcome.--A 25% loss in riceland habitat results in dabbling duck food deficiencies in all time periods except early November, which corresponds with the availability of ratooned rice (Figure 48). Food energy supplies for geese remain adequate in all time periods (Figure 49).

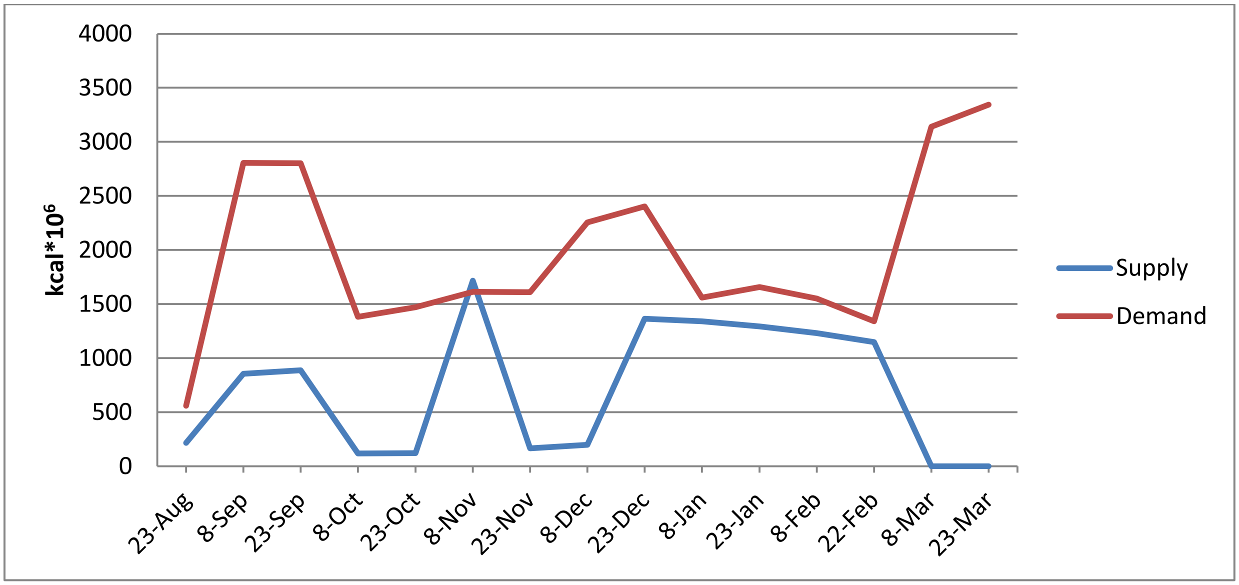


Figure 48. Scenario 2 results for dabbling ducks in the TXCP.

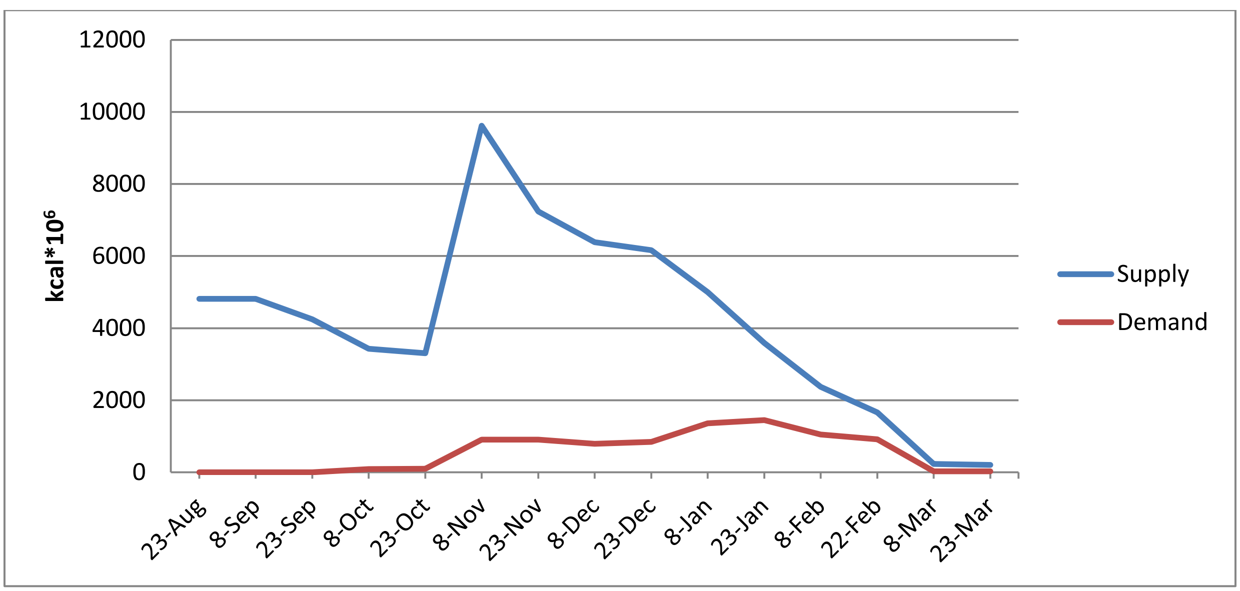


Figure 49. Scenario 2 results for geese in the TXCP.

Scenario 3.--Fifty percent reduction in riceland habitats in the TXCP.

Outcome.--A 50% loss in riceland habitat results in significant dabbling duck food deficiencies in all time periods (Figure 50). Goose food supplies also become deficient by late January (Figure 51).

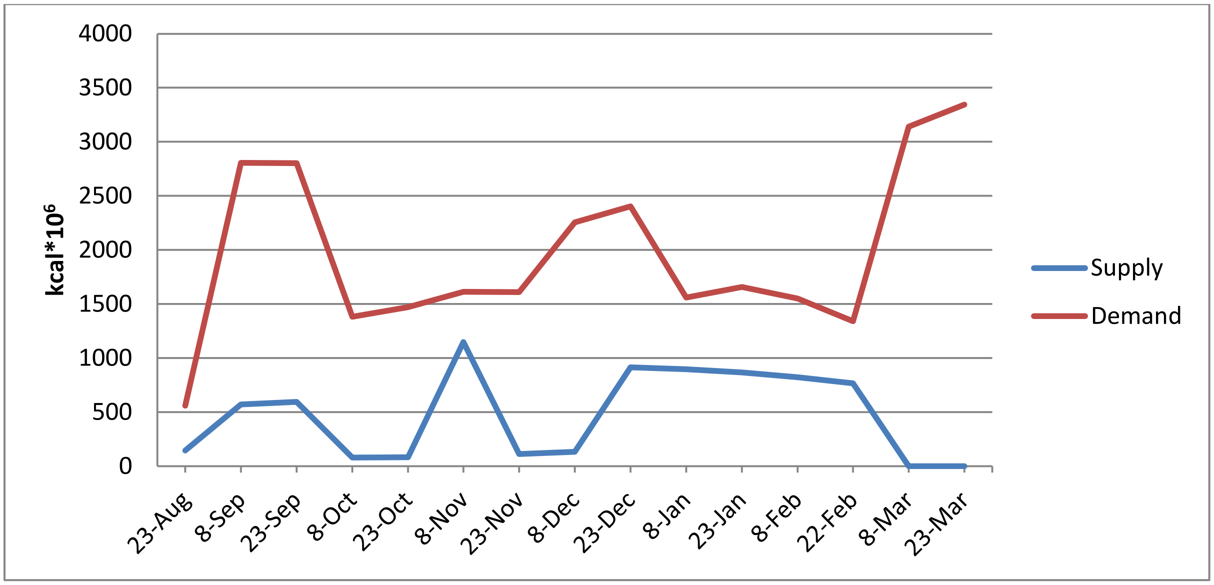


Figure 50. Scenario 3 results for dabbling ducks in the TXCP.

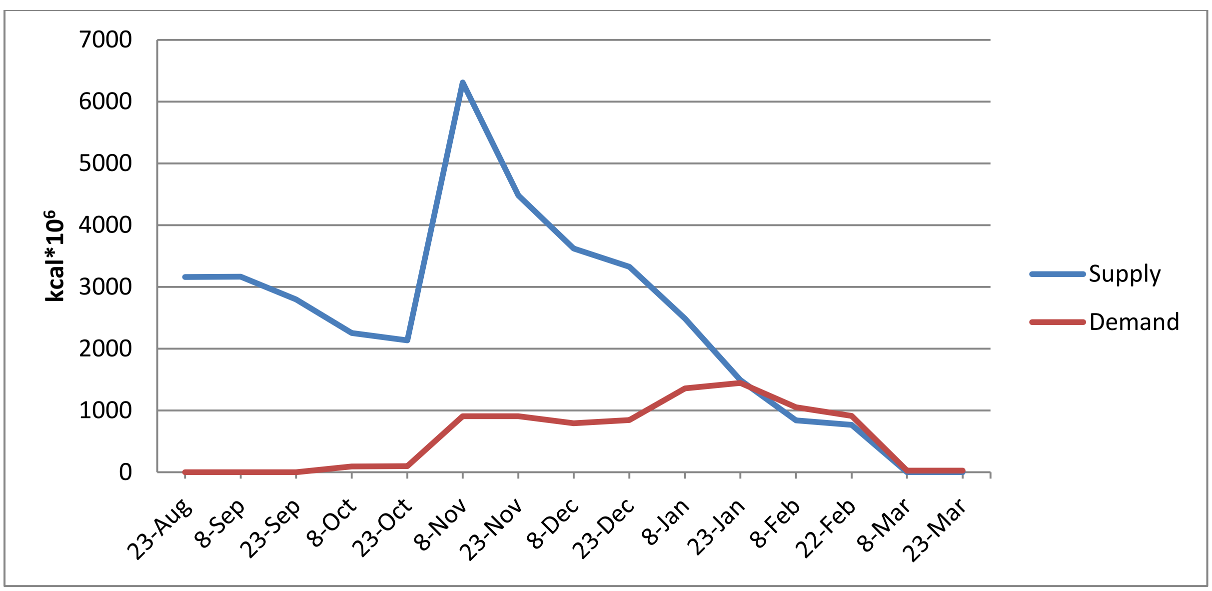


Figure 51. Scenario 3 results for geese in the TXCP.

Scenario 4.--All rice production is eliminated in the TXCP.

This scenario assumes that rice is no longer grown in the TXCP and that birds which relied on riceland habitats must now rely on coastal marsh.

Outcome.--Dabbling duck food supplies are exhausted by early October (Figure 52). Coastal marsh habitats in the TXCP are already assumed to support large numbers of dabbling and diving ducks (Table A-5). Shifting all ducks in the TXCP into coastal marsh puts a tremendous amount of foraging pressure on these coastal habitats, which is reflected in our results.

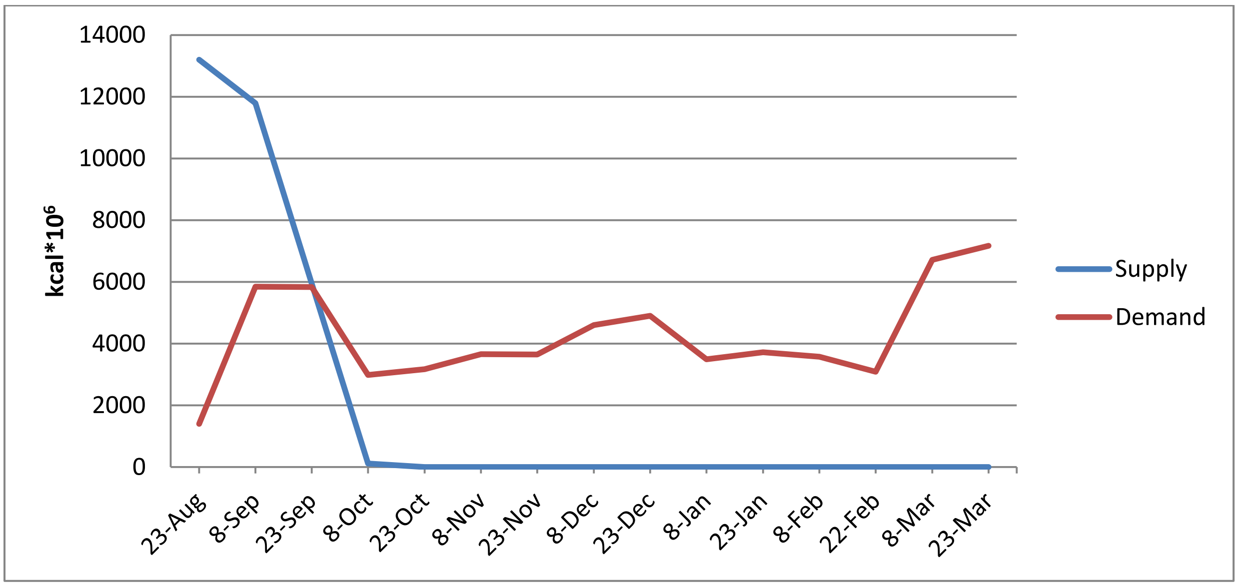


Figure 52. Scenario 4 results for dabbling ducks in the TXCP.

Louisiana Chenier Plain (LACP)

Scenario 1.--Current habitat conditions in the LACP

This scenario modeled dabbling duck and goose energy supplies under current habitat conditions in the LACP.

Table 7. Habitat acres used in Louisiana Chenier Plain (LACP) TRUEMET scenarios.

| Scenario | Flooded Ricelands | Flooded Soybeans | Coastal Marsh |
|---|---|---|---|
| #1 | 253,134 | 19,247 | 971,766 |
| #2 | 189,851 | 19,247 | 971,766 |
| #3 | 126,567 | 19,247 | 971,766 |
| #4 | 0 | 19,247 | 971,766 |

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Outcome.--Existing habitats in the LACP provide sufficient dabbling duck food resources in all time periods, with apparently large food surpluses in late fall and early winter (Figure 53). Large food surpluses also exist for geese (Figure 54).

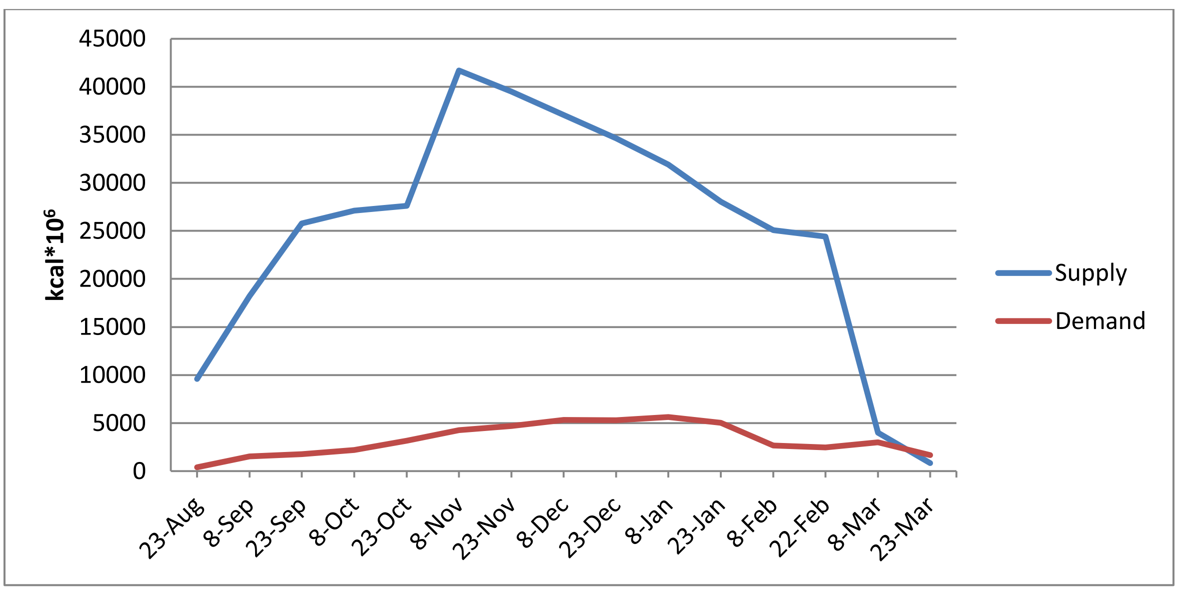


Figure 53. Scenario 1 results for dabbling ducks in the LACP.

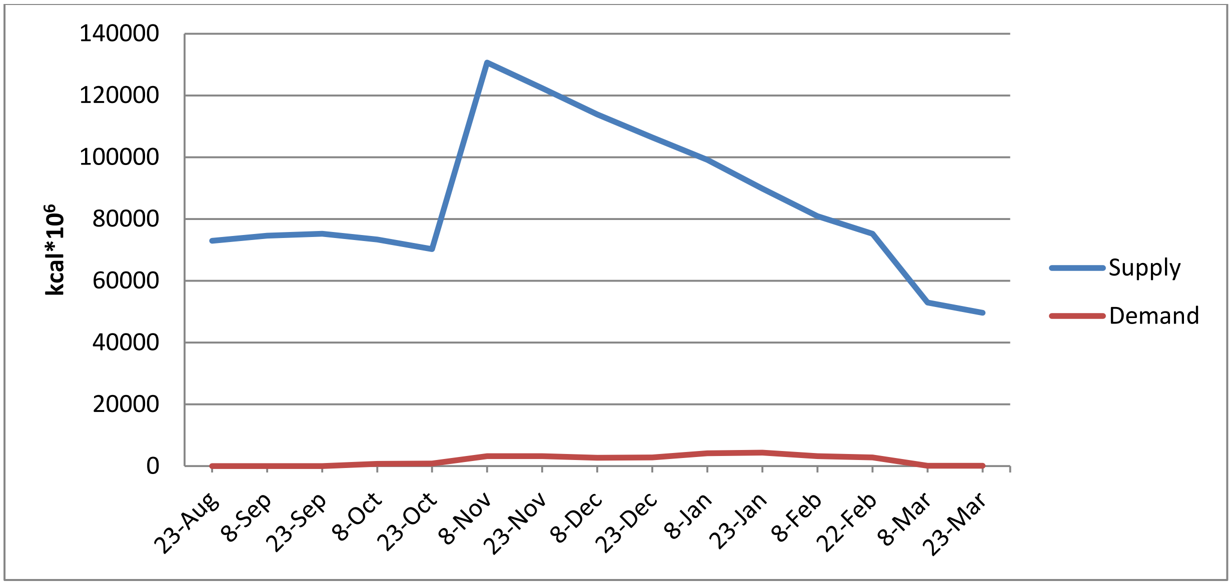


Figure 54. Scenario 1 results for geese in the LACP.

Scenario 2.--Twenty five percent reduction in riceland habitats in the LACP.

Outcome.--Dabbling duck food energy supplies remain adequate in all time periods except March when riceland habitats are reduced by 25% (Figure 55). Goose food supplies continue to be adequate in all time periods (Figure 56).

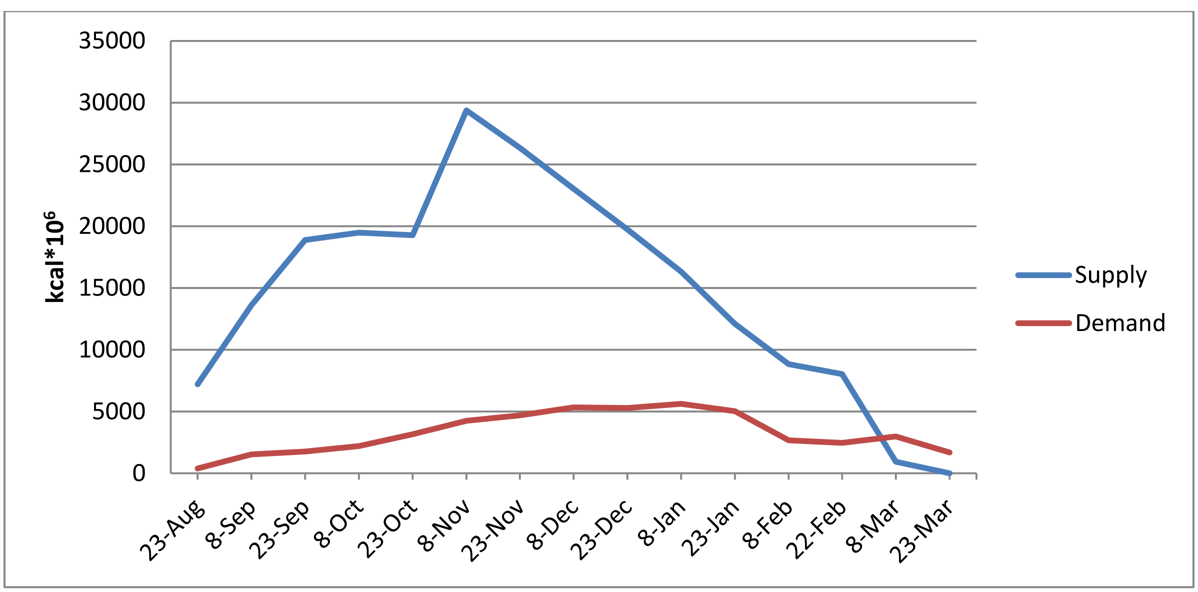


Figure 55. Scenario 2 results for dabbling ducks in the LACP.

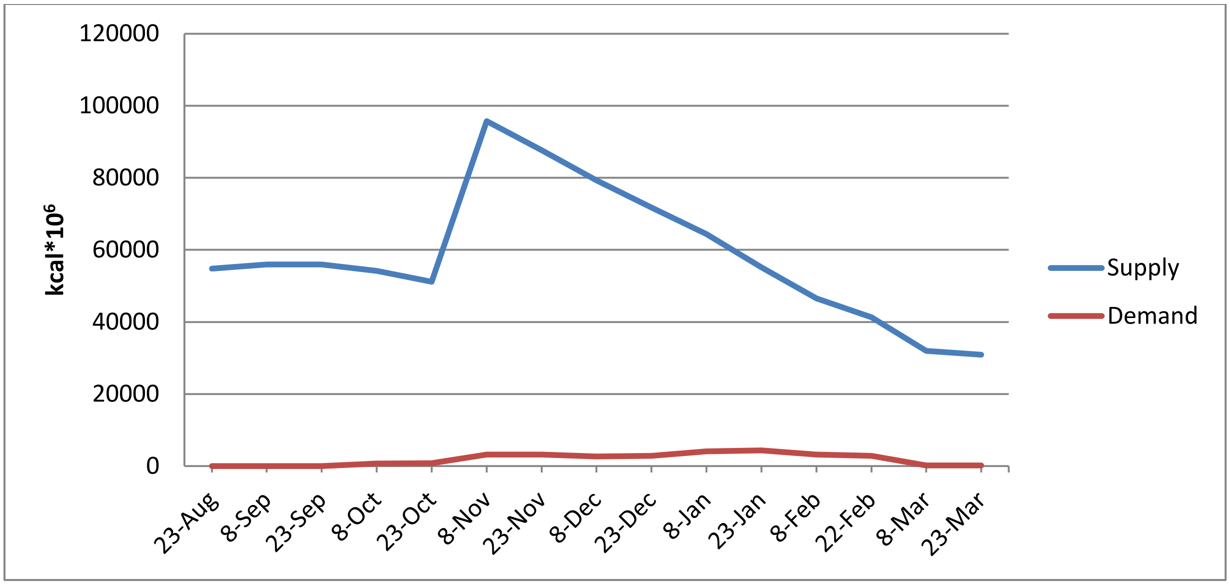


Figure 56. Scenario 2 results for geese in the LACP.

Scenario 3.--Fifty percent reduction in riceland habitats in the LACP.

Outcome.--A fifty percent reduction in riceland habitats results in dabbling duck food sources becoming insufficient by late December (Figure 57). In contrast, goose food supplies continue to remain adequate (Figure 58).

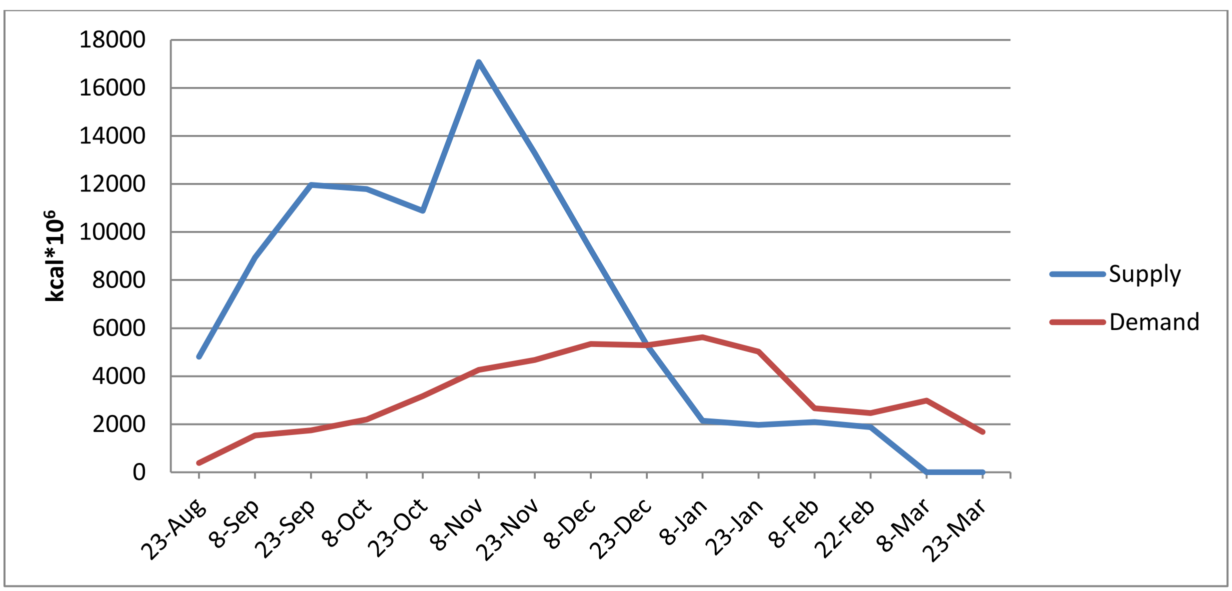


Figure 57. Scenario 3 results for dabbling ducks in the LACP.

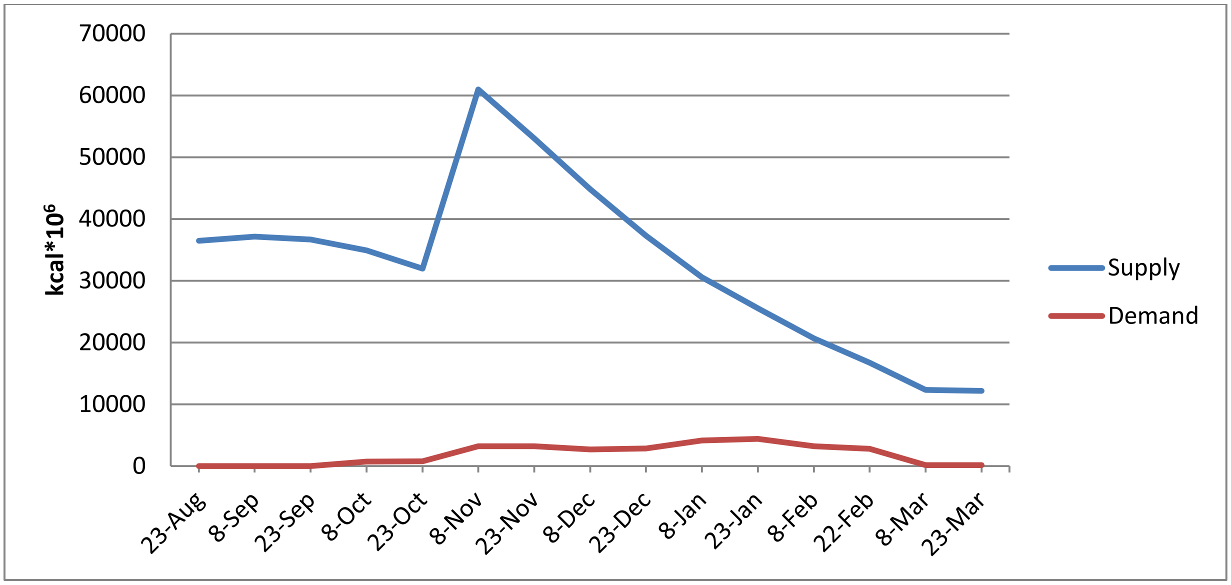


Figure 58. Scenario 3 results for geese in the LACP.

Scenario 4.--All rice production is eliminated in the LACP.

This scenario assumes that rice is no longer grown in the LACP and that birds which relied on riceland habitats must now rely on coastal marsh.

Outcome.--Dabbling duck food supplies are exhausted by early December (Figure 59). Coastal marsh habitats in the LACP are already assumed to support large numbers of dabbling and diving ducks (Table A-6). Shifting all ducks in the LACP into coastal marsh puts a tremendous amount of foraging pressure on these coastal habitats, which is reflected in our results.

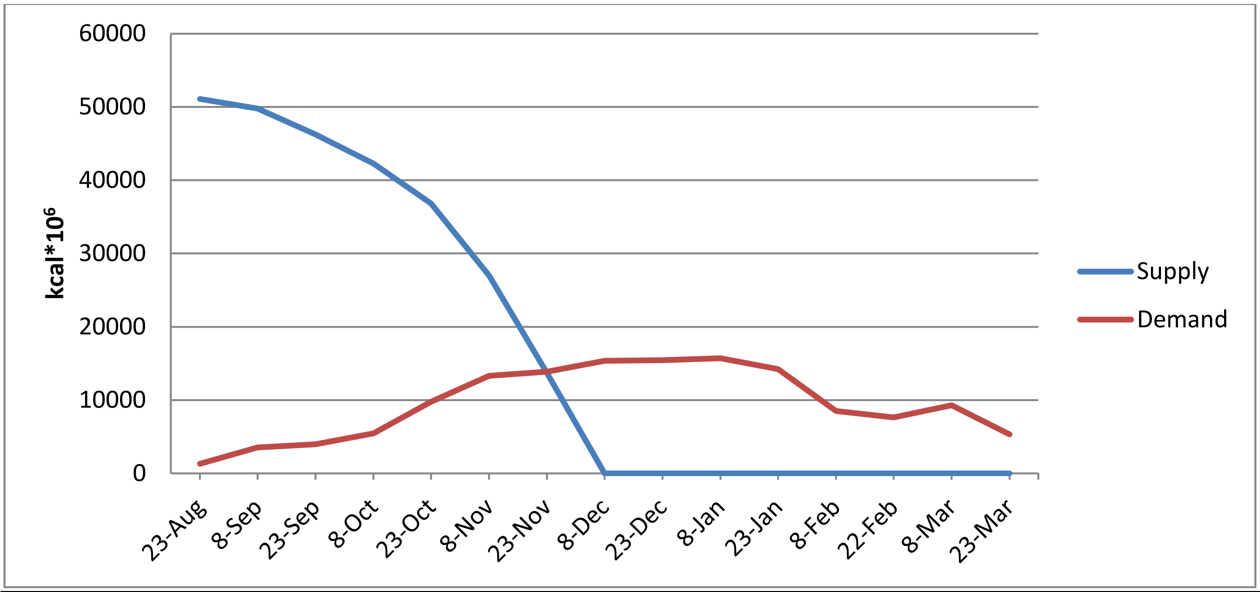


Figure 59. Scenario 4 results for dabbling ducks in the LACP.

<u>All Rice Producing Initiative Areas Combined (TXMC, TXCP, and LACP)</u>

Scenario 1.--Current habitat conditions in combined initiative areas.

This scenario forecasted dabbling duck and goose energy supplies where population objectives and existing habitats are combined for the TXMC, TXCP, and LACP. These three areas are contiguous within the boundaries of the GCJV. Combining these areas acknowledges the mobility of migratory waterfowl and their potential to redistribute across initiative area boundaries when trying to meet foraging demands. However, the extent to which these movements may occur is unknown, and the applicability of results from this scenario are therefore uncertain.

Outcome.--Dabbling duck food supplies remain adequate through late December, after which population energy demand exceeds population food energy supplies (Figure 60). Results for dabbling ducks are largely driven by habitat conditions in the LACP, where the amount of flooded ricelands greatly exceeds that found in the TXMC and TXCP (Table A-19). Dabbling duck food resources at this larger scale appear to be closer to population energy demand compared

Table 8 . Habitat acres used in TRUEMET scenarios where all rice producing initiative areas are combined.

| Scenario | Flooded Ricelands | Flooded Soybeans | Coastal Marsh |
|---|---|---|---|
| #1 | 345,182 | 24,058 | 1,558,490 |
| #2 | 258,887 | 24,058 | 1,558,490 |
| #3 | 172,591 | 24,058 | 1,558,490 |
| #4 | 0 | 24,058 | 1,558,490 |

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to results for the TXMC and TXCP. However, the food surplus seen in the LACP is also absent at this scale. For geese, food surpluses exist in all time periods (Figure 61).

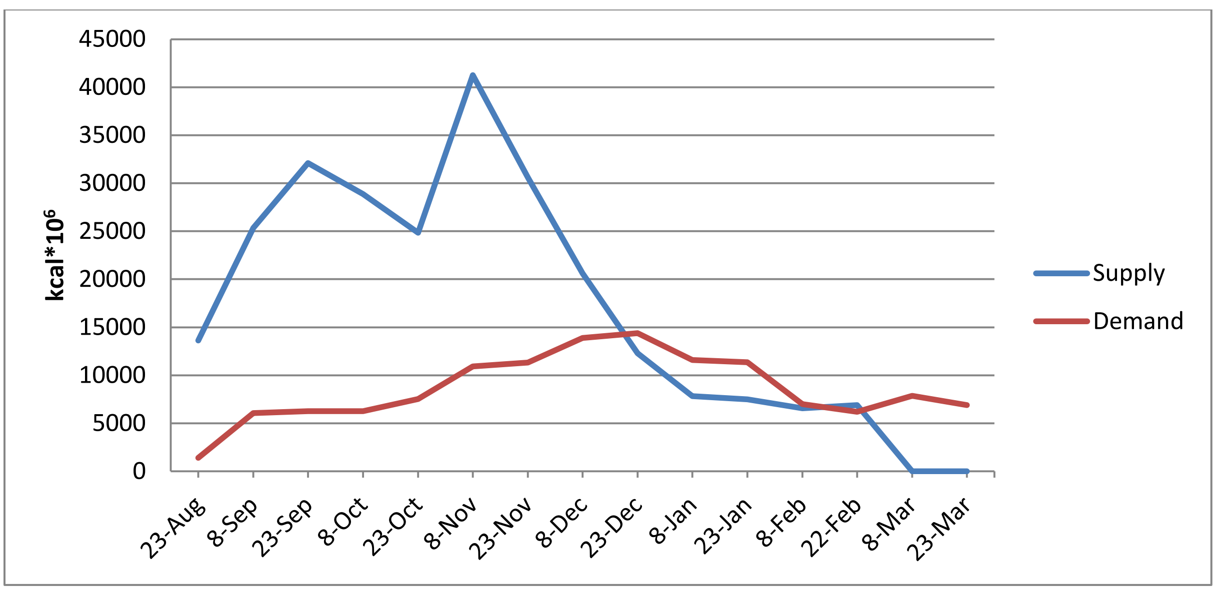


Figure 60. Scenario 1 results for dabbling ducks where all rice producing initiative areas in the GCJV are combined.

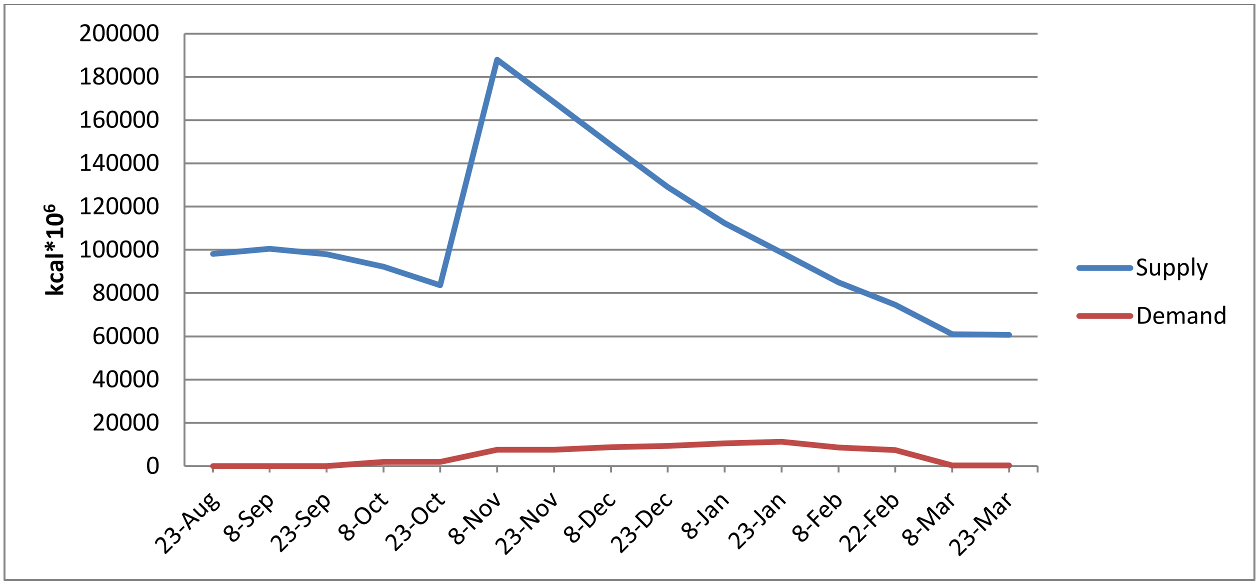


Figure 61. Scenario 1 results for geese where all rice producing initiative areas in the GCJV are combined.

Scenario 2.--Twenty five percent reduction in riceland habitats in the combined initiative areas.

Outcome.--Dabbling duck food resources become insufficient by early December with significant food deficits thereafter (Figure 62). Goose food supplies continue to be adequate in all time periods (Figure 63).

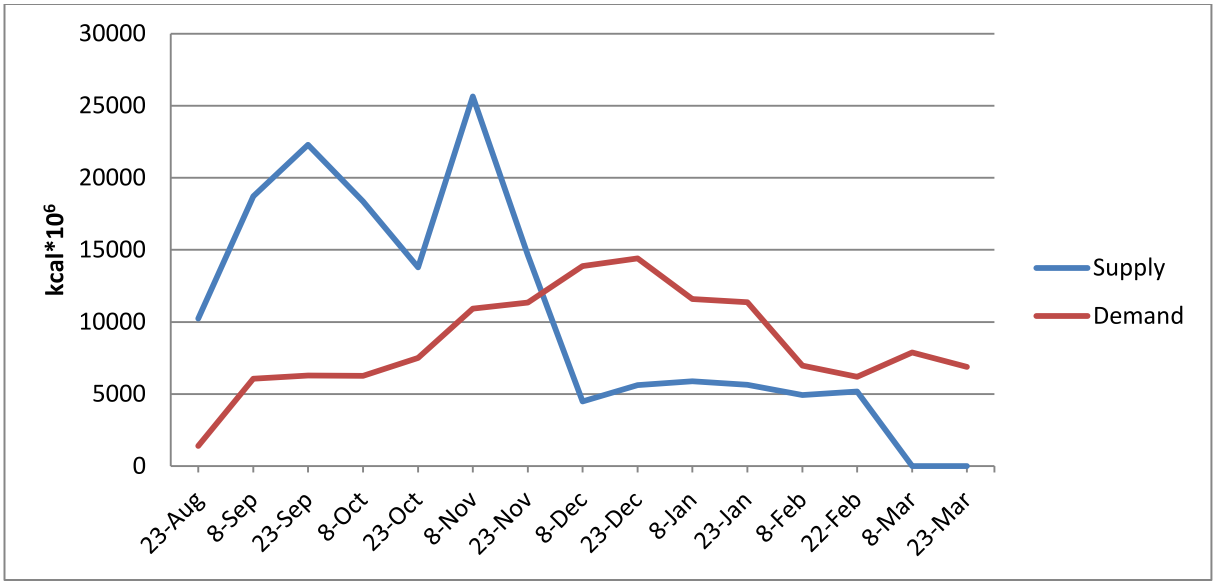


Figure 62. Scenario 2 results for dabbling ducks where all rice producing initiative areas in the GCJV are combined.

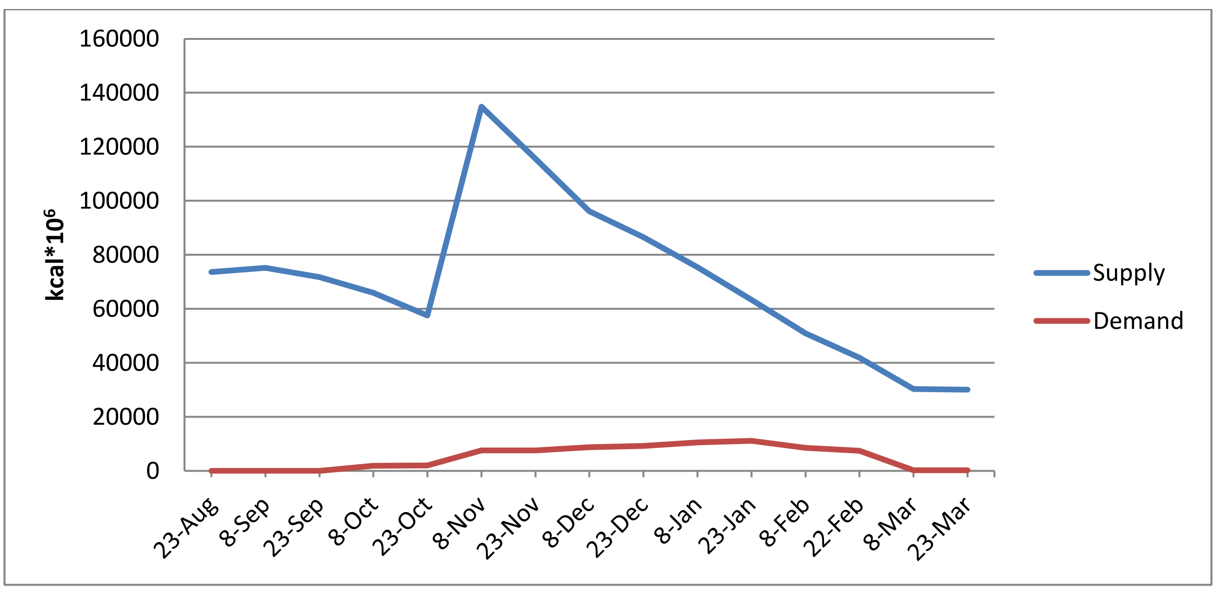


Figure 63. Scenario 2 results for geese where all rice producing initiative areas in the GCJV are combined.

Scenario 3.--Fifty percent reduction in riceland habitats in the combined initiative areas.

Outcome.--Dabbling duck food resources become insufficient by late October, except for a brief period in early November that corresponds to the flooding of harvested ratoon fields (Figure 64). Goose food supplies continue to be adequate although food surpluses are greatly reduced (Figure 65).

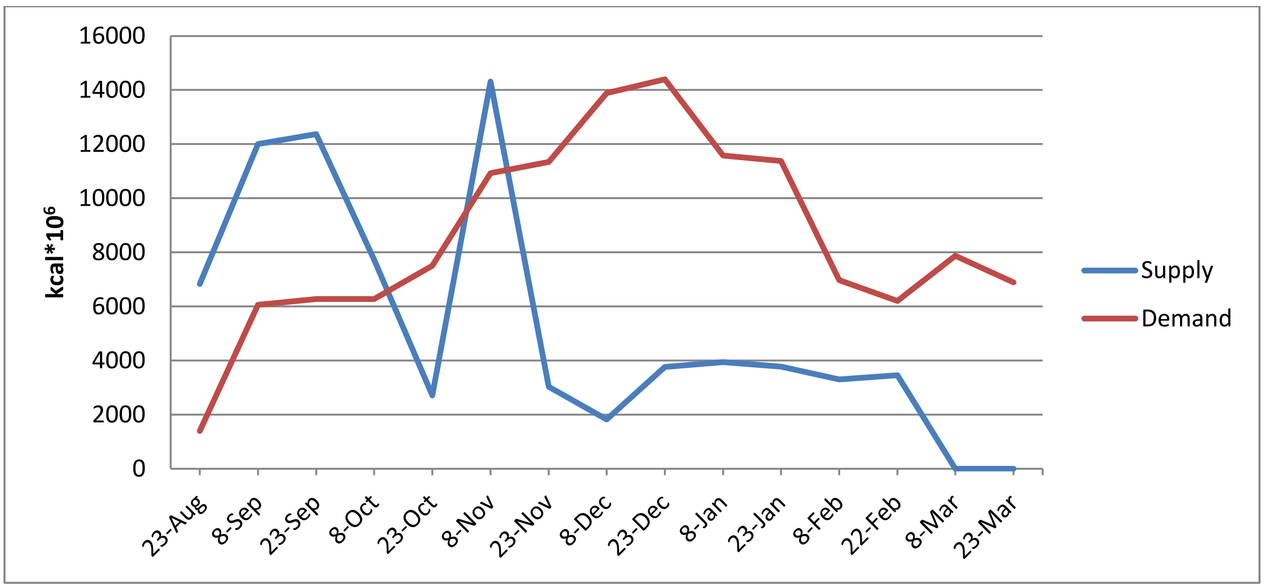


Figure 64. Scenario 3 results for dabbling ducks where all rice producing initiative areas in the GCJV are combined.

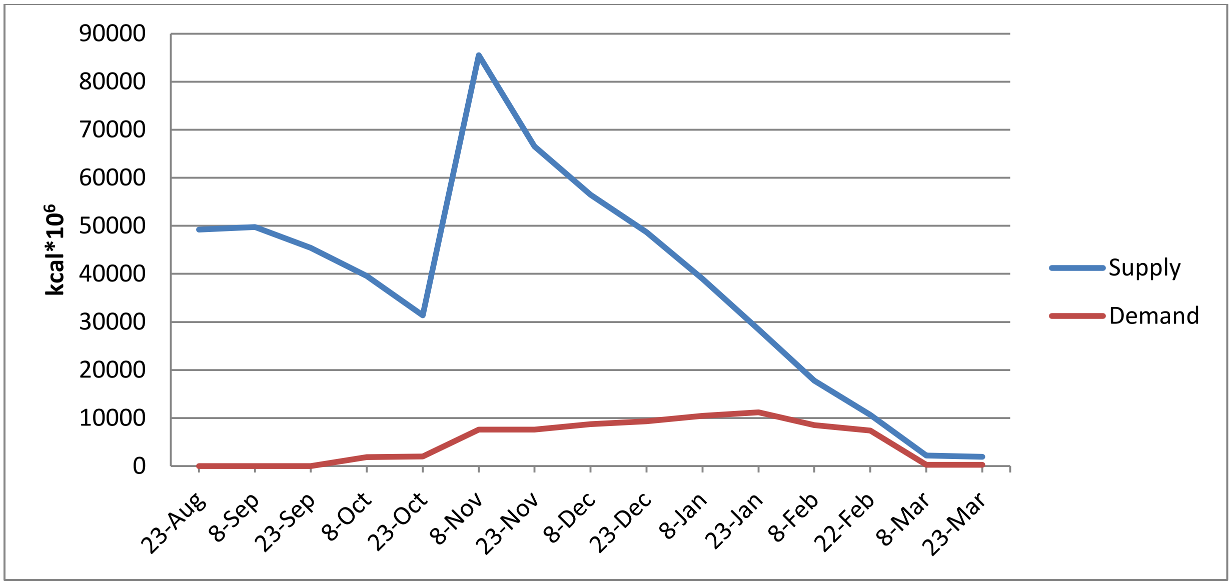


Figure 65. Scenario 3 results for geese where all rice producing initiative areas in the GCJV are combined.

Scenario 4.--All rice production is eliminated in the combined initiative areas.

This scenario assumes that rice is no longer grown in the TXMC, TXCP, and LACP, and that birds which relied on riceland habitats must now rely on coastal marsh.

Outcome.--Dabbling duck food supplies are exhausted by late November (Figure 66). Shifting all ducks in the TXMC, TXCP, and LACP into coastal marsh puts a tremendous amount of foraging pressure on these coastal habitats, which is reflected in our results.

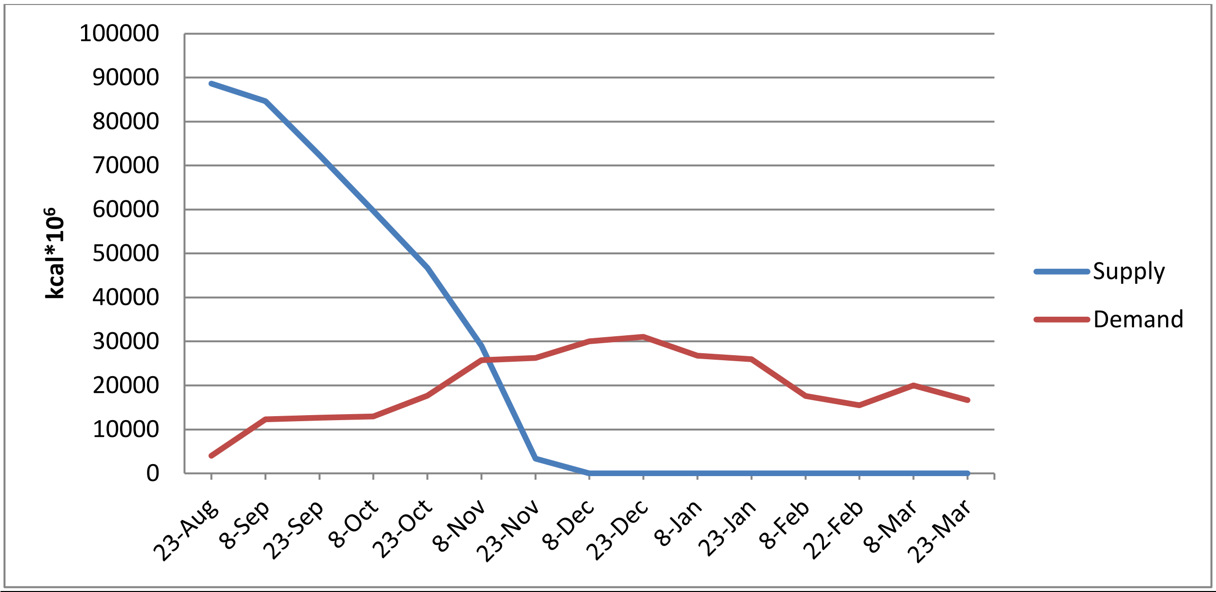


Figure 66. Scenario 4 results for dabbling ducks where all rice producing initiative areas in the GCJV are combined.

Entire GCJV excluding the Laguna Madre Initiative Area

Scenario 1.--Current habitat conditions in the GCJV

This scenario models dabbling duck and goose energy supplies under current habitat conditions in the GCJV (Table 9).

Outcome.--Modeling of current habitat conditions in the GCJV suggests that dabbling duck food supplies fall below population energy demand by early January (Figure 67), though some food continues to be provided through early March mostly due to continued flooding of ricelands. Our attempt to model current conditions for the entire GCJV is strongly influenced by our estimates of food production in coastal marsh habitats (Table A-24). Coastal marsh accounts for seventy-five percent of all habitat acres in the GCJV (Table A-20), and any attempt to model “current conditions” in the GCJV will be very sensitive to the food biomass estimates we assume for this habitat type.

Table 9. Habitat acres used in TRUEMET scenarios for the entire GCJV.

| Scenario | Flooded Ricelands | Flooded Soybeans | Coastal Marsh | Forested Wetlands |
|---|---|---|---|---|
| #1 | 345,182 | 24,058 | 3,512,204 | 792,120 |
| #2 | 0 | 24,058 | 3,512,204 | 792,120 |

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Obtaining accurate estimates of food biomass is likely more difficult in coastal marsh than agricultural habitats or highly managed wetlands where one or two plant species account for most of the food produced. Accordingly, the GCJV is now involved in a large-scale effort to refine waterfowl food production estimates for coastal marsh.

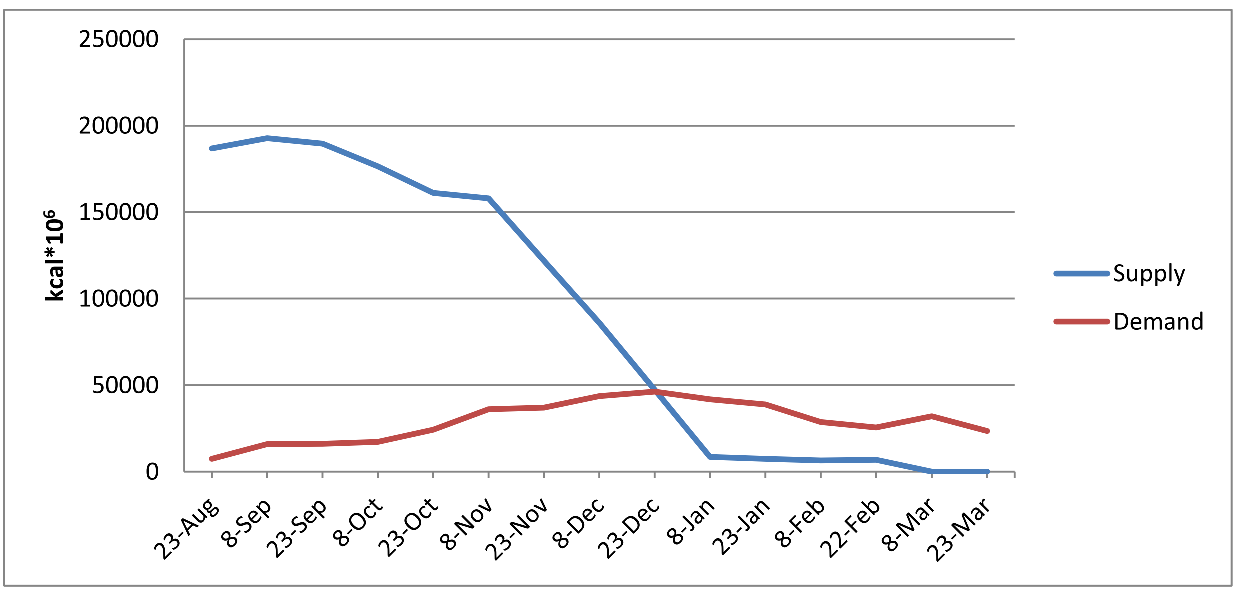


Figure 67. Scenario 1 results for dabbling ducks for the entire GCJV.

Scenario 2.--All rice production is eliminated throughout the GCJV.

Outcome.--Dabbling duck food supplies are completely exhausted by mid-December (Figure 68.)

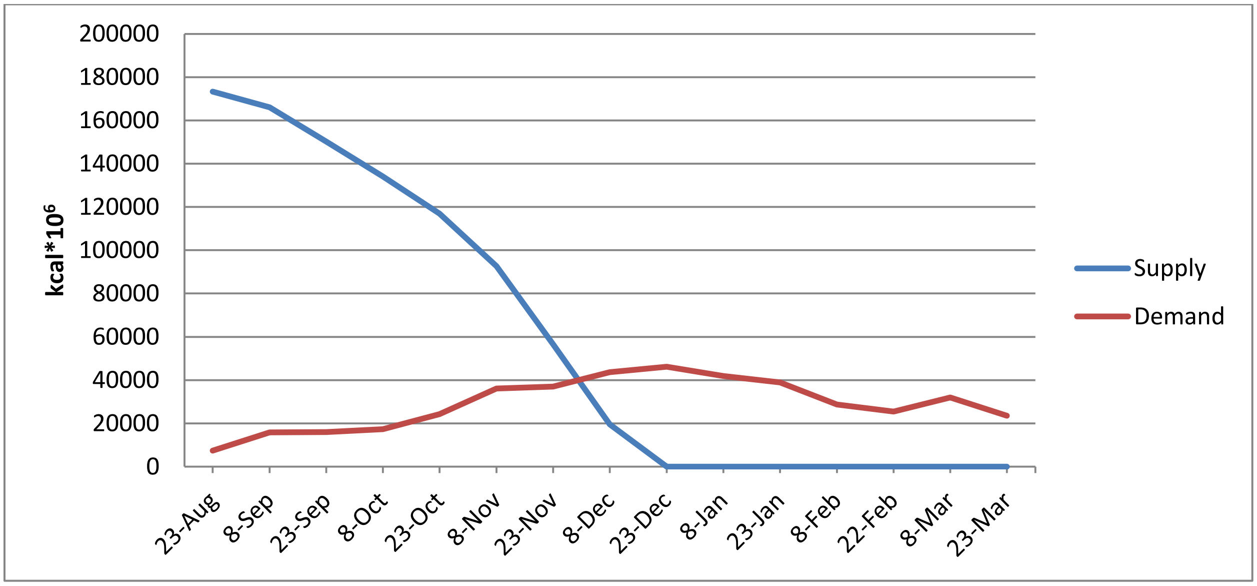


Figure 68. Scenario 2 results for dabbling ducks for the entire GCJV.

Economic Contribution of Ricefields

The capital cost of replacing existing flooded rice habitats with managed seasonal wetlands ranged from a high of 2 billion dollars in the CVJV to a low of 200 million dollars in the LMVJV. The total cost of replacing all flooded rice habitats in the U.S. with nearly 500,000 acres of managed seasonal wetlands would approach 3.5 billion dollars (Table 10). We also estimated the cost of replacing flooded rice habitat in the LMVJV if these existing habitats were ratooned and subsequently harvested, and thus provided significantly more food resources. The capital cost of replacing flooded rice habitat in the LMVJV under this scenario was nearly 2.4 billion dollars.

Table 10. Estimated capital costs of replacing flooded rice habitats with managed seasonal wetlands.

| Joint Venture | Restored MSW[a] (acres) | Land Purchase Costs per Acre | Restoration[b] Costs per Acre | Total Cost |
|---|---|---|---|---|
| CVJV | 186,188 | $8,000 | $3,000 | $2,048,068,000 |
| GCJV | 266,019 | $2,750 | $1,800 | $1,210,386,450 |
| LMVJV | 34,613 | $4,000 | $1,800 | $200,755,400 |
| Total | 486,820 | | | $3,459,209,850 |

[a] Acres of managed seasonal wetlands that would have to be restored to replace the food energy currently provided by flooded rice habitats (see Table 2).

[b] Includes vendor and staff costs.

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The annual O & M costs of maintaining publically managed seasonal wetlands in place of flooded rice habitats ranged from a high of nearly 40 million dollars a year in the GCJV to a low of just over 5 million dollars a year in the LMVJV (Table 11). If flooded rice habitat in the LMVJV was ratooned and harvested, these costs would exceed 60 million dollars as these ratooned habitats equate to significantly more managed wetlands.

Table 11. Annual O & M costs of maintaining publically managed seasonal wetlands in place of existing flooded rice habitat.

| Joint Venture | Restored MSW[a] (acres) | Annual O & M Costs per Acre | Total Annual O & M Costs |
|---|---|---|---|
| CVJV | 186,188 | $150 | $27,928,200 |
| GCJV | 266,019 | $150 | $39,902,850 |
| LMVJV | 34,613 | $150 | $5,191,950 |
| Total | 486,820 | | $73,023,000 |

[a] Acres of managed seasonal wetlands that would have to be restored to replace the food energy currently provided by flooded rice habitats (see Table 2).

## Discussion

Over half of all dabbling ducks that winter in the U.S. occur in the CVJV, LMVJV, and GCJV. Winter-flooded ricefields provide over forty-percent of the food energy available to dabbling ducks in the CVJV and GCJV, and eleven percent in the LMVJV. Rice accounts for an even higher percentage of all goose foods in these Joint Ventures. It is highly unlikely that the population goals established by the North American Waterfowl Management Plan could be met in the absence of riceland habitats.

Winter-flooded ricefields and managed seasonal wetlands provide many of the same wetland functions for waterfowl and other wetland dependent birds (Eadie et al. 2008). Managed seasonal wetlands in the CVJV, LMVJV, and GCJV total just over 285,000 acres, while winter-flooded ricelands exceed 1 million acres . Thus much of the shallow freshwater habitat preferred by dabbling ducks, especially pintails, is now provided by rice. Replacing these flooded rice habitats with managed seasonal wetlands would be cost prohibitive. Capital costs alone would exceed 3.5 billion dollars. Moreover, public agencies are in no position to afford the annual O & M costs of maintaining the nearly 500,000 acres of additional managed wetlands that would be needed to offset the loss of flooded rice habitat. These annual costs are now borne by rice growers in the course of normal farming operations.

Agricultural practices change in response to a variety of factors and we should anticipate that the food provided by ricefields will vary over time. For example, early maturing rice has reduced the amount of food provided in MAV ricefields. Yet, ratooning even a small fraction of these fields would produce tremendous waterfowl benefits. This highlights the unrivalled potential that ricelands offer compared to alternate land uses. Ricefields alone in the CVJV and GCJV could meet nearly all the food requirements of dabbling ducks and geese if post-harvest practices were optimal. While this is an unreasonable expectation, it speaks to the remarkable potential of rice. The short term value of rice to waterfowl may rise and fall in response to agricultural practices but intact rice landscapes will always offer conservation opportunities. The key to preserving these opportunities is maintaining rice agriculture on these landscapes.

*Central Valley Joint Venture*

Rice provides nearly half of all the food energy available to dabbling ducks from flooded habitats in the Central Valley, and over seventy percent of all white goose foods. The elimination of rice production in the Central Valley would be catastrophic for waterfowl. Food supplies for both ducks and geese would be exhausted by early January, just as bird populations are peaking . Nearly half of all duck-use-days in the U.S. portion of the Pacific Flyway occur in the Central Valley (Ducks Unlimited, unpublished data), and the loss of rice would likely impact waterfowl at the continental scale. Pintails, which winter in disproportionate abundance in the Valley, would be especially affected.

While loss of the California rice industry is unlikely, post-harvest practices that now benefit waterfowl are far from secure. The food supplies available to dabbling ducks in the Central Valley are highly sensitive to changes in winter-flooding of harvested rice fields. Even a fifty percent decline in winter-flooding produces dabbling duck food shortages well in advance of spring migration. Complete loss of winter-flooding would result in dabbling duck food supplies being exhausted by mid-January.

While California's record drought has already produced apparent declines in winter-flooded rice, the water supplies used for this post-harvest practice were under increasing pressure even before the drought. There are few, if any, environmental issues in California that rival the importance of instream flows in the Sacramento River and the downstream effects on endangered fish species. Most of the water used for winter flooding of rice originates from the federally operated Central Valley Project and the State Water Project. Both of these water projects store water in upstream reservoirs that is released as needed for beneficial uses, and both projects must be operated in a manner that meets the needs of endangered fish species and other public trust resources. To meet these obligations, instream flow and water quality standards have been established for the Sacramento River and the Sacramento – San Joaquin River Delta (the Delta). When natural flows are insufficient the Projects are required by the State Water Board to release water to meet flow and quality standards.

Operation of the Central Valley Project is the responsibility of the Bureau of Reclamation (BOR). In the 1950's, the BOR and senior water rights holders in the Sacramento Valley entered into negotiations to settle a longstanding dispute over water rights in the Sacramento River. The resulting contracts (SRS Contracts), executed in 1964, established the amount of water available for BOR from the Sacramento River for the operation of the Central Valley Project (CVP), and quantified the monthly diversions of the water rights holders (SRS Contractors). SRS contracts established water supply certainty for SRS Contractors and the BOR.

SRS contracts had a forty year term expiring in 2004. In 2005, the BOR and SRS Contractors entered into long-term renewal contracts. The renewal of SRS Contracts gave rise to instant litigation on behalf of National Resource Defense Council (NRDC). The plaintiffs challenged the 2005 renewal contracts, asserting that they should be rescinded due to BOR's failure to comply with Section 7(a)(2) of the Endangered Species Act regarding the effect of contract renewal on the delta smelt. NRDC was unsuccessful in rescinding the renewal contracts though they have appealed the decision. The case demonstrates how ESA concerns may ultimately affect SRS Contractors, the same contractors that supply water for winter flooding of rice. In a letter to the BOR dated September 27, 2013, the NRDC argued that "fall water deliveries (for winter flooding of harvested ricefields) are not necessary for successful rice cultivation in the Sacramento Valley".

Less water for winter-flooded rice may produce permanent shifts toward post harvest practices that are detrimental to waterfowl. Rice growers need a reliable and affordable means of decomposing rice straw, and it's unreasonable to expect otherwise. If water sources used for winter-flooding become increasingly unpredictable, more growers will turn to dry incorporation to decompose straw. Any shift towards dry incorporation, and its impacts on waterfowl, has to be considered in the long history of California rice. Before the burn ban of the early 1990's most rice growers used fire to eliminate rice straw. Although some fields were winter-flooded to provide hunting opportunities, the total acres of winter-flooded rice was only twenty to twenty five percent of today (Eadie et al. 2008). However, burning is a waterfowl friendly practice that increases waterfowl foraging efficiency by exposing waste rice seeds without destroying them. The rapid transition from burning to winter-flooding in the 1990's eliminated any consequences that might have otherwise been felt by losing this waterfowl friendly practice. We may now being entering an era where burning is no longer permitted on a significant scale and where winter flooding is greatly reduced because of declining water supplies. The only option for many rice growers will be a move towards more dry incorporation, the least desirable of all straw decomposition alternatives for ducks.

Declines in rice acreage or winter-flooded rice in the Central Valley could be partially offset by wetland restoration. Between 1990 and 2003, an estimated 65,000 acres of wetlands were restored in the Central Valley (CVJV 2006). However, wetland restoration in the Valley appears to have slowed over the past decade. Since 2003 approximately 20,000 acres of wetlands have been restored, or about a third restored during the previous ten years (K. Petrik pers. comm.). This decline in the rate of wetland restoration is undoubtedly related to opportunity…there simply aren't the restoration opportunities that existed twenty years ago.

Our evaluation of rice habitat in the Central Valley was partially based on waterfowl population goals developed by the CVJV. However, there is some evidence that bird use of the Valley may have increased since these goals were established. White goose counts in the fall of 2013 approached 1.25 million birds, or nearly double the CVJV population goal. Dark goose counts exceeded 800,000 birds in 2012, or twice the CVJV goal (USFWS 2014). More geese will increase the foraging pressure on both flooded and unflooded rice habitats, and the apparent surplus in goose foods suggested in many of our model simulations may no longer be valid.

Events outside the Central Valley may also increase the long-term importance of rice to waterfowl. Many waterfowl that winter in the Central Valley migrate through the Klamath Basin in fall where they rely heavily on the Lower Klamath Basin National Wildlife Refuge (LKNWR). However recent droughts, the needs of ESA fish, and clarification of water rights in the Klamath Basin have drastically curtailed refuge water deliveries. During the past year only forty percent of the wetland habitat traditionally provided by LKNWR was available for fall migrating waterfowl. Water shortages are likely to persist at LKNWR and may ultimately accelerate bird migration into the Central Valley. If this occurs rice habitat will be required to sustain even more birds.

Lower Mississippi Valley Joint Venture

Although more rice is produced in the MAV than in any other region of the U.S., the amount of food provided by harvested rice fields in the LMVJV is significantly lower than in the CVJV and GCJV. Seed variety improvements that have allowed rice to be harvested earlier are largely responsible for this decline in food value. Rice harvest in the MAV now occurs in August and September, well before fall migration. The loss of rice seed to germination, decomposition, and consumption by other wildlife appears to be extensive after harvest and before waterfowl arrive (Manley 1999, Stafford 2004, Kross 2006, Eadie et al. 2008). The unintended consequences of this early rice harvest explain why flooded ricefields provide only eleven percent of the total food energy available to dabbling ducks in the LMVJV, and why removing rice habitats from our TRUEMET scenarios had little effect on the on the relationship between food energy demand and food energy supplies for dabbling ducks.

Despite the low amount of food currently provided by ricefields in the LMVJV, the potential of the MAV's 1.85 million rice acre base is easily imagined. Twenty percent or 388,000 acres of this 1.85 million acre rice base is now winter-flooded. If these same winter-flooded fields were ratooned and harvested, the amount of food provided to dabbling ducks from flooded rice fields would increase nearly twelve-fold if we assume that these fields provide the same amount of food as ratooned fields in the GCJV. Our TRUEMET results suggest that ratooning and flooding twenty percent of the MAV rice base would largely eliminate any food shortfalls in the LMVJV, and in fact, these ratooned habitats alone could meet dabbling duck food energy needs from early fall through late February.

Rice fields are now being ratooned on a limited basis in the MAV south of I-40. Developing rice varieties that mature quicker and are more cold tolerant could increase the feasibility of ratooned rice crops throughout the MAV. Widespread ratooning in the MAV would dramatically increase the waterfowl carrying capacity of the LMVJV as it would provide an abundant food source that coincides with peak waterfowl populations, and which is not subject to decomposition and germination rates now seen in MAV ricefields. Further research is needed to investigate the economics of ratooning rice crops in the MAV, including additional input costs for fertilizer or irrigation. As new information becomes available, conservation delivery in the LMVJV will need to design programs that identify incentives and cost effective practices that encourage rice producers to ratoon first crop rice.

Policy efforts are already underway to encourage ratooning in the MAV and Gulf Coast. Although most ratooned fields in the Gulf Coast are harvested, some growers allow this second crop of rice to remain standing either as forage for commercial crawfish operations or because yields on this second crop may not be high enough to warrant harvesting. In both cases, these unharvested ratoon fields are often used to hunt waterfowl. Standing ratoon crops are generally too dense to attract waterfowl and must be disked, rolled, or otherwise treated prior to the hunting season to provide open water areas for the birds.

The Migratory Bird Treaty Act (MBTA) allows waterfowl to be hunted over fields where grain has been scattered as a result of normal agricultural practices" based on the determination of the applicable State office of the Cooperative Extension System of the Department of Agriculture at the request of the Secretary of the Interior." There is now some uncertainty among hunters, farmers, and law enforcement officials about "normal agricultural practices" in ratooned ricefields that are not harvested. It is legal to hunt in managed wetlands that are disked, rolled, mowed, or otherwise treated. Because managed wetlands and unharvested ratooned fields can provide similar amounts of food, practices that are now legal in managed wetlands (e.g. mowing) should arguably be permitted in ratooned ricefields as well.

Resolving the confusion over normal agricultural practices in unharvested ratooned fields may be important to promoting ratooning of rice in the MAV. Volunteer ratoon crops appear to be increasingly common in the MAV south of I-40. Although little if any of this second crop rice is harvested, it could provide tremendous waterfowl benefits if purposely flooded in fall and winter. Hunters that lease rice fields from producers now pay between $5,000 - $10,000 per field or blind. If the producer has performed any rolling, disking, mowing or other treatment of a standing ratooned field it remains unclear whether that field may be hunted under existing MBTA language. Hunting leases are often executed in summer or early fall while ratoon crops may be developing, leading to concerns and questions as to whether even a small area near a blind may be treated to facilitate waterfowl hunting.

Ratooned ricefields that are not harvested are likely to be highly sought after by hunters, provided they can be legally hunted. The lease payments associated with these fields may be sufficient enough alone to incentivize the practice of ratooning in some parts of the MAV if MBTA concerns can be addressed. The Hunter and Farmer Protection Act of 2013 seeks to resolve the confusion over interpretation of normal agricultural practices relative to the treatment of ratooned rice, and places the determination of normal agricultural practices regarding rice culture in the hands of USDA State Extension Office officials that are best qualified to make such determinations. Ducks Unlimited is currently supporting this policy effort.

Gulf Coast Joint Venture

Based on landscape conditions and available riceland-based waterfowl habitats modeled in our analyses, ricelands provided 42% of total food resources for dabbling ducks in the GCJV, but this percentage varies among Initiative Areas. Analyses of current riceland-based habitat conditions indicated that food resources in the TXMC and TCP are insufficient to satisfy foraging demands of dabbling duck population objectives, whereas habitat is abundant and exceeds demand in the LACP. However, analyses of total potential foraging capacity of riceland-based habitats (i.e., food resources that would be available if all riceland acres were flooded) exceeds demand across all Initiative Areas, even at current, historically low riceland acreages within this region.

Our analyses of current conditions were based on habitat abundance as observed during fall/winter 2010-11 and 2011-12, two years during which coastal Texas was experiencing a severe drought, which likely limited the availability of water for flooding ricelands during winter in addition to reduced natural flooding. Additionally, crawfish aquaculture, which requires fields to be flooded to depths of 12-18 inches from approximately November – June of the following year, is more prevalent in the LACP than the TXCP or TMC. Crawfish production in southwest Louisiana, an area that roughly corresponds with the LACP Initiative Area, averaged approximately 130,000 acres during 2010 and 2011 (Louisiana State University Agricultural Center 2010, 2011). Thus, crawfish aquaculture, which is frequently practiced in rotation with active rice (McClain et al. 2007), was likely responsible for a significant portion of the total riceland-based waterfowl habitat documented in the LACP and a large reason for the substantial differences in flooded acreage between Louisiana and Texas. Indeed, while rice agriculture provides the infrastructure and forage base for a large percentage of the crawfish aquaculture in Louisiana, waterfowl conservationists are increasingly recognizing the supplementary benefits to wintering waterfowl habitat that crawfish aquaculture itself provides.

Although drought undoubtedly impacted habitat abundance in the TXMC and TCP during the years upon which our analyses were based, our results were consistent with previous analyses reflecting a range of environmental conditions. In earlier analyses, habitat abundance in the TXMC was insufficient to satisfy waterfowl foraging demands during all but the wettest of years assessed, whereas the ability of TXCP habitats to satisfy foraging demands of population objectives was highly sensitive to observed precipitation ranges (GCJV, unpublished data). Similarly, the abundance of flooded riceland habitats in the LACP were sufficient to satisfy dabbling duck foraging demands during all years assessed, even those representing relatively dry conditions (GCJV, unpublished data). Staff of the GCJV are currently conducting a more comprehensive analyses of historical wintering waterfowl habitat conditions in rice-growing regions within the GCJV geography. These data will help clarify the extent to which winter habitat conditions have tracked long-term declines in planted rice acreage and inform additional assessments of the impacts of these declines on the ability of the GCJV region to support target waterfowl populations. A more robust understanding of the relationships among planted rice acreage, environmental conditions, and abundance of riceland-based winter waterfowl habitat will further enhance our ability to forecast impacts of future rice declines on winter waterfowl habitat within the GCJV region.

Although our analyses were primarily conducted at the level of individual Initiative Areas to be consistent with conservation planning strategies of the GCJV, we also modeled food supply and demand collectively across the TXMC, TXCP, and LACP to acknowledge the possibility that waterfowl could redistribute within the GCJV region in search of limited food resources. While it is realistic to expect waterfowl to move across large landscapes while searching for limited resources during winter, or redistribute among regions in response to changing landscape conditions across years (Reinecke et al. 1992, Pearse et al. 2008), comparisons of supply and demand across Initiative Areas does not acknowledge the sociopolitical considerations embedded within population and habitat objectives that are established at smaller scales (e.g., Initiative Areas). Most notably, these sociopolitical considerations reflect a desire to provide waterfowl habitats in amounts and at scales required to satisfy resource needs of both waterfowl populations and humans that appreciate and use the waterfowl resource. While habitat supply in excess of demand for one Initiative Area could numerically compensate for habitat supply that is below demand in another Initiative Area, partners of the GCJV likely would not consider these conditions to reflect conservation success, especially if the habitat deficit was great in one or more individual Initiative Areas. However, landscapes upon which wintering waterfowl depend are changing, in many cases being driven by forces that are largely irreversible (e.g., urban expansion). Going forward, it is reasonable to expect that Joint Venture partnerships will have to more explicitly address the realities of a changing landscape and its implications for providing habitat sufficient to meet demands of population objectives that were based on abundances and distributions observed 30-40 years prior.

Our analyses revealed that current riceland habitat conditions in the GCJV are sufficient to satisfy goose energy demands, and that these demands continued to be met under most scenarios reflecting additional declines in planted rice acreage. This was driven largely by our decision to model unflooded rice fields as being available foraging habitat for geese. While geese regularly forage in unflooded, harvest rice fields (Hobaugh 1984), factors beyond food abundance undoubtedly affect the abundance and distribution of geese within wintering geographies. Indeed, based on data from December aerial surveys, average annual abundance of white geese on the Texas coast was approximately 900,000 from the mid-1970s through the late-1990s, but have declined since, averaging approximately 400,000 from 2003 – current (Texas Parks and Wildlife Department, unpublished data). These declines in goose abundance corresponded to a time period during which planted rice on the Texas coast declined from 992,000 to 466,000 acres, yet analyses would almost certainly have revealed sufficient habitat to meet the needs of geese over this time period. While hypotheses for the decline of wintering white geese on the Texas coast is outside the scope of this report, it is clear that factors beyond numerical measures of habitat and food resource availability affect distribution and abundance of waterfowl during winter (Pearse et al. 2008, Brasher 2010).

Although the scenarios for future rice decline represent largely arbitrarily selected values (e.g., 25%, 50% reductions), they nevertheless represent reasonable and informative possibilities. For example, our analyses for the GCJV region reflected habitat conditions prior to recent decisions by LCRA to curtail releases of water for downstream irrigation. As an immediate result of the LCRA decision in spring 2012, planted rice acreage in the TXMC declined by 52,000 acres. This represented a 36% decline in the TXMC and a 30% decline in total rice acreage along the Texas coast from levels observed in 2010-11. Thus, our scenarios of future declines could be viewed as conservative, at least for some regions. Rice production in the LACP has been relatively stable over the past 5 years. The likelihood and magnitude of future declines in this area are difficult to forecast, although projections for rising input costs (e.g., fuel, fertilizer, water), low commodity prices, and continued high opportunity costs associated with Gulf Coast ricelands suggests it is reasonable to expect declines of some degree (Baldwin et al. 2011).

In the absence of rice agriculture, it is a virtual certainty that the Gulf Coast region will be unable to support wintering waterfowl at levels reflected by either GCJV population objectives or waterfowl abundances observed in more recent periods. Multiple efforts will be required to ensure rice agriculture remains profitable and maintains a meaningful footprint within this region, thus continuing to provide abundant and valuable habitat for wintering waterfowl. Fortunately, the LCRA is moving forward with construction of a downstream reservoir to supplement water supplies within the TXMC. The reservoir will be designed to capture and store up to 90,000 acre-feet of water from the Colorado River when river conditions allow, thus increasing the LCRA firm water supply by approximately 15%. The addition of this reservoir will provide another source of irrigation water, while reducing demand on water releases from the primary storage reservoirs of Lakes Buchanan and Travis. Although the addition of this water is unlikely to reverse the trend of declining rice acreage in the TXMC, it at least represents a potential positive development for retaining the rice acreage that remains. Nevertheless, policy efforts will continue to be needed to ensure rice producers are represented in discussion and decisions about water availability from

LCRA and likely other water authorities and irrigation districts along the Gulf Coast as human populations and associated water demands continue to grow within this region.

Lastly, efforts and programs to help increase the efficiency and profitability of rice farming operations will play important roles in maintaining rice agriculture on the Gulf Coast. For example, Ducks Unlimited has recently launched a Riceland Stewardship Program in south Louisiana to aid rice producers with various water and energy efficiency tests and improvements, as well as providing technical assistance on how to maximize the quality of winter waterfowl habitat within the constraints of current farming operations. This program has thus far been well-received, and may soon be expanded to other regions. While challenges to maintaining rice agriculture on the Gulf Coast are substantial, a few positive developments have occurred in recent years, and these provide a valuable foundation from which to expand and pursue additional innovative approaches to help support the Gulf Coast rice industry.

**Summary**

Rice habitats provide a significant fraction of the food energy available to dabbling ducks and geese that winter in the U.S., and it is unlikely that the population goals of the NAWMP could be met in the absence of rice. Although the CVJV, LMVJV, and GCJV are linked by their rice landscapes, these Joint Ventures face different challenges in maintaining and increasing the importance of rice habitats to waterfowl. Water supplies used for winter-flooding are under increasing pressure in the CVJV, and many producers may be forced to adopt straw decomposition practices that provide far fewer waterfowl benefits than winter-flooding. In the LMVJV, research and extension programs that increase the feasibility of ratooning rice are needed in order to increase the amount of food provided by ricefields. Finally long-term declines in rice acreage on the Gulf Coast, especially on the Texas Mid- Coast, are particularly worrisome. Halting this decline and winter-flooding a greater percentage of the acres that still remain will be necessary to meet the needs of GCJV waterfowl in the future.

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# APPENDIX I

## TABLES & FIGURES –METHODS SECTION

## Tables

Table A-1 Population goals for dabbling ducks in the CVJV excluding wood ducks.

| Period | Population Goal |
|---|---|
| Aug 16 – Aug 30 | 721,054 |
| Aug 31 – Sept 14 | 998,382 |
| Sept 15 – Sept 29 | 1,275,710 |
| Sept 30 – Oct 14 | 2,163,161 |
| Oct 15 – Oct 29 | 2,939,680 |
| Oct 30 – Nov 13 | 3,439,586 |
| Nov 14 – Nov 28 | 4,048,992 |
| Nov 29 – Dec 13 | 5,102,840 |
| Dec 14 – Dec 28 | 5,546,565 |
| Dec 29 – Jan 12 | 5,324,703 |
| Jan 13 – Jan 27 | 4,714,580 |
| Jan 28 – Feb 11 | 4,159,923 |
| Feb 12 – Feb 26 | 3,605,268 |
| Feb 27 – Mar 13 | 2,939,680 |
| Mar 14 – Mar 28 | 2,224,173 |

Table A-2 Population goals for dabbling ducks in the LMVJV excluding wood ducks.

| Period | Population Goal |
|---|---|
| Oct 1 – Oct 15 | 143,170 |
| Oct 16 – Oct 31 | 401,889 |
| Nov 1 – Nov 15 | 836,745 |
| Nov 16 – Nov 30 | 1,539,851 |
| Dec 1 – Dec 15 | 2,489,874 |
| Dec 16 – Dec 31 | 2,748,556 |
| Jan 1 – Jan 15 | 3,127,486 |
| Jan 16 – Jan 31 | 3,329,976 |
| Feb 1 – Feb 15 | 3,433,648 |
| Feb 16 – Feb 28 | 3,393,342 |
| Mar 1 – Mar 15 | 1,802,482 |
| Mar 16 – Mar 31 | 881,385 |

Table A-3 Population goals for dabbling ducks in the GCJV excluding wood ducks.

| Period | Population Goal |
|---|---|
| Aug 16 – Aug 31 | 2,021,470 |
| Sept 1 – Sept 15 | 5,743,387 |
| Sept 16 – Sept 30 | 5,808,350 |
| Oct 1 – Oct 15 | 5,662,321 |
| Oct 16 – Oct 31 | 7,026,182 |
| Nov 1 – Nov 15 | 10,105,033 |
| Nov 16 – Nov 30 | 10,015,239 |
| Dec 1 – Dec 15 | 11,561,900 |
| Dec 16 – Dec 31 | 11,217,743 |
| Jan 1 – Jan 15 | 10,609,298 |
| Jan 16 – Jan 31 | 9,285,690 |
| Feb 1 – Feb 15 | 7,139,734 |
| Feb 16 – Feb 28 | 7,844,497 |
| Mar 1 – Mar 15 | 8,995,406 |
| Mar 16 – Mar 31 | 6,595,941 |

Table A-4 Population goals for dabbling ducks (excluding wood ducks) and diving ducks in the GCJV Texas Mid-Coast.

| Period | Dabbling Ducks (Ag. Habitats)[a] | Dabbling Ducks (Coastal Habitats) | Dabbling Ducks (All Habitats) | Diving Ducks[b] (Coastal Habitats) |
|---|---|---|---|---|
| Aug 16 – Aug 31 | 123,621 | 174,455 | 298,076 | 0 |
| Sept 1 – Sept 15 | 627,998 | 333,307 | 961,305 | 1 |
| Sept 16 – Sept 30 | 629,927 | 330,095 | 957,022 | 1 |
| Oct 1 – Oct 15 | 770,592 | 448,282 | 1,218,874 | 1,574 |
| Oct 16 – Oct 31 | 769,521 | 445,070 | 1,214,591 | 1,574 |
| Nov 1 – Nov 15 | 1,317,417 | 746,599 | 2,064,016 | 56,374 |
| Nov 16 – Nov 30 | 1,316,346 | 743,386 | 2,059,732 | 56,374 |
| Dec 1 – Dec 15 | 1,627,702 | 724,590 | 2,352,292 | 66,489 |
| Dec 16 – Dec 31 | 1,626,631 | 721,378 | 2,348,009 | 66,489 |
| Jan 1 – Jan 15 | 1,182,109 | 591,671 | 1,773,780 | 61,157 |
| Jan 16 – Jan 31 | 1,181,039 | 588,458 | 1,769,497 | 61,157 |
| Feb 1 – Feb 15 | 792,548 | 504,617 | 1,297,165 | 70,864 |
| Feb 16 – Feb 28 | 791,447 | 501,405 | 1,292,882 | 70,864 |
| Mar 1 – Mar 15 | 625,115 | 526,625 | 1,151,740 | 47,418 |
| Mar 16 – Mar 31 | 624,044 | 523,413 | 1,147,457 | 47,418 |

[a] Primarily riceland habitat.

[b] Diving duck population goals have been discounted by the GCJV for percentage of their diet estimated to be composed of invertebrates, bivalves and other foods not accounted for in carrying capacity analyses.

Table A-5 Population goals for dabbling ducks (excluding wood ducks) and diving ducks in the GCJV Texas Chenier Plain.

| Period | Dabbling Ducks (Ag. Habitats)[a] | Dabbling Ducks (Coastal Habitats) | Dabbling Ducks (All Habitats) | Diving Ducks[b] (Coastal Habitats) |
|---|---|---|---|---|
| Aug 16 – Aug 31 | 188,853 | 244,581 | 433,434 | 0 |
| Sept 1 – Sept 15 | 1,120,720 | 1,168,983 | 2,289,703 | 5 |
| Sept 16 – Sept 30 | 1,120,123 | 1,167,192 | 2,287,315 | 5 |
| Oct 1 – Oct 15 | 475,827 | 525,104 | 1,000,931 | 265 |
| Oct 16 – Oct 31 | 475,230 | 523,313 | 998,543 | 265 |
| Nov 1 – Nov 15 | 549,324 | 644,104 | 1,193,428 | 12,220 |
| Nov 16 – Nov 30 | 548,727 | 642,313 | 1,191,040 | 12,220 |
| Dec 1 – Dec 15 | 751,596 | 750,364 | 1,501,960 | 25,993 |
| Dec 16 – Dec 31 | 750,999 | 748,572 | 1,499,571 | 25,993 |
| Jan 1 – Jan 15 | 573,779 | 638,628 | 1,212,407 | 25,015 |
| Jan 16 – Jan 31 | 573,182 | 636,837 | 1,210,019 | 25,015 |
| Feb 1 – Feb 15 | 578,567 | 675,904 | 1,254,471 | 17,276 |
| Feb 16 – Feb 28 | 577,970 | 674,113 | 1,252,083 | 17,276 |
| Mar 1 – Mar 15 | 1,267,920 | 1,365,285 | 2,633,205 | 5,323 |
| Mar 16 – Mar 31 | 1,267,323 | 1,363,493 | 2,630,816 | 5,323 |

[a] Primarily riceland habitat.

[b] Diving duck population goals have been discounted by the GCJV for percentage of their diet estimated to be composed of invertebrates, bivalves and other foods not accounted for in carrying capacity analyses.

Table A- 6 Population goals for dabbling ducks (excluding wood ducks) and diving ducks in the GCJV Louisiana Chenier Plain.

| Period | Dabbling Ducks (Ag. Habitats)[a] | Dabbling Ducks (Coastal Habitats) | Dabbling Ducks (All Habitats) | Diving Ducks[b] (Coastal Habitats) |
|---|---|---|---|---|
| Aug 16 – Aug 31 | 100,681 | 205,709 | 306,390 | 0 |
| Sept 1 – Sept 15 | 576,054 | 676,662 | 1,252,716 | 0 |
| Sept 16 – Sept 30 | 654,887 | 750,529 | 1,405,416 | 0 |
| Oct 1 – Oct 15 | 774,303 | 1,013,043 | 1,787,347 | 29,246 |
| Oct 16 – Oct 31 | 966,749 | 1,730,717 | 2,697,466 | 47,673 |
| Nov 1 – Nov 15 | 1,308,266 | 2,378,585 | 3,686,851 | 151,660 |
| Nov 16 – Nov 30 | 1,400,223 | 2,331,614 | 3,731,837 | 224,616 |
| Dec 1 – Dec 15 | 1,578,205 | 2,543,430 | 4,121,635 | 234,622 |
| Dec 16 – Dec 31 | 1,424,514 | 2,353,448 | 3,777,963 | 252,512 |
| Jan 1 – Jan 15 | 1,677,774 | 2,512,574 | 4,190,348 | 324,126 |
| Jan 16 – Jan 31 | 1,394,894 | 2,090,849 | 3,485,743 | 313,614 |
| Feb 1 – Feb 15 | 851,875 | 1,382,392 | 2,234,267 | 281,726 |
| Feb 16 – Feb 28 | 912,101 | 1,529,729 | 2,441,830 | 182,014 |
| Mar 1 – Mar 15 | 974,554 | 1,619,274 | 2,593,828 | 204,356 |
| Mar 16 – Mar 31 | 505,094 | 863,089 | 1,368,183 | 102,178 |

[a] Primarily riceland habitat.

[b] Diving duck population goals have been discounted by the GCJV for percentage of their diet estimated to be composed of invertebrates, bivalves and other foods not accounted for in carrying capacity analyses.

Table A-7 Population goals for wood ducks in the LMVJV.

| Period | Population Goal |
|---|---|
| Oct 1 – Oct 15 | 48,678 |
| Oct 16 – Oct 31 | 136,642 |
| Nov 1 – Nov 15 | 284,493 |
| Nov 16 – Nov 30 | 523,549 |
| Dec 1 – Dec 15 | 846,557 |
| Dec 16 – Dec 31 | 934,509 |
| Jan 1 – Jan 15 | 1,063,345 |
| Jan 16 – Jan 31 | 1,132,192 |
| Feb 1 – Feb 15 | 1,167,440 |
| Feb 16 – Feb 28 | 1,153,736 |
| Mar 1 – Mar 15 | 612,844 |
| Mar 16 – Mar 31 | 299,671 |

Table A-8 Population goals for geese in the CVJV.

| Period | White Geese | Dark Geese | Total Geese |
|---|---|---|---|
| Aug 16 – Aug 30 | 0 | 0 | 0 |
| Aug 31 – Sept 14 | 0 | 0 | 0 |
| Sept 15 – Sept 29 | 87 | 62,970 | 63,057 |
| Sept 30 – Oct 14 | 272 | 197,068 | 197,340 |
| Oct 15 – Oct 29 | 63,560 | 293,163 | 356,723 |
| Oct 30 – Nov 13 | 169,659 | 363,944 | 533,603 |
| Nov 14 – Nov 28 | 306,686 | 400,552 | 707,238 |
| Nov 29 – Dec 13 | 519,001 | 312,964 | 831,965 |
| Dec 14 – Dec 28 | 625,022 | 255,302 | 880,324 |
| Dec 29 – Jan 12 | 575,788 | 258,017 | 833,805 |
| Jan 13 – Jan 27 | 581,147 | 238,024 | 819,171 |
| Jan 28 – Feb 11 | 584,881 | 216,378 | 801,259 |
| Feb 12 – Feb 26 | 563,324 | 192,040 | 755,364 |
| Feb 27 – Mar 13 | 316,078 | 104,978 | 421,056 |
| Mar 14 – Mar 28 | 28,702 | 25,783 | 54,485 |

Table A-9 Population goals for geese in the LMVJV.

| Period | Population Goal |
|---|---|
| Oct 1 – Oct 15 | 151,113 |
| Oct 16 – Oct 31 | 974,444 |
| Nov 1 – Nov 15 | 1,888,124 |
| Nov 16 – Nov 30 | 3,038,178 |
| Dec 1 – Dec 15 | 2,866,386 |
| Dec 16 – Dec 31 | 2,759,811 |
| Jan 1 – Jan 15 | 2,203,077 |
| Jan 16 – Jan 31 | 2,629,375 |
| Feb 1 – Feb 15 | 2,228,527 |
| Feb 16 – Feb 28 | 2,282,610 |
| Mar 1 – Mar 15 | 908,272 |
| Mar 16 – Mar 31 | 523,807 |

Table A-10 Population goals for geese in the GCJV.

| Period | TX Mid-Coast | TX Chenier Plain | Louisiana Chenier Plain | GCJV Total[a] |
|---|---|---|---|---|
| Aug 16 – Aug 31 | 0 | 0 | 0 | 0 |
| Sept 1 – Sept 15 | 356 | 6 | 60 | 473 |
| Sept 16 – Sept 30 | 356 | 6 | 60 | 473 |
| Oct 1 – Oct 15 | 118,227 | 10,699 | 86,715 | 246,080 |
| Oct 16 – Oct 31 | 118,227 | 10,699 | 86,715 | 246,080 |
| Nov 1 – Nov 15 | 423,903 | 110,812 | 380,035 | 1,080,244 |
| Nov 16 – Nov 30 | 423,903 | 110,812 | 380,035 | 1,080,244 |
| Dec 1 – Dec 15 | 639,918 | 96,917 | 319,068 | 1,228,987 |
| Dec 16 – Dec 31 | 639,918 | 96,917 | 319,068 | 1,228,987 |
| Jan 1 – Jan 15 | 612,720 | 166,217 | 494,901 | 1,510,677 |
| Jan 16 – Jan 31 | 612,720 | 166,217 | 494,901 | 1,510,677 |
| Feb 1 – Feb 15 | 520,553 | 129,243 | 388,448 | 1,227,726 |
| Feb 16 – Feb 28 | 520,553 | 129,243 | 388,448 | 1,227,726 |
| Mar 1 – Mar 15 | 8,514 | 2,814 | 17,892 | 34,135 |
| Mar 16 – Mar 31 | 8,514 | 2,814 | 17,892 | 34,135 |

[a] Includes goose population goals for all initiative areas in the GCJV.

Table A-11 Daily energy needs of dabbling ducks in the GCJV.

| Period | Daily Energy Need (kcal/day) |
|---|---|
| Aug 16 – Aug 31 | 223.8 |
| Sept 1 – Sept 15 | 185.9 |
| Sept 16 – Sept 30 | 186.0 |
| Oct 1 – Oct 15 | 211.4 |
| Oct 16 – Oct 31 | 222.0 |
| Nov 1 – Nov 15 | 231.6 |
| Nov 16 – Nov 30 | 234.5 |
| Dec 1 – Dec 15 | 233.7 |
| Dec 16 – Dec 31 | 234.6 |
| Jan 1 – Jan 15 | 227.5 |
| Jan 16 – Jan 31 | 228.7 |
| Feb 1 – Feb 15 | 223.8 |
| Feb 16 – Feb 28 | 218.0 |
| Mar 1 – Mar 15 | 202.1 |
| Mar 16 – Mar 31 | 199.6 |

Note: For model simulations that were specific to a GCJV initiative area the daily energy needs of dabbling ducks differed slightly from that presented in Table A-11.

Table A-12 Daily energy needs of white geese in the CVJV.

| Period | Daily Energy Need (kcal/day) |
|---|---|
| Aug 16 – Aug 30 | 0 |
| Aug 31 – Sept 14 | 0 |
| Sept 15 – Sept 29 | 499 |
| Sept 30 – Oct 14 | 499 |
| Oct 15 – Oct 29 | 632 |
| Oct 30 – Nov 13 | 632 |
| Nov 14 – Nov 28 | 636 |
| Nov 29 – Dec 13 | 635 |
| Dec 14 – Dec 28 | 622 |
| Dec 29 – Jan 12 | 575 |
| Jan 13 – Jan 27 | 557 |
| Jan 28 – Feb 11 | 541 |
| Feb 12 – Feb 26 | 525 |
| Feb 27 – Mar 13 | 520 |
| Mar 14 – Mar 28 | 503 |

Table A-13 Daily energy needs of dark geese in the CVJV.

| Period | Daily Energy Need (kcal/day) |
|---|---|
| Aug 16 – Aug 30 | 0 |
| Aug 31 – Sept 14 | 0 |
| Sept 15 – Sept 29 | 522 |
| Sept 30 – Oct 14 | 522 |
| Oct 15 – Oct 29 | 522 |
| Oct 30 – Nov 13 | 538 |
| Nov 14 – Nov 28 | 538 |
| Nov 29 – Dec 13 | 544 |
| Dec 14 – Dec 28 | 540 |
| Dec 29 – Jan 12 | 497 |
| Jan 13 – Jan 27 | 498 |
| Jan 28 – Feb 11 | 553 |
| Feb 12 – Feb 26 | 553 |
| Feb 27 – Mar 13 | 549 |
| Mar 14 – Mar 28 | 538 |

Table A-14 Daily energy needs of geese in the GCJV.

| Period | Daily Energy Need (kcal/day) |
|---|---|
| Aug 16 – Aug 31 | 0 |
| Sept 1 – Sept 15 | 583.4 |
| Sept 16 – Sept 30 | 583.4 |
| Oct 1 – Oct 15 | 580.3 |
| Oct 16 – Oct 31 | 580.3 |
| Nov 1 – Nov 15 | 555.5 |
| Nov 16 – Nov 30 | 555.5 |
| Dec 1 – Dec 15 | 551.2 |
| Dec 16 – Dec 31 | 551.2 |
| Jan 1 – Jan 15 | 549.8 |
| Jan 16 – Jan 31 | 549.8 |
| Feb 1 – Feb 15 | 550.3 |
| Feb 16 – Feb 28 | 550.3 |
| Mar 1 – Mar 15 | 566.9 |
| Mar 16 – Mar 31 | 566.9 |

Note: For model simulations that were specific to a GCJV initiative area the daily energy needs of geese differed slightly from that presented in Table 14.

Table A-15 Acres of foraging habitat available to dabbling ducks and geese in the CVJV.

| Flooded Rice (Harvested) | Dry Rice[a] (Harvested) | Total Rice (Harvested) | Managed Seasonal Wetland | Flooded Corn (Harvested) | Dry Corn[b] (Harvested) | Total[c] Foraging Habitats |
|---|---|---|---|---|---|---|
| 305,227 | 179,866 | 485,093 | 197,232 | 27,500 | 51,296 | 761,123 |

[a] Excludes 25% of all dry rice acres in the Sacramento Valley that are believed to provide few food resources because of post-harvest practices.

[b] Excludes 50% of all dry corn acres in the Sacramento Valley that are believed to provided few food resources because of post-harvest practices. Excludes all corn grown in the San Joaquin Valley and Tulare Basin because of post-harvest practices.

[c] Excludes cropland that may be flooded from one to several weeks in the Tulare Basin.

Table A-16 Acres of foraging habitat available to ducks and geese in the LMVJV.

| Flooded Rice (Harvested) | Dry Rice (Harvested) | Managed Seasonal Wetland | Forested Wetlands | Flooded[a] Crops (Harvested) | Flooded Crops (Unharvested) | Total Foraging Habitats |
|---|---|---|---|---|---|---|
| 388,028 | 1,462,720 | 87,943 | 1,379,447 | 698,458 | 8,795 | 4,025,391 |

[a] Predominantly soybeans.

Table A-17 Estimated Rice Base (acres) in each of the GCJV's rice producing initiative areas, and for the GCJV as a whole.

| Initiative Area | Planted Rice | Idled Ricelands | Alternative Crops[a] | Rice Base[b] |
|---|---|---|---|---|
| LA Chenier Plain | 297,650 | 223,238 | 74,412 | 595,300 |
| TX Chenier Plain | 31,725 | 60,278 | 3,172 | 95,175 |
| TX Mid-Coast | 142,900 | 228,640 | 57,160 | 371,540 |
| GCJV Total | 472,275 | 512,156 | 134,745 | 1,119,175 |

[a] Alternative crops that provide waterfowl food sources are mostly soybeans.

[b] Equals Planted Rice + Idled Ricelands + Alternative Crops.

Table A-18 Riceland habitat categories (acres) in each of the GCJV's rice producing initiative areas, and for the GCJV as a whole.

| Initiative Area | First Crop Rice[a] Not Ratooned | Harvested[b] Ratoon | Unharvested[c] Ratoon | Idle Ricelands | Total Riceland Habitat |
|---|---|---|---|---|---|
| LA Chenier Plain | 208,355 | 84,830 | 4,465 | 223,238 | 520,888 |
| TX Chenier Plain | 20,621 | 10,549 | 555 | 60,278 | 92,003 |
| TX Mid-Coast | 50,015 | 88,241 | 4,644 | 228,640 | 371,540 |
| GCJV Total | 278,991 | 183,620 | 9,664 | 512,155 | 984,431 |

[a] Planted rice fields that are harvested in July or August and not ratooned.

[b] Planted rice fields that are harvested in July or August then ratooned (second cropped) and harvested in November.

[c] Planted rice fields that are harvested in July or August then ratooned (second cropped) and left un-harvested.

Table A-19 Peak estimates of flooded riceland habitat in each of the GCJV's rice producing initiative areas, and for the GCJV as a whole.

| Initiative Area | Rice[a] | Idled Rice Lands | Total |
|---|---|---|---|
| LA Chenier Plain | 147,816 | 105,318 | 253,134 |
| TX Chenier Plain | 20,974 | 25,307 | 46,281 |
| TX Mid-Coast | 15,349 | 30,418 | 45,767 |
| GCJV Total | 183,959 | 161,043 | 345,002 |

[a] Includes first crop rice that is not ratooned and ratooned ricefields that are both unharvested and harvested.

Table A- 20 Foraging habitats (acres) available to dabbling ducks in the GCJV.

| Initiative Area[a] | Flooded[b] Ricelands | Flooded Soybeans | Coastal Marsh | Forested Wetlands | Total |
|---|---|---|---|---|---|
| LA Chenier Plain | 253,134 | 19,247 | 971,766 | 0 | 1,244,147 |
| TX Chenier Plain | 46,281 | 2,592 | 250,968 | 0 | 299,661 |
| TX Mid-Coast | 45,767 | 2,219 | 335,756 | 0 | 383,742 |
| MS. River Coastal Wetlands | 0 | 0 | 1,883,506 | 543,320 | 2,426,826 |
| Coastal MS. | 0 | 0 | 70,208 | 148,000 | 319,008 |
| Mobile Bay | 0 | 0 | | 100,800 | |
| GCJV Total | 345,182 | 24,058 | 3,512,204 | 792,120 | 4,673,384 |

[a] Excludes the Laguna Madre initiative area where food resources are mostly seagrass.

[b] Includes peak flooding estimates for harvested and unharvested rice fields and idled rice lands.

Table A-21 Food biomass estimates (kg/acre) adjusted for giving up densities for waterfowl foraging habitats in the CVJV.

| Harvested Rice Fields | Managed Seasonal Wetlands | Harvested Corn Fields |
|---|---|---|
| 122.7 | 242.2 | 210.2 |

Table A-22 Food biomass estimates (kg/acre) adjusted for giving up densities for waterfowl foraging habitats in the LMVJV.

| Harvested Rice | Managed Seasonal Wetlands | Forested Wetlands | "Other" Harvested Crops[a] | "Other" Unharvested Crops |
|---|---|---|---|---|
| 13.8 | 187.9 | 6.9 | 7.3 | 1,489.2 |

[a] Weighted estimate of moist soil and HMU habitats.
[b] Predominantly soybeans.

Table A-23 Food biomass estimates (kg/acre) adjusted for giving up densities for Rice habitats in the GCJV.

| Initiative Area | First Crop Rice[a] Not Ratooned | Harvested[b] Ratoon | Unharvested[c] Ratoon | Early Idled[d] Ricelands | Late Idled[e] Ricelands |
|---|---|---|---|---|---|
| LA Chenier Plain | 123.4 | 212.8 | 686.3 | 76.9 | 127.7 |
| TX Chenier Plain | 123.4 | 212.8 | 686.3 | 76.9 | 127.7 |
| TX Mid-Coast | 126.8 | 107.9 | 686.3 | 110.8 | 186.5 |

[a] Planted rice fields that are harvested in July or August and not ratooned.

[b] Planted rice fields that are harvested in July or August then ratooned (second cropped) and harvested in November.

[c] Planted rice fields that are harvested in July or August then ratooned (second cropped) and left un-harvested.

[d] Food biomass values assumed for idled ricelands that are flooded prior to November 1.

[e] Food biomass values assumed for idled ricelands that are flooded after November 1.

Table A-24 Food biomass estimates (kg/acre) adjusted for giving up densities for non-rice waterfowl foraging habitats in the GCJV.

| Initiative Area[a] | Coastal Marsh | Forested Wetlands | Flooded Soybeans |
|---|---|---|---|
| LA Chenier Plain | 34.6 | Not Present | 7.3 |
| TX Chenier Plain | 33.7 | Not Present | 7.3 |
| TX Mid-Coast | 43.6 | Not Present | 7.3 |
| MS. River Coastal Wetlands | 23.2 | 6.5 | Not Present |
| Coastal MS. | 32.6 | 1.6 | Not Present |
| Mobile Bay | 32.6 | 1.6 | Not Present |
| Weighted GCJV Value[b] | 29.2 | 5.0 | 7.3 |

[a] Excludes the Laguna Madre initiative area where food resources are mostly seagrass.

[b] Weighted estimate based on the area of forested wetlands in each initiative area and their associated foraging value.

Table A-25 True Metabolizable Energy (kcal/g) of foods used in TRUEMET simulations.

| Food Type | CVJV | LMVJV | GCJV |
|---|---|---|---|
| Rice Grain | 3.0 | 3.0 | 3.0 |
| Moist-Soil Seeds | 2.5 | 2.47 | 2.5 |
| Forested Wetland Foods | NA | 2.76 | 2.76 |
| Coastal Marsh Foods | NA | NA | 1.56 |
| Soybeans | NA | 3.08 | 3.08 |
| Corn | 3.9 | 3.9 | NA |

NA – Not applicable.

Table A-26 Habitats used by waterfowl in the CVJV to meet their food energy requirements.

| Waterfowl Guild | Flooded Rice (Harvested) | Dry Rice (Harvested) | Managed Seasonal Wetland | Flooded Corn (Harvested) | Dry Corn (Harvested) |
|---|---|---|---|---|---|
| Dabbling Ducks | x | | x | x | x |
| Dark Geese | x | x | x | x | x |
| White Geese | x | x | | x | x |

Table A-27 Habitats used by waterfowl in the LMVJV to meet their food energy requirements.

| Waterfowl Guild | Flooded Rice (Harvested) | Dry Rice (Harvested) | Managed Seasonal Wetland | Forested Wetlands | Flooded[a] Crops (Harvested) | Flooded Crops (Unharvested) |
|---|---|---|---|---|---|---|
| Dabbling Ducks | x | | x | x | x | x |
| Geese[a] | x | x | x | | x | x |
| Wood Ducks | | | | x | | |

[a] Geese in the LMVJV are assumed to meet 25% of their energy needs from flooded habitats, excluding forested wetlands.

Table A-28 Habitats used by waterfowl in the GCJV to meet their food energy requirements.

| Waterfowl Guild | Flooded[a] Rice | Dry Rice[a] | Flooded Idled Ricelands | Flooded Soybeans | Coastal[b] Marsh | Forested Wetlands |
|---|---|---|---|---|---|---|
| Dabbling Ducks | x | | x | x | x | x |
| Geese[a] | x | x | x | x | | |

[a] Includes rice that is harvested and unharvested.

[b] A small fraction of geese in the GCJV are assumed to meet their food energy needs from coastal marsh.

## Figures

Figure A-1 Migration chronology index for mallards in the LMVJV. An index of 1.0 corresponds to the peak of migration.

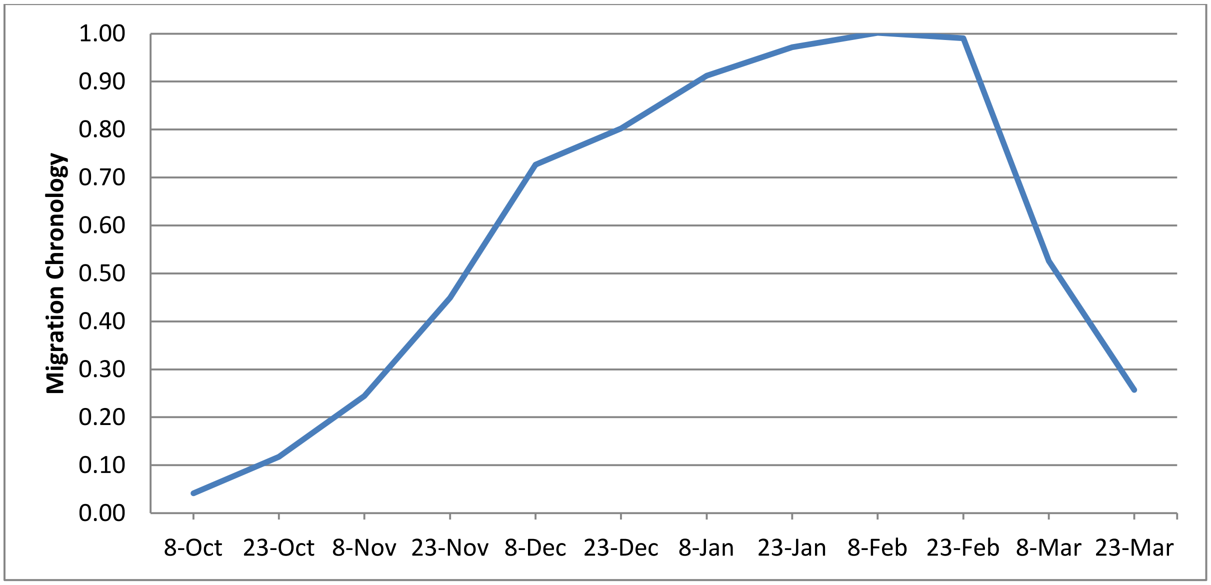


Figure A-2 Migration chronology index for snow geese in the LMVJV. An index of 1.0 corresponds to the peak of migration.

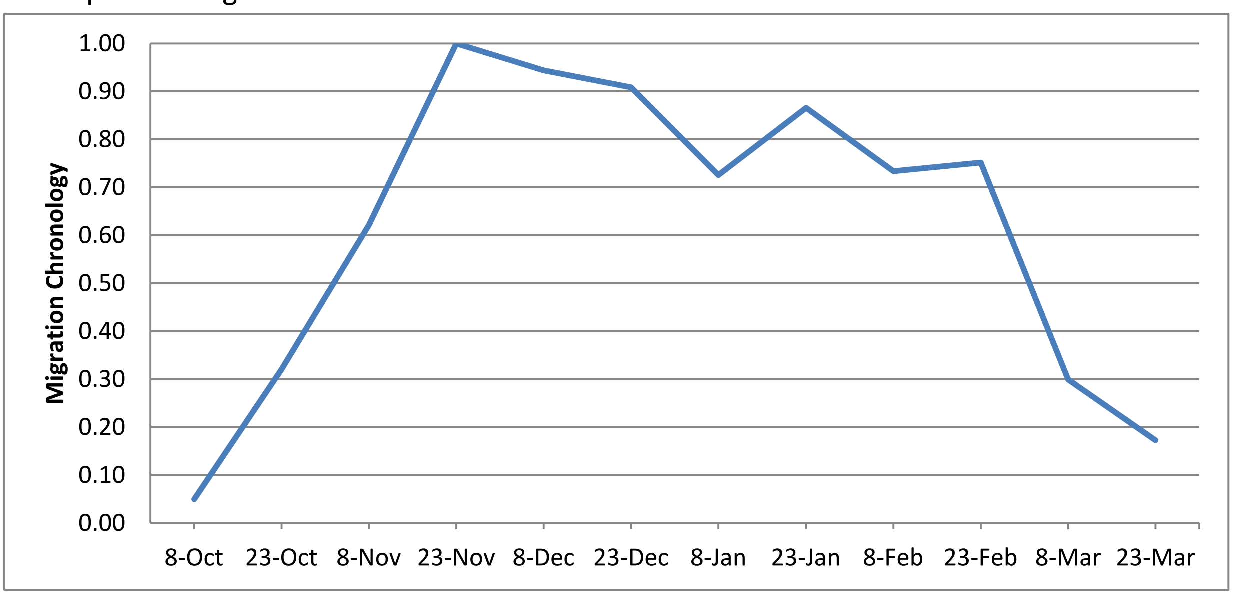

Figure A-3   Availability of winter-flooded rice habitat in the CVJV.

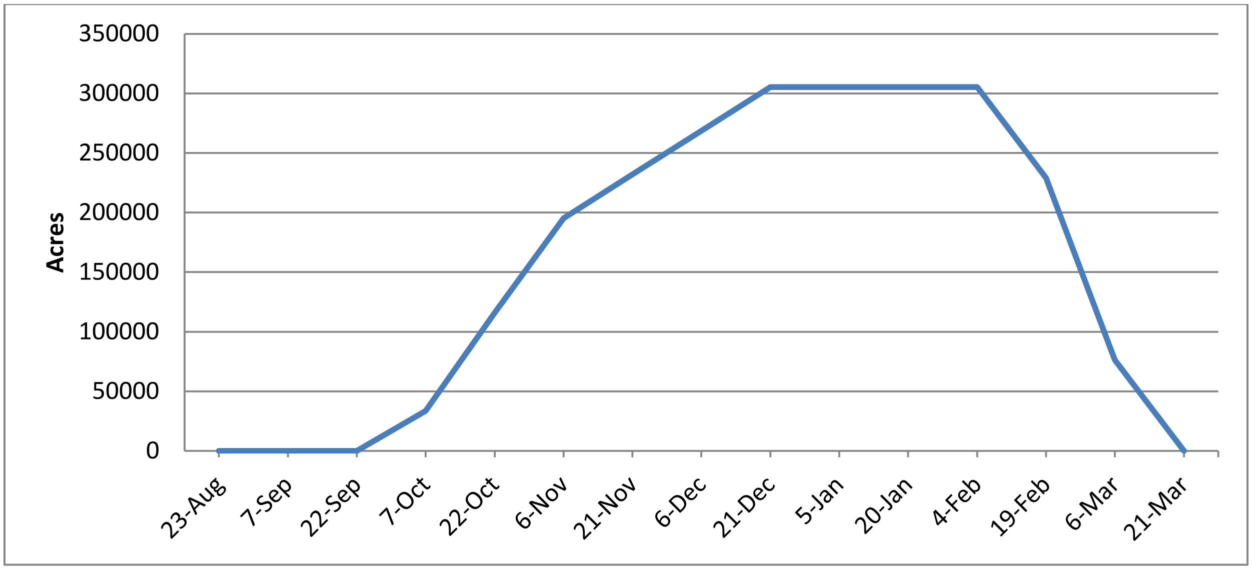


Figure A-4   Availability of managed seasonal wetlands in the CVJV.

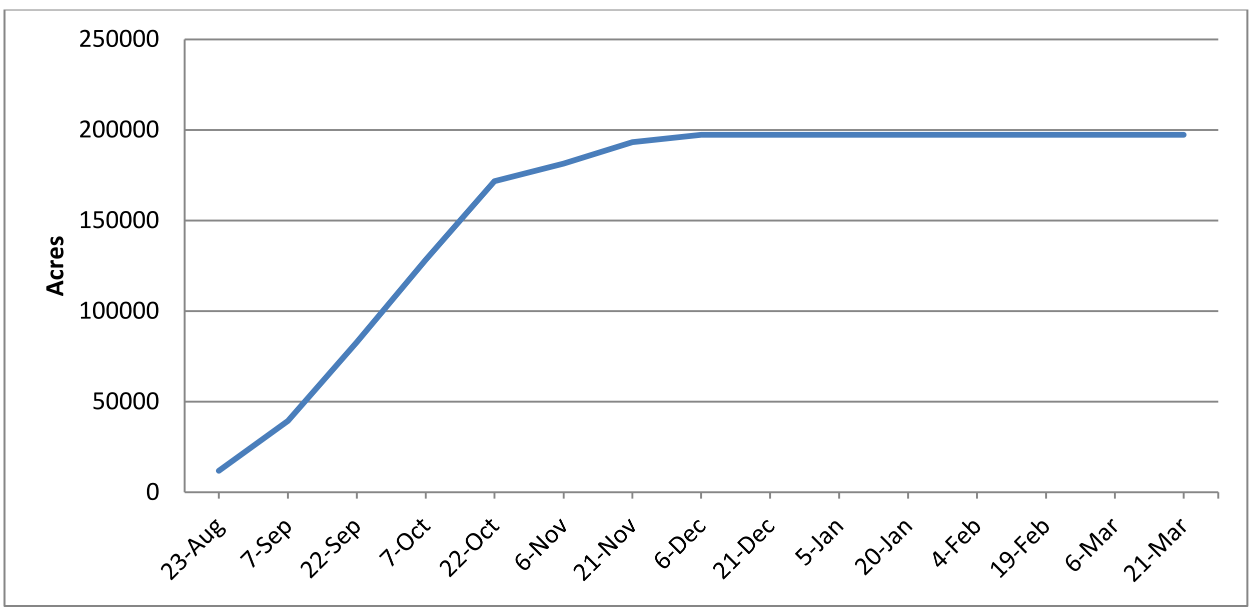

Figure A-5 Availability of winter-flooded rice habitat in the LMVJV.

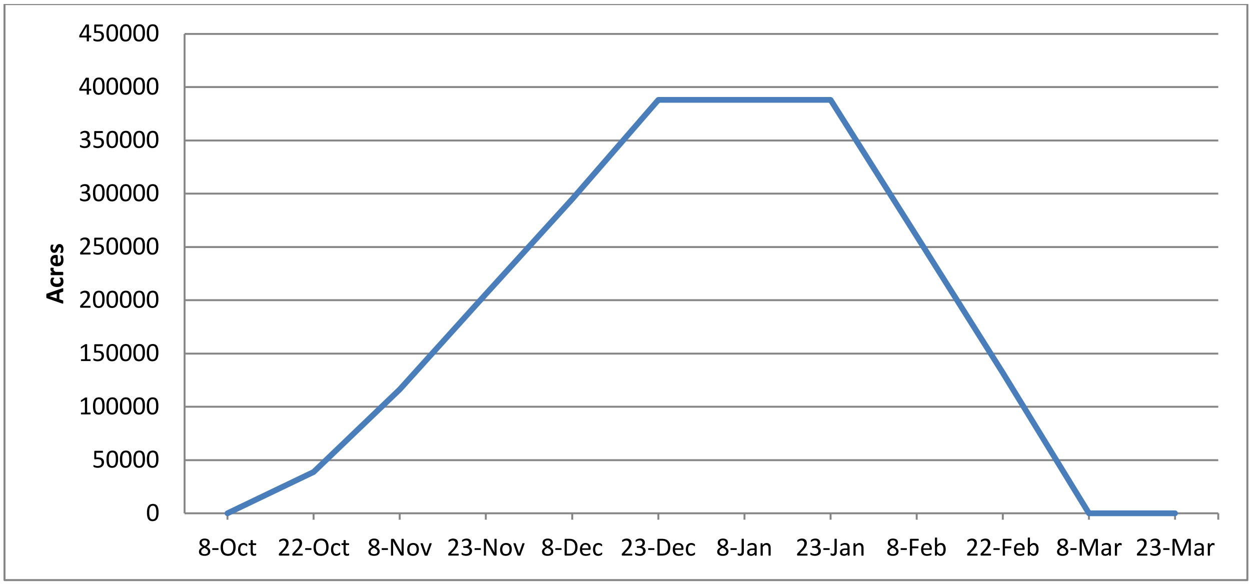


Figure A-6 Availability of managed seasonal wetlands in the LMVJV.

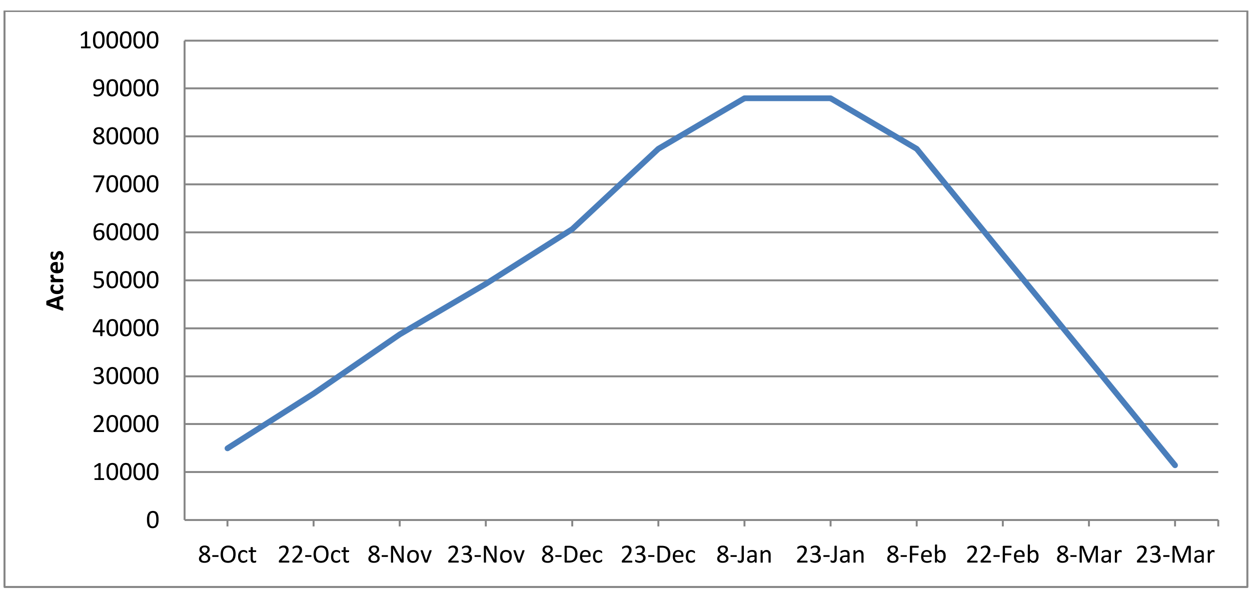

Figure A-7 Availability of forested wetlands in the LMVJV.

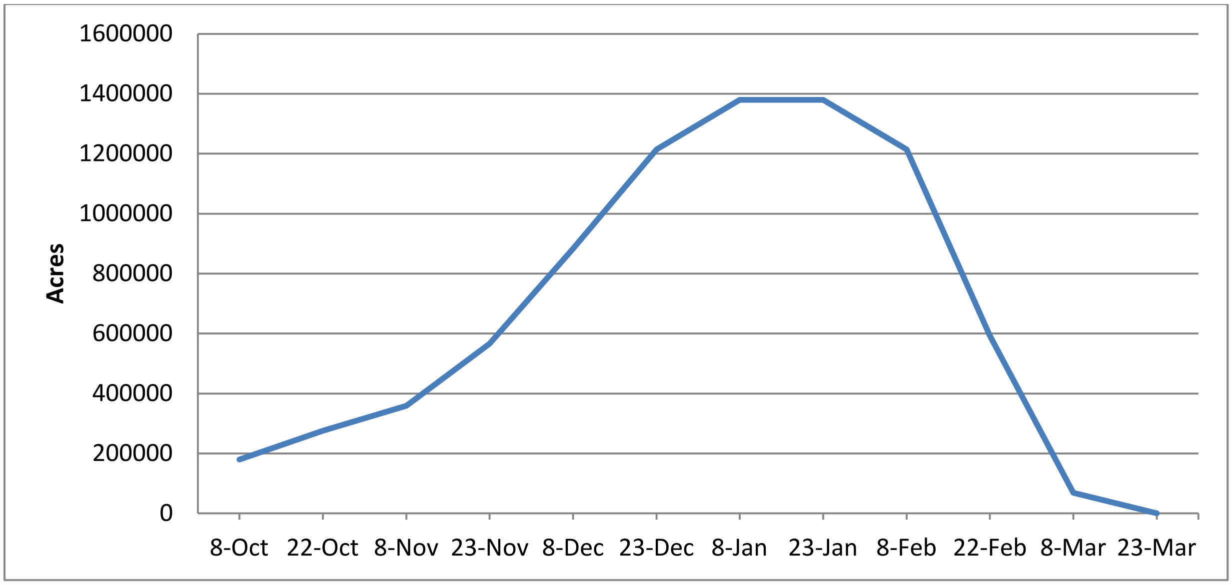


Figure A-8 Availability of flooded harvested crops in the LMVJV.

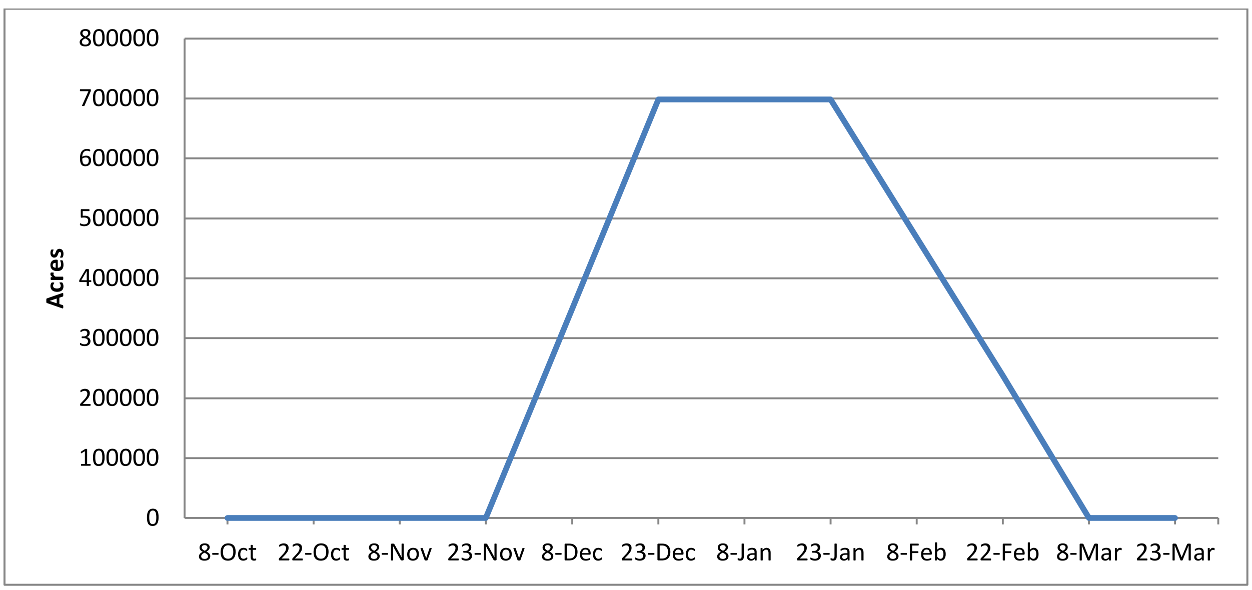

Figure A-9 Availability of flooded un-harvested crops in the LMVJV.

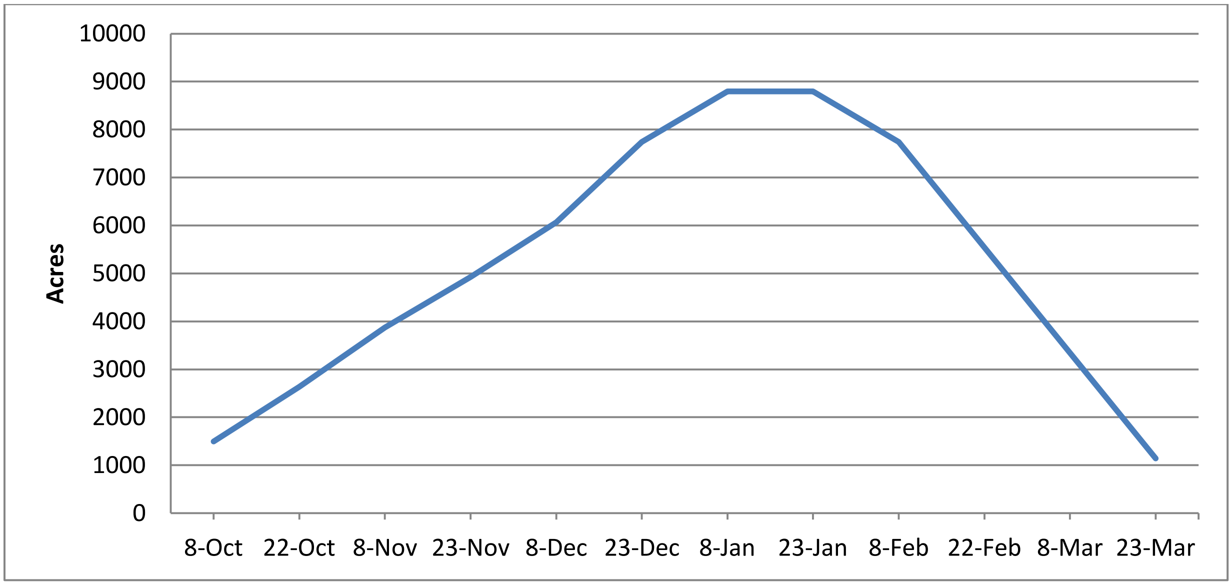


Figure A-10 The availability of flooded riceland habitat in the Texas Mid-Coast initiative area of the GCJV.

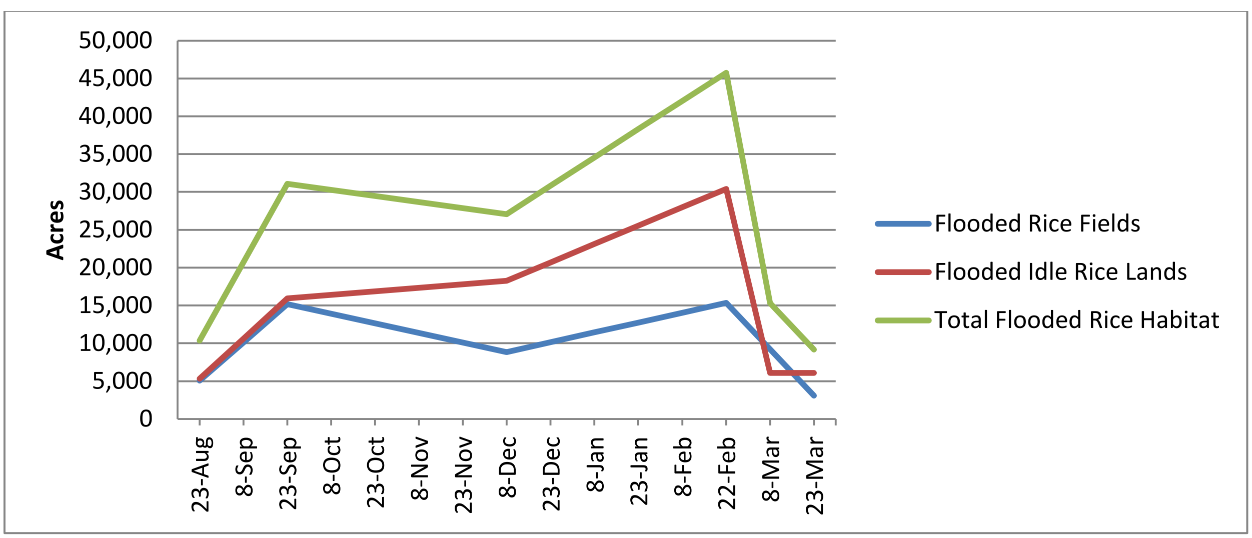

Figure A-11 The availability of flooded riceland habitat in the Texas Chenier Plain initiative area of the GCJV.

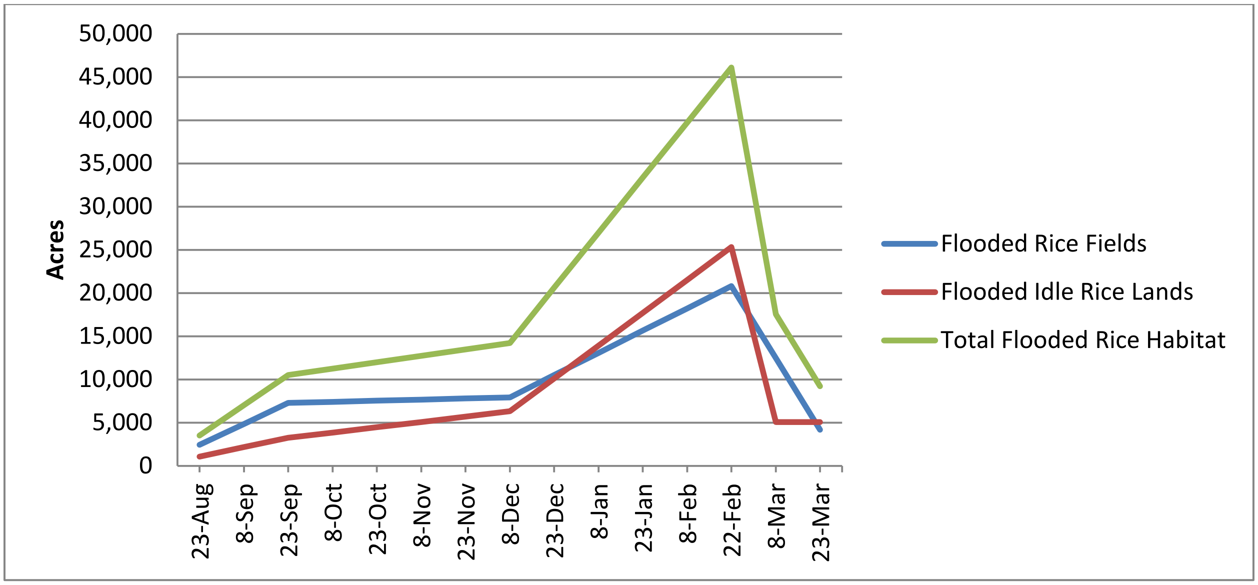


Figure A-12 The availability of flooded riceland habitat in the Louisiana Chenier Plain initiative area of the GCJV.

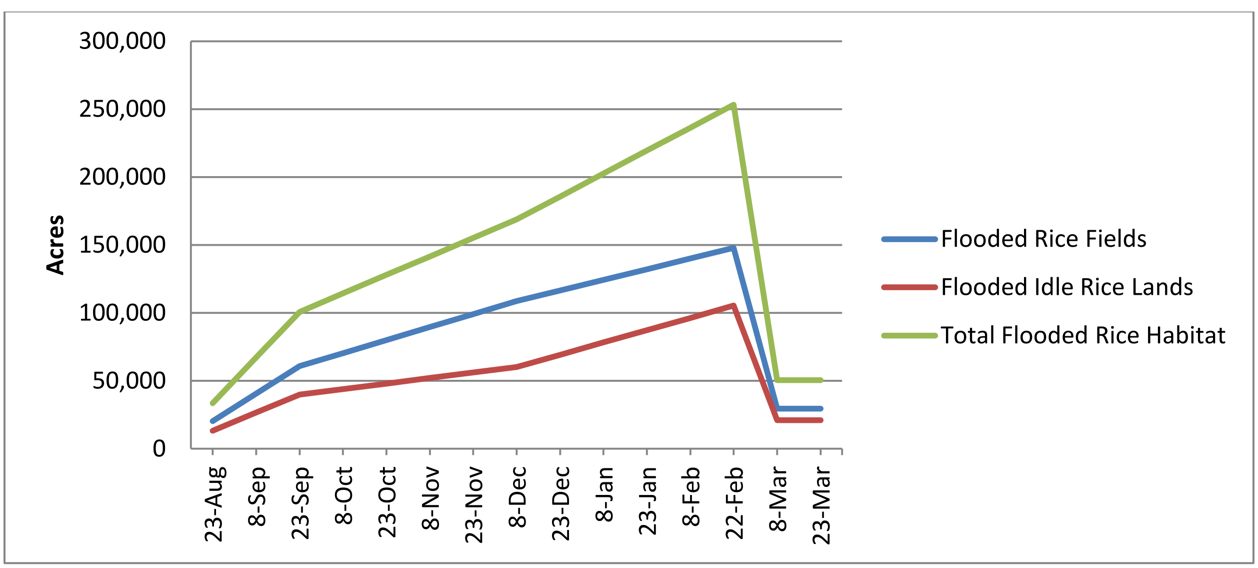

Figure A-13   The availability of flooded riceland habitat for the GCJV as a whole.