PEST MANAGEMENT STRATEGIC PLAN FOR CALIFORNIA WILD RICE PRODUCTION 2025

SOURCE

Title	Pest Management Strategic Plan for Wild Rice in California
PDF Document	https://ipmdata.ipmcenters.org/documents/pmsps/CAWildRicePMSPfinal.pdf
Source Type	Pest Management Strategic Plan
Source Data	May 27, 2025
Workshop Date	March 26, 2024
Settings	Wild Rice
Region	Western
States	California
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EXECUTIVE SUMMARY

The Pest Management Strategic Plan for California Wild Rice Production is the first Pest Management Strategic Plan (PMSP) conducted for wild rice production in California. The PMSP was developed through a California wild rice discussion session in 2024. The session included growers, pest control advisors, and UC Cooperative Extension. In addition to the stakeholders' expertise, the UC IPM Pest Management Guidelines, the Pest Management Strategic Plan for California Rice Production, the Wild Rice Production in California manual, and the UC Wild Rice Online website also provided production and pest management information.

This is the first PMSP for wild rice. It is our expectation that the information provided in the Pest Management Strategic Plan for California Wild Rice Production may inspire research and extension and improve the ability to solve important pest issues in California wild rice.

Wild rice is a specialty commodity grown in California, valued at $12,810,750 in 1997 (USDA, 2000). The most current value available for wild rice was $10,122,000 in 2022 (USDA, 2022). Cultivated wild rice production began in the Sacramento Valley in 1972, and by 1986, California had become the largest center for commercial production in the world. The development spread from Sacramento, Yuba, and Sutter counties north to Tehama County, west to Lake County, and into northeastern California's Shasta, Lassen, and Modoc counties. Approximately 57 percent of the production occurs in the Sacramento Valley, with the remaining 43 percent in northeastern California. From 1999 to 2005, about 50 growers produced wild rice on approximately 13,500 acres across nine California counties (Marcum, 2007).

Wild rice has been a successful crop in California. It easily adapts to basins in the Sacramento Valley and flat irrigated pastureland in northeastern California. The California climate is advantageous for wild rice production, with dry, rainless summers that limit disease development and the absence of insect pests, which cause economic damage in other states, such as Minnesota. The general lack of thunderstorms during harvest reduces the risk of major pre-harvest losses. A long growing season in the Sacramento Valley provides flexibility in scheduling planting and harvesting dates. In northeastern California, the colder, shorter growing season associated with higher elevation (>3,000 ft) and latitude (>41°N) provides sufficient winter chilling to break seed dormancy, allowing production from both fall seedings and volunteer seed left in the field after harvest (Marcum, 2007).

Research

Overall, stakeholders identified the need to improve wild rice yields. They discussed practices such as variety selection, planting timing, seeding rates, and planting methodologies. Additionally, stakeholders highlighted several general issues in wild rice production and potential solutions. Common problems among California wild rice growers include seed storage, varietal lodging susceptibility/resistance, and shattering.

For weeds, critical needs include herbicide phytotoxicity and the need for new herbicides and new formulations. Specific pests mentioned that require more research on biology and management include watergrass and arrowhead.

Regulatory

The main regulatory need is the registration of new pesticide products. For herbicides, new herbicide products are necessary to mitigate weed pressures from broadleaves, grasses, and sedges. Herbicides approved for rice production should be tested and considered for inclusion in wild rice cultivation. Similarly, new insecticides are needed to prevent or reduce arthropod pests in wild rice. Pesticide labels for rice should be adjusted to allow their use in wild rice. For disease management, newly registered fungicides are required to help prevent or reduce fungal and bacterial pathogens in wild rice.

General regulatory concerns include managing water discharges and maintaining burn permits. Additionally, collaboration with regulatory agencies has been requested to address residue contaminants in wild rice products.

Education

Critical educational needs include raising public awareness about wild rice in California and encouraging stakeholders in the wild rice industry to consider its future. Up-to-date pest management guidelines are essential to inform management decisions and provide effective pesticide options.

Critical Pest Management Needs for the California Wild Rice Industry

Research Priorities

General

1. Shattering: Study ways to decrease or work with the shattering nature of wild rice.
2. Seed storage: Discover techniques that will facilitate the cold storage of wild rice seeds. Study potential options for increasing the 1-year storage lifespan of seeds.
3. Variety Development: Create new varieties with improved yields. Develop further varieties based on local needs and challenges, such as a pythium or lodging-resistant wild rice. Growers are currently limited to a few select wild rice varieties. There is also interest in the conduction of seed studies.
4. Expansion of research-environment, techniques, and applications: Most of the research is conducted by the UCCE wild rice farm advisor located in Sutter-Yuba county. The few studies conducted have been of benefit to identify applicable weed management tools. The scope of research should increase as there are two regions in California with varying environmental factors.
    - Increase funding for management tools and addition of plots in other wild rice growing counties.
5. Fertility: Test varying application rates of nitrogen and differences between organic and conventional fields.
6. Seeding rates: Test varying seeding rates of wild rice seed.
7. Planting applications and timing: Identify potential application strategies for greater planting efficiency as well as better planting dates. Air seeding is the typical practice though there are variations with the use of volunteer wild rice in the Northern part of California. Timing of planting is critical to wild rice proper heading and pollination as well as for minimizing bird predation.
8. Water use and recharge: Test different water-use methods for water savings and potential recharge.

Weed Management

1. Herbicide development and efficacy: Create partnerships between university and industry to make existing herbicide rice formulations available for wild rice, which has no currently available registered herbicides. Study application techniques for efficacy and minimal phytotoxicity and yield loss in wild rice. In partnership with industry, work towards making herbicides economically priced.
2. Weeds: Develop weed management strategies for troublesome weeds that cause detrimental effects on yields. Study the movement and effects of weed seeds. Some weeds identified by growers as problematic are listed below:
    - Watergrasses (*Echinochloa spp.*)
    - Sprangletop (*Leptochloa spp.*)
    - Arrowhead (*Sagittaria montevidensis*)
    - Plantain (*Alisma plantago-aquatica*)
    - Juncus (needlegrass) (*Juncus roemerianus*)

Arthropod Management

1. Insect pests and monitoring: Develop pest management strategies for identified insect pests in wild rice production systems. Monitor insect pest movement and identify potential new pests (if any). Some insect pests identified by wild rice growers as problematic:
    - Midges (larval stage) (*Orseolia oryzae*)
    - Tadpole shrimp *(Triops longicaudatus)*
    - Apple snails *(Pomacea canaliculata)*
2. Insecticide development and efficacy: Create partnerships between university and industry to further develop insecticide options, which currently have minimal options. Insect pests are not diminishing and continue to be a problem in wild rice production.

Disease Management

1. Diseases: Develop disease management strategies for deleterious diseases that have negative impacts on wild rice development. Some diseases of notable consideration as problematic by wild rice growers are *Phytophthora erythroseptica* and *Pythium torulosum*.
2. Red root (*Pythium torulosum)*: a fungal disease, has been observed as a new problem when establishing wild rice stands following subsequent years. Anecdotally, it was noted by growers that there is an effect of soil pH. Studies are needed for this disease, specifically in the Northern region of California where it is becoming more present year by year since information is lacking. Growers in the Southern region have demonstrated an interest in understanding red root, although there is uncertainty about its presence in this region.
3. Fungicide development and efficacy: Create partnerships between university and industry to further develop fungicide options. Fungal diseases can negatively impact wild rice stands. As such, there is interest in a greater selection of fungicide tools to mitigate fungal and bacterial pressures.
4. Straw management: study residue management practices to identify best forms of management for greater reductions of disease pressures, which could grow spores in the straw. Currently, the Northern area uses water to decompose the straw while Southern straw management tills the straw into the soil.

Vertebrate Management

1. Blackbirds (*Turdus spp.*): Studies to improve or develop better blackbird management studies are critical. Blackbirds have been identified as a very serious pest during the wild rice growing season. Although various management strategies are present for wild rice growers to mitigate blackbird damage, efficacy is variable from management tools, listed as follows:
    - Radio control planes (commonly used)
    - Bird cannons, guns, bangers (more efficacious when used in combination)
    - Predator boxes
    - Non-effective: audio deterrents, repellents (costly and time-consuming), lasers

    Cages, previously supplied by wildlife services, were considered an effective blackbird management strategy, but are no longer available. Predator boxes are notable as effective for blackbird control, but quantities are insufficient. The tools identified as non-effective could use more research to increase their potential effectiveness against blackbirds. There is interest in knowing if lasers can be made effective when days are sunny.

2. Waterfowl: There is concern over the growing snow geese population and the effects that increasing numbers may have on wild rice since waterfowl, like blackbirds, will also eat wild rice seeds, to a lesser extent. Other birds of concern, specifically in the Southern region, are ibises and cranes. In the past, the Southern region was negatively affected by ibis and crane nesting habits (stomping up to 10 acres). On the upside, growers observed waterfowl have been a positive presence to aid in straw decomposition. Migration patterns are of interest to the growers as well since it has been observed that younger birds stay in California longer compared to the older birds.
3. Muskrats (*Ondatra zibethicus*): Develop management strategies to mitigate muskrat presence. Muskrats pull wild rice plants off the soil and dig holes through the levees.

Regulatory Priorities

General

1. Burn permits:

- Maintain burn permits, which vary by county and type of permit, although not a common practice.

2. Water discharges:

- Coordinate with regulation to offset the misapplication or inappropriate use of chemicals in wild rice. Encourage registrants to mitigate the use of chemicals that may not be necessary.

3. Residue contaminants:

- At market, residues, such as rice herbicides and arsenic, have on occasion been found on wild rice products, specifically organic wild rice. One specific rice herbicide residue is propanil although it is not registered to be sprayed on wild rice. Work with regulatory agencies to identify residue sources and understand reasons for rejection of product even when residues are under the allowable limit.

Weed Management

1. Registration and labeling:

- Register herbicide products to mitigate weed pressures caused by broadleaves, grasses, and sedges.
- Adjust herbicide labels used in rice production to include their use in wild rice production.

Arthropod Management

1. Registration and labeling:

- Register insecticide and other related products as supplemental pesticides for prevention or reduction of pest pressures on wild rice. Adjust pesticide labels used in rice for use in wild rice.

Disease Management

1. Registration:

- Register fungicide products that aid in the prevention or reduction of fungal and bacterial pathogens in wild rice.

Education Priorities

General

1. Public awareness and education:

- Raise awareness to the general public about wild rice production with emphasis on its environmental benefits, cost, and native origins to the United States. Educate about wild rice nutritional quality and culinary preparation as well as cost per serving.

2. Water use:

- Provide education on water usage, which uses similar amounts to other types of crops, and quality. Growers emphasize stormwater collection for use during the growing season.

3. Industry outreach:

- Increase knowledge of California wild rice production within the agricultural industry. The specialty crop nature of wild rice has led to less industry funding and extension, leaving wild rice growers to be creative with problems encountered.

4. Retailer awareness and understanding:

- Raise retailer awareness of wild rice production in California. Previously, seed storage issues have been a problem since there are no retailers that sell wild rice. On the other hand, retailers will expect reliable producers for wild rice products, which can be challenging since amounts harvested vary yearly and are tied to yearly cost swings.

5. Extension:

- Increase assessment of wild rice soils, nitrogen content, and water for grower knowledge. More general extension work from the wild rice farm advisor.

6. Outreach:

- Create and host meetings that are of interest to wild rice growers, and publish more material (newsletters, etc.). Some topics of interest are:
    - Breeding programs. There is specific interest in wild rice stand studies since lodging could be a great issue in wild rice.
    - Findings from novel research
    - EPA approval/labeling and product information

7. Content updates:

- Update the Wild Rice Production book, which was previously published in 2007.

8. Crop insurance:

- Crop insurance is available in all counties. However, growers and other industry members appear to be unaware. More extension information and efforts should be made in this area.

Weed Management

1. Herbicide applications:

- When herbicides are available, demonstrate herbicide stewardship to minimize possible herbicide resistance, contamination, and maintain efficacy.

Arthropod Management

1. Pest education:

- Teach how to quantify pest damages in wild rice and pest identification strategies.

- Create and share economic injury thresholds for insect pests of concern, such as midges, which can greatly weaken wild rice in high populations.

Disease Management

1. Disease education:

- Educate about disease identification strategies and how to diagnose severity levels.

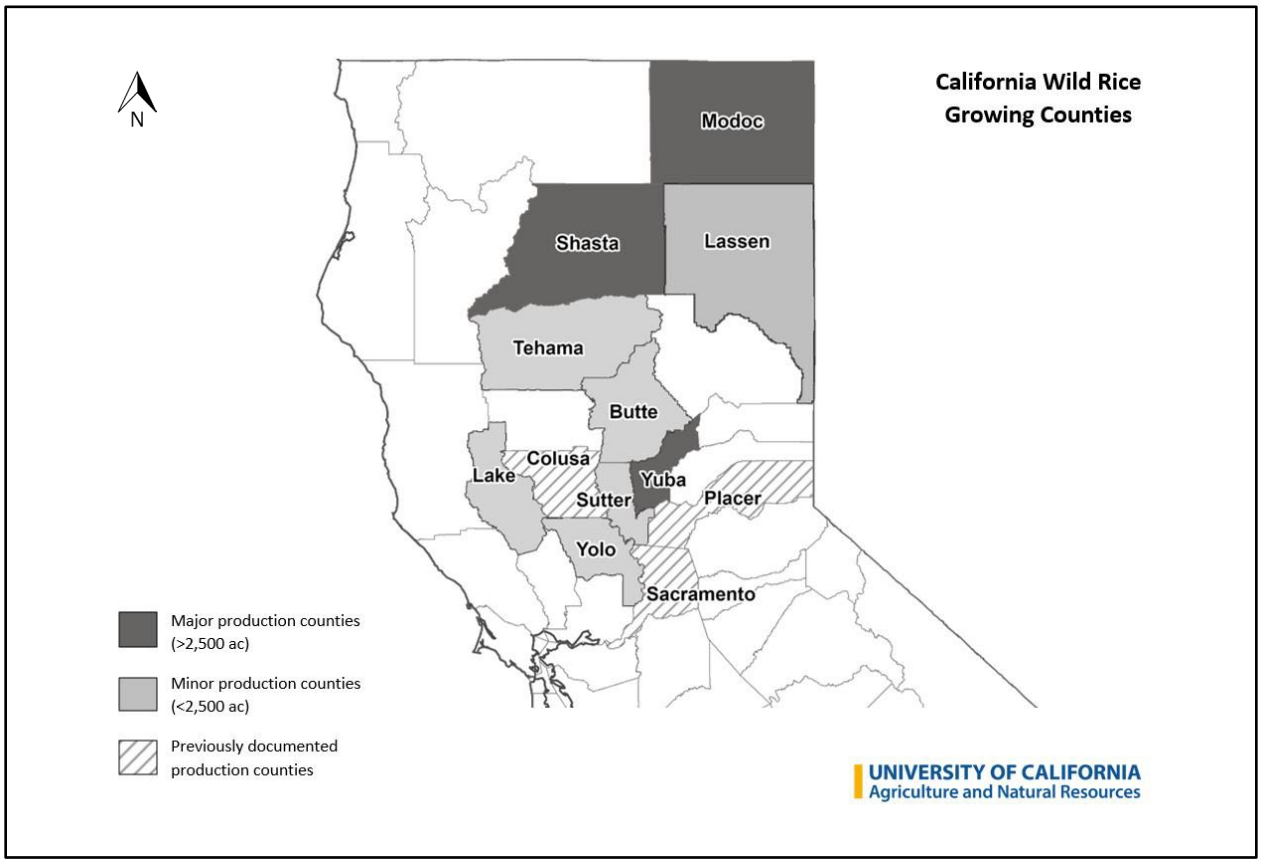
California Wild Rice Production Overview

Wild rice (*Zizania palustris var. interior* [Fassett] W. Dore) is a semi-aquatic grass species native to North American. Its seed grain must be heat-cured after harvest to ensure proper storage and prepare them for cooking and consumption. Wild rice has been a successful crop in California due to its expensive flat lands and climate. The dry, rainless summer weather helps limit the damage from diseases and pests, while the general absence of thunderstorms during harvest reduces the risk of major pre-harvest losses. Additionally, a long growing season in the Sacramento Valley provides flexibility in scheduling planting and harvest dates. Wild rice requires about 90 to 115 days to produce mature seeds, but the actual number of days from planting to seed maturity varies widely. The common wild rice varieties grown in California are 'Johnson', 'K2', and 'Franklin'. Among these three wild rice varieties, 'Franklin' generally produces higher yield due to its high yield and high shatter resistance (Marcum, 2007).

Cultivated wild rice production began in the Sacramento Valley in 1972. By 1986, California had become the world's largest center for commercial wild rice production although it is a specialty crop. In 2005, wild rice was cultivated in 9 counties in Northern California, including Yolo, Sutter, Yuba, Placer, Butte, Lake, Lassen, Shasta, and Modoc (Marcum, 2007). By 2021, wild rice cultivation in California had expanded to include up to 12 counties, with the addition of Sacramento, Colusa, and Tehama. Currently, there is a Northern region, which is higher in elevation and surrounded by mountain terrain, and a Southern region more distinguished as valley terrain. Due to the climate differences, growers follow different timelines in wild rice production. From 1999 to 2005, approximately 50 growers produced wild rice on about 13,500 acres. Over the past decade, production has ranged from 2,530 to 8,840 tons. In 1997, wild rice in California was valued at $12,810,750. By 2022, the total value had declined to $10,122,000. Between 2014 and 2022, the value of wild rice fluctuated, reaching a peak of $14,517,000 in 2016 and a low of $6,413,000 in 2020 (USDA, 2022).

Despite its economic and agricultural significance, wild rice does not appear as its own crop in reputable state reports made such as those of the CDFA and USDA. It is typically combined as an "other" or not mentioned at all.

California Wild Rice-Producing Counties



Map based on 2021 crop reports and grower knowledge. Map designed by Consuelo B Baez Vega, 2024.

Pollinator Protection

Wild rice is a wind- and self-pollinated crop that does not require bee pollination or managed pollinators. Normally bees prefer other forage resources than wild rice. However, because bees also forage for water, they may be exposed to pesticides while collecting water from flooded wild rice fields. This is particularly important to consider when applying highly toxic pesticides to bees, such as carbamates, organophosphates, pyrethroids, or neonicotinoids. Monitor your field for water-foraging bees before applying these pesticides. Consult your local agricultural commissioner to check for managed hives within a one-mile radius and inform beekeepers 48 hours before application (UC IPM, 2023).

Some wild rice weeds and blooming vegetation along field margins provide nectar and pollen for local pollinators. To protect these pollinators, avoid pesticide drift onto blooming vegetation and ensure that pesticide applications do not coincide with pollinators visiting flowers. Mowing blooming vegetation along levees before pesticide applications can reduce the risk to pollinators. For insecticides that are systemic, have extended residual toxicity, or are highly toxic to bees, it is best to wait until the bloom period ends before applying these pesticides (UC IPM, 2023).

Some combinations of insecticides and fungicides have synergistic effects that substantially increase bee mortality compared to the effects of either of these pesticides applied alone. For example, pyrethroid (Insecticide Resistance Action Committee: IRAC 3A) or neonicotinoid (IRAC 4A) insecticides combined with demethylation inhibitor (DMI; Fungicide Resistance Action Committee: FRAC 3) fungicides such as propiconazole are more toxic to bees when applied at the same time. To protect pollinators, avoid tank-mixing pesticides that have these synergistic effects (Debiase, et al. 2020).

For more details on a pesticide's synergistic effects and its overall toxicity to honey bees and their brood, see the Bee Precaution Pesticide Ratings database (http://ipm.ucanr.edu/beeprecaution/).

For more information about how to reduce bee exposure to pesticides, see the Best Management Practices to Protect Bees from Pesticides (http://ipm.ucanr.edu/mitigation/protect_bees.html) and How to Reduce Bee Poisoning from Pesticides (http://ipm.ucanr.edu/PDF/PMG/pnw591.pdf).

California Wild Rice Pest Descriptions

(alphabetized by common name)

Arthropods

Armyworms
True armyworms (*Pseudaletia unipuncta*)
Western yellowstriped armyworm (*Spodoptera praefica*)

For more information on identification, monitoring, and management of this pest, see:
https://ipm.ucanr.edu/agriculture/rice/armyworms/#gsc.tab=0

Armyworms are present in wild rice fields but have not been considered an issue, Armyworm larvae go through 6 instar stages. It is difficult to find armyworms in their early stages since they are small and consume very little foliage. They become more observable in early summer when they reach the fifth and sixth instars (UC IPM, 2024).

To monitor, choose a part of the field where you have observed injury. Walk into the field and inspect plants in a small area around you from the water level to the top of the leaves. Check the water surface for armyworms that may drop from the plants. Determine if 25% or more of the foliage has been removed by armyworms and if they are still present. Record your observations. Repeat this procedure every 5 to 10 feet across a transect until 10 stops have been examined. Repeat this procedure in several areas of the field to create a confident estimate of the average field condition (UC IPM, 2024).

There are no cultural or biological methods to control these insects in wild rice (USDA, 2000). However, early weed management in and around fields may help limit the development of armyworm infestations (DeBiase, et al., 2021).

From panicle emergence to grain maturity, consider application of insecticide if 10% of the panicles in the area sampled are damaged and true armyworms are observed. If true armyworms are not observed but panicle loss is 10% or more, check for the larvae in the evening. If larvae are not found, do not spray because they have probably pupated and will do no further damage. Limit insecticide application to those areas of the field with economic damage (DeBiase, et al., 2021).

Midges
(*Orseolia oryzae*)

For more information on identification, monitoring, and management of this pest, see:
https://ipm.ucanr.edu/agriculture/rice/rice-seed-midges/#gsc.tab=0
https://anrcatalog.ucanr.edu/pdf/21622.pdf

The midge adult is a small, delicate, mosquito-like fly. It lacks scales on its wings and does not have functional mouthparts. Adults are non-biting and usually are inconspicuous unless there are enough to

form a “cloud.” The adults usually come from wet areas adjacent to wild rice basins and lay their eggs in newly flooded wild rice basins.

Midges can damage wild rice in California if numbers are large. The larvae damage wild rice plants by abrading leaf margins. The damage is more common in first-year basins, where the wild rice stand is often thin. During the establishment year, malathion can be applied for midge control. When wild rice plants are able to produce new leaves that are larger, it is less susceptible to damage by midges (Marcum, 2007).

Normally, midge damage can be controlled by applying insecticide. If monitoring indicates the midge damage is severe, a grower can drop the level of water in the basin as an emergency measure and reflooded after 3 to 4 days (USDA, 2000).

Grasshoppers
(Acrididae)

For more information on identification, monitoring, and management of this pest, see:
https://ipm.ucanr.edu/PMG/PESTNOTES/pn74103.html

Grasshoppers have been an issue for the wild rice industry in California, particularly in the northern regions. These insects typically arrive in swarms and can cause extensive damage over a considerably longer period during major outbreaks.

Grasshoppers are general feeders but show a preference for young green plants. Grasshoppers have chewing mouthparts that can help them to remove large sections of wild rice leaves and sometimes consume entire plants. Their population sizes fluctuate yearly, with severe outbreaks occurring approximately every 8 to 10 years. Some outbreaks can last two or three years. Favorable conditions, such as warm, moist springs that produce abundant food in foothills and uncultivated areas, can lead to population surges (UC IPM, 2013).

When numbers are low, grasshoppers can be handpicked and squashed. In wild rice fields, where grasshopper migration frequently occurs, an effective strategy is to maintain an attractive field border of tall grass or lush green plants around the perimeter to trap and divert the insects away from the wild rice. During major migrations in agricultural and rangeland areas, the best approach is to treat grasshoppers with an insecticide early in the season when they are still young nymphs in uncultivated areas.

Tadpole Shrimp
(Triops longicaudatus)

For more information on identification, monitoring, and management of this pest, see:
https://ipm.ucanr.edu/agriculture/rice/tadpole-shrimp/#gsc.tab=0

Tadpole shrimps are a small crustacean species, similar to tadpoles in appearance, that live in temporary bodies of water where they prey on anything their mandible mouthparts can chew, such as smaller insects

and young plants. They go through rapid molting phases until reaching maturity, which they tend to reach 1.5 inches in length. Adults typically lay reddish, circular eggs on the soil, which some hatch one to three days after flooding a field and continue to hatch one to two weeks afterwards. Eggs can remain viable on unflooded soil for various years due to a phase called diapause, which is a form of dormancy until the field is flooded. Tadpole shrimps are typically present for approximately a month until numbers deplete ,and hatchings will not occur until the next year.

Their habitat preferences make wild rice and rice fields ideal environments for their growth, which has led to them being pests when seedlings have not emerged from the water. Tadpole shrimp affect seedling growth by chewing on the stems and by uprooting seedlings when they dig around the area. This digging behavior also causes murky water, negatively affecting light penetration, which slows seedling growth.

Monitor tadpole shrimp presence and density frequently during the first two weeks after flooding to determine if further management will be needed. Some management strategies are to apply an insecticide treatment to the affected field, apply copper sulfate (acceptable for organic fields, some restrictions may apply), or flood the field then fully drain the field after emergence to dry them out (similar to a stale seedbed) (UC IPM, 2024).

Diseases

Fungal brown spot
(*Bipolaris oryzae*)

For more information on identification, monitoring, and management of this pest, see: (Marcum, 2007).

Fungal brown spot has been observed in the past but is not currently a concern in California. Fungal brown spot lesions are oval, uniform, evenly distributed, and approximately the size and shape of sesame seeds. The spots are dark brown with yellow margins, and some have a light center. Spot blotch usually does not have a halo and the larger lesions are often more irregular in shape.

The occasional infections that do occur are seen in dense stands late in the season when heavy dews are more prevalent. The disease is also a greater problem in locations where wild rice has been continually produced for a number of years. Crop rotation can help reduce the inoculum.

Red root
(*Pythium torulosum*)

For more information on identification, monitoring, and management of this pest, see: (Marcum, 2007)

Red root of wild rice is caused by *Pythium torulosum.* The fungus colonizes the primary root of wild rice seedlings, turning it brick red. Secondary roots may be colonized, but surviving roots are usually white. The disease causes seedling death and is often associated with other conditions that weaken seedlings, such as cloudy water or midge feeding. Poor seed germination and low seed vigor are often associated with the disease.

Crop rotation may reduce the occurrence of this disease. Basins with severe losses to red root can in many cases be replanted with viable seed if there is enough time left in the growing season to produce a crop.

Phytophthora root rot
(Phytophthora erythroseptica)

For more information on identification, monitoring, and management of this pest, see:
https://ipm.ucanr.edu/agriculture/sugarbeet/phytophthora-and-pythium-root-rots/#gsc.tab=0

Phytophthora root rot has been an issue in California wild rice production. It is caused by *Phytophthora erythroseptica.* It builds up in soil due to the lack of crop rotation.

Wild rice with phytophthora root rot appears wilted in the early stages of disease development and eventually wilts permanently, especially when hot, dry conditions prevail. Initial infection occurs at the base of lateral roots, causing a small necrotic lesion. As the disease progresses, it appears as a wet root rot

and advances upward toward the crown. Rotted tissue turns brown with a distinguishing blackish margin adjacent to healthy tissue (Marcum, 2007).

Crop rotation and stand thinning may reduce the occurrence of this disease. Basins that share a common water system often have similar incidences of the disease (Marcum, 2007).

Algae

For more information on identification, monitoring, and management of this pest, see:
https://ipm.ucanr.edu/agriculture/rice/special-weed-problems/#gsc.tab=0
https://anrcatalog.ucanr.edu/pdf/21622.pdf
(Marcum, 2007)

Algae is a timing issue in wild rice production in California. The species of algae present in a wild rice field shift during the growing season from green algae and diatoms in early May to dominance by blue-green algae in late May-early June (UC IPM, 2023).

The amount of algae present in fields is associated with the concentration of phosphate and nitrogen in the water. In most cases, higher phosphorus and nitrogen levels result in a greater abundance of algae (UC IPM, 2023).

Algae damages wild rice plants by sucking up oxygen and forming a mat on the water surface over wild rice plants before emergence. The greatest injury is caused when the algae prevents the emerging seedlings from reaching the floating leaf stage. Once the wild rice stands out of water, algae is no longer an issue.

An early application of copper sulfate when seedlings have only one or two leaves is the preferred treatment. Keeping the water moving through basins can also reduce algae damage. Growers sometimes use a garden-type hand-held fertilizer spreader to treat trouble spots, such as corners of basins where water movement is slow and algae damage is often more severe. Placing mesh bags that contain coarse (rock) copper sulfate in weirs to dissolve in flowing water is not recommended because of distribution problems within the slow-moving water. Most algae can be controlled with 2.4 pounds of copper sulfate per acre-foot of water (about 1 ppm). If the water is hard it will require more copper sulfate to control the algae; application rates can be up to 10.88 pounds of copper sulfate per acre-foot. Copper sulfate will not provide good control of blue-green algae (Marcum, 2007; DPR, 2025). In 2022, 32,200.99 pounds of copper sulfate were applied to 2,407.19 acres of California's wild rice fields (DPR, 2022).

Weeds

For more information on weed identification, monitoring, and management, see: https://ipm.ucanr.edu/agriculture/rice/integrated-weed-management/#gsc.tab=0

For optimal wild rice yields, it is essential to control various algae, broadleaf, and grass weeds that have adapted to the aquatic environment. Effective weed control strategies include preventive measures, crop or fallow rotation, the use of certified seed, and proper water and fertilizer management.

Weeds in wild rice are usually controlled by a combination of methods. Deep water is the best long-term control for weeds in wild rice. Plant weed-free seed to avoid introducing weeds and use dense wild rice stands that will successfully compete with weeds. Fallowing land for a year or periodically planting an alternative crop helps control weeds. Glyphosate may be used to control weeds after harvest or while the basin is fallow (Marcum, 2007).

Important Weeds in California Wild Rice Production

All of these weeds can be a minor issue or a major issue depending on the populations infesting a particular field.

Annual Grasses:

- Barnyardgrass (*Echinochloa crus-galli*)
- Bearded sprangletop (*Leptochloa fascicularis*)
- Watergrasses (*Echinochloa spp.*)

Annual Broadleaves:

- California arrowhead (*Sagittaria montevidensis*)
- Common arrowhead (*Sagittaria latifolia*)
- Ducksalad (*Heteranthera limosa*) (can also be perennial)
- Gregg's arrowhead (*Sagittaria longiloba*)
- Redstem (*Ammannia spp.*)
- Waterhyssop (*Bacopa spp.*)
- Pondweed (*Potamogeton nodosus*)
- Heartshape false pickerelweed (*Monochoria vaginalis)*

Annual Sedges: (all down on the scale of issue)

- Ricefield bulrush (*Scirpus mucronatus*)
- River bulrush (*Scirpus fluviatilis*)
- Smallflower umbrella sedge (*Cyperus difformis*)
- Spikerush (Eleocharis palustris),

Perennials:

- Broadleaf cattail (*Typha latifolia*)
- Common waterplantain (*Alisma plantago-aquatica*)

- Spikerush (*Eleocharis palustris*)
- Waterplantain (*Alisma triviale*)
- Juncus needle grass (*Juncus Roemerianus*)

Broadleaf cattail

For more information on identification, monitoring, and management of this pest, see:
https://anrcatalog.ucanr.edu/pdf/21622.pdf
(Marcum, 2007)

Broadleaf cattail grows in shallow water and areas with poor drainage. Plants are 4 to 8 feet tall and usually grow in colonies. Cattails are perennial weeds that reproduce by rootstocks (rhizomes) and by minute airborne seeds that germinate readily in mud and shallow water. The seeds remain viable in soil for more than 5 years. An established plant has an extensive rhizome system and erect stem with long, narrow leaves. The flowers take the form of a long, cylindrical spike at the end of the stem. New infestations of solitary plants may be successfully eliminated by hand roguing.

The most widely used control method for cattails is spring disking, which cuts the rhizomes, exhausting root reserves. Repeated cutting of plants below the water level can control individual plants since cattails need oxygen from their aerial leaves for respiration, but this usually is only partially successful at best and is not a widespread practice because of its high labor cost (Marcum, 2007).

Common arrowhead
(*Sagittaria latifolia Willd.*)

For more information on identification, monitoring, and management of this pest, see:
https://anrcatalog.ucanr.edu/pdf/21622.pdf
(Marcum, 2007)

Common arrowhead is a rooted aquatic perennial weed with arrow-shaped leaves that reproduces by seeds and specialized storage roots (tubers). The lower leaves are all basal with petioles as long as the water is deep. Plants are 1 to 2 feet tall with white flowers. The seeds are flat, 1⁄8 inch wide with marginal wings, and are clustered into a spherical head. The weed grows in shallow water and usually is not a serious problem in wild rice (Marcum, 2007). Besides, Shark H2O® (carfentrazone) exhibits effective arrowhead control.

Watergrass
(*Echinochloa* spp.)

For more information on identification, monitoring, and management of this pest, see:
https://anrcatalog.ucanr.edu/pdf/21622.pdf
(Marcum, 2007)

Watergrass is the most competitive and difficult weed to control in California wild rice. Plants can emerge under both continuously flooded conditions and flushed conditions, causing huge yield losses. Watergrass is one of the first weed groups in which herbicide resistance was found (in the early 2000s). A

continuous flood of 7 to 8 inches can suppress watergrass, but deep water alone rarely gives complete control. In contrast, continuous flooding to a depth of 4 to 5 inches, in combination with approved herbicides, such as Shark H2O (carfentrazone), provides good control of watergrass weeds (USDA, 2000; DPR, 2025).

Vertebrates

Blackbirds

(*Turdus spp.*)

For more information on identification, monitoring, and management of this pest, see:
https://wildrice.ucdavis.edu/sites/g/files/dgvnsk14566/files/inline-files/256326.pdf
https://ipm.ucanr.edu/agriculture/cole-crops/birds/#gsc.tab=0

Blackbirds (family Icteridae) are considered by growers to be the primary vertebrate pests of wild rice. This is due to their numbers and prolonged presence during the growing season. The yield loss caused by blackbirds can range from 1% to 50% (Gorenzel, 1994).

Most blackbird damage takes the form of an increase in shattering, although their feeding also damages the crop. Blackbird depredation on wild rice begins when the first kernels are in the milk stage. Blackbirds do not consume the entire seed at this stage; rather, they squeeze the hulls and force the soft kernel out through the split between the hulls. As the wild rice kernels mature and turn dark, the blackbirds separate the hull and awn from the seed and eat the entire seed. Crop losses of 10 percent and more are common. Little is known about where the damaging blackbirds come from, that is, whether they are migratory or resident. Blackbirds will nest in basins, and they generally cause more damage when there is suitable vegetation for habitat in nearby ditches and ponds (Marcum, 2007).

In a study on blackbirds (Gorenzel, 1994), the birds first appeared in wild rice fields by July, with August being the period of greatest damage. However, some growers in the Sacramento Valley reported the heaviest damage occurring in May and June, indicating that early plantings were not immune to damage.

The most successful control method for blackbirds is trapping. The USDA Wildlife Services animal damage control program has designed a successful trap for depredating birds. Traps should be kept supplied with food and water until the birds can be sorted to remove protected species and humanely euthanize other species with carbon dioxide. Other methods for blackbird management include the periodic patrol of basins at irregular times during the morning and evening and the use of shotguns and cracker shells to scare birds. Some growers successfully move or “herd” birds away from basins with commercial spray planes, ultralight aircraft, or power parachutes, but the birds will quickly return if no alternative feeding and roosting areas are available (Marcum, 2007).

Other birds

Geese (*Anser spp.*), ducks (Anatidae), coots (*Fulica americana*), etc.

For more information on identification, monitoring, and management of this pest, see:
https://anrcatalog.ucanr.edu/pdf/21622.pdf

As for the geese and ducks, they damage wild rice by feeding on young plants in the floating leaf stage. Propane cannons will provide some control, but at least one is needed per basin to achieve measurable

control. Roving patrols with shotguns loaded with cracker shells can reinforce the effectiveness of propane cannons.

In northeastern California, growers rely upon the survival of unharvested wild rice left in the field to volunteer the next season's crop, and birds' feeding after harvest threatens volunteer stands. Stand damage is most severe if growers do not disc the basins after harvest and if they flood the basins during winter, a practice that encourages bird use of the fields. By not flooding fields in the winter, a grower can reduce waterfowl activity there. To reduce the loss of seed to birds, growers can roll their fields after harvest to facilitate drying and then disk seed deep enough to be beyond the reach of birds.

Biological control of bird pests involves natural predators like raptors and bobcats, though their impact is minimal. Cultural control starts with habitat modification, such as removing roosting trees and eliminating brush piles to discourage birds from nesting. Monitoring bird populations and movements weekly can help anticipate and mitigate damage, especially to fruiting buds and newly sprouted crops. Keeping detailed records of past bird activity aids in planning effective control strategies (UC IPM).

Frightening devices, combining noisemakers and visual repellents like mylar streamers and scare-eye balloons, can deter birds if used in rotation to prevent habituation. Shooting can control small numbers of birds like scrub jays and magpies but requires appropriate permits. Trapping, using devices like the modified Australian crow trap, is effective for species such as house finches and crowned sparrows when carried out over large areas. Successful trapping needs experienced personnel and proper placement of traps. Repellents that rely on objectionable tastes, odors, or learned aversions can also be used to protect crops from bird damage (UC IPM).

List of Common Pests, Pest Management Practices, and Worker Activities by Crop Stage

Preplant to Planting
(North: March - June; South: March - July)

This time period begins in the spring, which wild rice growers utilize to prepare their fields. For seedbed preparation, basins will be leveled if they have not been, and levees will be erected (a minimum of 3 feet recommended). Growers will till the land and incorporate fertilizer into the soil, which lessens volatility. No-till is not a common practice since, based on growers' experiences, it does not work for wild rice.

Seeds are removed from their winter-soaked storage and warmed up for 2 to 3 days at an ambient temperature to initiate germination. It is recommended to check the germination of the seeds 2 weeks prior to planting. Expected germination rates are at 70% or more. One method to check for germination rates is to select a known amount of seed into a pan or cup to hold room-temperature water. In 14 days, a successful germinated seed will produce a cotyledon longer than the seed. Seed amount to be planted should be adjusted to obtain proper germinable seeds per square foot, based on tested germination results.

Timing of planting is very critical as a delayed planting will have negative effects on wild rice growth (reduced tillers, shorter height, earlier flowering, and seed production). Soaked seeds are planted at a rate of 100 to 150 pounds per acre typically between April and May. Wild rice is planted aerially or with a broadcast spreader onto a flooded field. Alternatively, planting can be dry-seeded with immediate flooding to prevent desiccation. Water management plays a key factor in planting since too little water (less than 6 inches) will affect weed suppression and crop yields. Too much or cloudy water can reduce sunlight penetration and seeds could die.

Migrating waterfowl are a pest of concern during this period, so deterrent actions are used to mitigate their presence.

Pest management-related worker activities at this time include:

- Land leveling
- Spring tillage
- Fertilizer incorporation
- Seed warming for germination initiation
- Aerial or ground application of seed
- Deterring migrating waterfowl

Early Vegetative Phase (Germination to Sixth Leaf Stage of Wild Rice)
(North: March - June; South: April - July)

A usual wild rice stand is 7 to 11 plants per square foot, based on the 100 to 150 lbs of seed applied per acre and with a 70% germination rate. A high-density stand can cause lodging issues and nitrogen deficiencies while a low-density stand negatively affects the wild rice plants competitive ability with weeds. A low stand can also cause harvest timing issues due to the asynchronous maturity of panicles.

Deterrent actions to manage waterfowl is continued. Midges can be an issue at this stage and are managed by dropping the water level of the severely affected basin. Monitoring of midges can be done by sliding a mud-coated leaf between two fingers.

Water is actively managed at necessary depths for optimal growth during these stages. Management consists of the use of flashboards to control water inputs and outputs. Small pumps may be used to recycle water from drainage ditches into the flooded fields. Deeper water is used for long-term weed management since there is a limited amount of herbicides for use, which will also slow the growth of the wild rice plant.

Pest management-related worker activities at this time includes:

- Monitoring and managing:
    - Waterfowl
    - Midges
    - Weeds (general water-tolerant species)

Late Vegetative Phase (wild rice growth stage)
North Management (May - July)
South Management (May - August)

Growers may encounter plantain issues during the late vegetative phase of wild rice. Applying Shark H2O (carfentrazone) by aerial or dry application can effectively manage plantain, especially when the plants are young.

- Shark H2O (carfentrazone) when plantain is young (good management)
    - Aerial application, dry application

Pest management-related worker activities at this time includes:

- The monitoring and management of
    - Plantain
- Aerial application, dry application of Shark H2O (carfentrazone)

Reproductive Phase: Panicle Initiation to Flowering
North Management (May - July)
South Management (June - July)

There are no known pest issues during the wild rice reproductive phase in California.

Ripening and Maturity Phase: Grain Formation to Harvest
North Management (July - October)
South Management (June - August)

Wild rice should be harvested when the grain in the primary panicles is dark-colored and shatters easily with a light touch. Once the crop matures, growers should harvest the panicles immediately, as shattering losses can occur quickly, sometimes within a day or two.

Fields may require early harvesting if adverse weather, such as high temperatures and low humidity, is imminent or if blackbirds threaten the crop by eating seeds and snapping off the flowers. For more information on blackbird management strategies, refer to the previous section, California Wild Rice Pest Descriptions - Blackbirds.

Postharvest
North Management (July - October)
South Management (August - October)

The major steps in the processing of wild rice are separation of immature kernels, aging, parching, dehulling, scarification, cleaning, grading, and packaging (Marcum, 2007l).

During the separation of immature kernels, a separator is used to remove immature kernels to improve overall processing efficiency. The separator uses air currents and a slotted screen to separate the unfinished wild rice from other combine waste, including weeds and weed seeds. However, in California, most wild rice growers adjust the combine to harvest a higher percentage of mature wild rice kernels, eliminating the need for a separator.

Aging requires managing a large number of microorganisms, as well as heat and moisture. Aging typically takes place in either 4-by-4-foot steel bins or bottom-dump aluminum trailers over 4 to 7 days. After harvest, the bins are weighed and periodically flooded to reduce the risk of damage from heat caused by plant and microbe respiration. Many growers believe aging is necessary for wild rice color development, flavor enhancement, and hull degradation, which also makes

dehulling more efficient. After aging, the moisture content of wild rice is approximately 40 to 45 percent.

Wild rice is traditionally processed using a batch rotary parcher, also known as a drum parcher, or by parboiling in California. The parcher consists of a drum supported on rollers to allow continuous rotation. Propane gas burners heat the drum's exterior surface, reaching interior temperatures of up to 280°F. Parching is complete when the white center of the kernels turns dark and glassy. Parching causes the kernel to shrink, loosening the hull. After parching, wild rice seeds pass through screens to remove stalk fragments and other waste. In parboiling, wild rice is placed in a chamber where pressurized steam achieves the same gelatinization process as the drum parcher. After parboiling, the wild rice is dried in a large rotary drum, allowing continuous heating and drying, and efficiently processing large volumes of wild rice.

In the dehulling process, California wild rice growers commonly use a double-roll huller. In this machine, wild rice kernels fall between two closely spaced, rubber-covered rollers that roll at different speeds, imparting a rubbing action to the kernels. Hulling should immediately follow parching to minimize the development of cracks in the wild rice. Cracks often result in broken kernels, reducing crop value and causing greater variability in cooking time.

Scarification removes a portion of the outer layer of the wild rice kernel. Grading of the finished wild rice kernels varies among different processing plants and marketing organizations, with kernels usually sorted by both length and width.

Some wild rice growers stomp the field in the fall to push the seed into the field.

Management

- In the Northeast, rolling of acres (wet) is common (for weed control and straw decomposition)
- Flooding practices**:**
    - Flooding sometimes done to keep volunteer seed viable (North only)
    - No flooding in the Southern area for the crop

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California Wild Rice Work Group Members

Pest Management Strategic Plan Meeting attendees:

First Name	Last Name
Troy	Clark
Sarah	Marsh
Jake	Stokes
Whitney	Brim-DeForest
Brad	Criner
Mike	Denny
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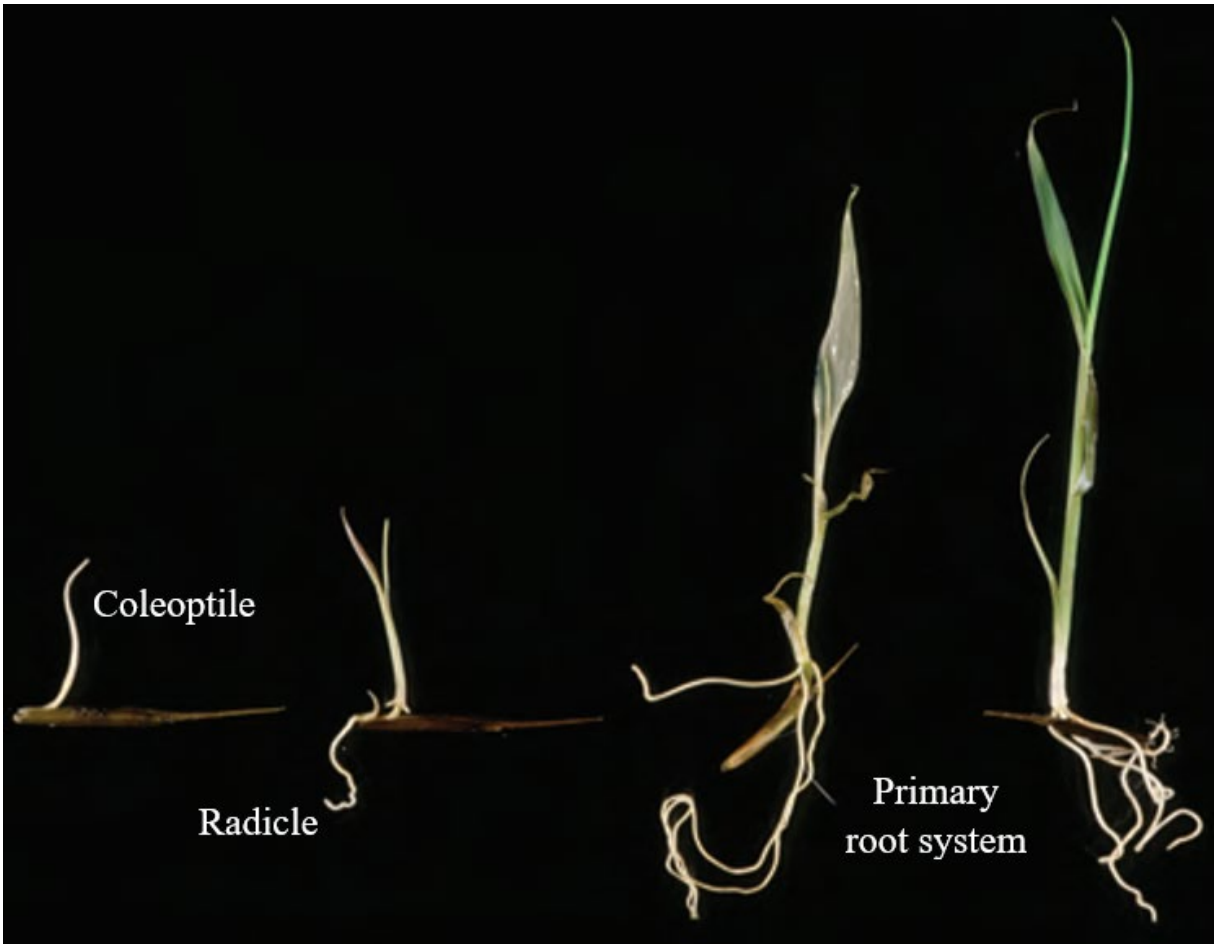
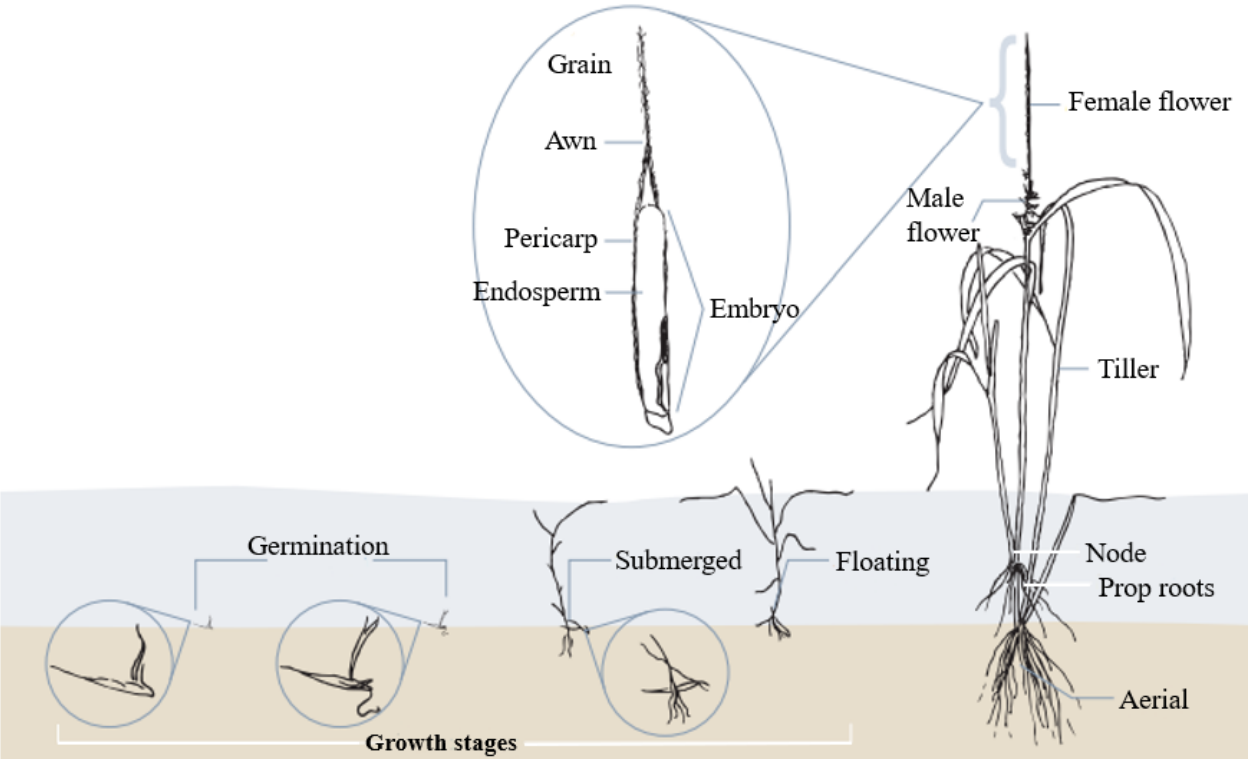
Ryan	Hill
Lupe	Calceta
Rick	Maller
Taiyu	Guan
Cameron	Boyd
Ben	Martin
Samuel	Ayala
Robert	Sisson
Andy	Oiler

Appendices

Appendix 1: Growth Stages of Wild Rice



Wild rice germination stage. Adapted from figure 3. Wild rice germination. Marcum, D., B. 2007. Cultivated Wild Rice Production in California. University of Agriculture and Natural Resources UC ANR publication 21622.



Wild rice growth stages. Adapted from figure 4. Life cycle of wild rice. Marcum, D., B. 2007. Cultivated Wild Rice Production in California. University of Agriculture and Natural Resources UC ANR publication 21622.

Crop Development Timeline (North)

Crop Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Preplant			x	x	x	x						
Germination			x	x	x	x						
Seedling/ Leaf Development				x	x	x						
Tillering (varies)					x	x	x					
Panicle Initiation					x	x	x					
Flowering					x	x	x					
Maturity							x	x	x	x		

Crop Development Timeline (South)

Crop Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Preplant			x	x	x	x	x					
Germination				x	x	x	x					
Seedling/ Leaf Development				x	x	x	x					
Tillering					x	x	x	x				
Panicle initiation						x	x					
Flowering						x	x					
Maturity						x	x	x				

Appendix 2: Annual Wild Rice Production Statistics

Field Crop Acreage, Production, and Value[1]

Year	Planted Acres	Harvested Acres	Yield per Acre (Tons)	Production (Tons)	Price per Dollars ($)	Total Value ($)
2022	na	10,156	0.51	2,530	1,850.59	10,122,000
2021	na	9,971	0.76	7,040	1,399.86	11,448,000
2020	na	8,760	0.72	6,340	1,011.51	6,413,000
2019	na	12,350	0.79	8,840	1,155.43	11,727,000
2018	na	10,490	0.78	8,130	1,407.87	11,446,000
2017	na	9,785	0.85	8,292	1,745.90	14,477,000
2016	na	9,295	0.82	7,645	1,898.89	14,517,000
2015	na	8,960	0.76	6,810	1,742.88	11,869,000
2014	na	8,460	0.78	6,620	1,643.66	10,881,000

[1]USDA. California county Agricultural Commisioners' Data Listing. At time of publication, 2023 data was not available.

Appendix 3: Production and Worker Activity Timeline

Production and Worker Activity Timeline:

North management

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Field drain								x	x	x		
Seedbed preparation[1]				x	x	x						
Flooding (in-season)				x	x	x						
Planting				x	x	x						
Fertilization				x	x	x						
Weed management					x	x						
Arthropod management						x						
Disease management*												
Vertebrate management			x	x	x	x	x	x				
Harvest							x	x	x	x		
Post harvest							x	x	x	x		

x = Pest-management-related worker activities occur at this time, which includes manual labor, machine labor, and aerial applications.

[1]Includes plowing, drying, tilling, and leveling.

In north may not drain in the spring (planting into water)

* no management takes place

South management

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Field drained		x	x									
Seedbed preparation[1]			x	x	x	x						
Flooding			x	x	x	x						
Planting			x	x	x	x						
Fertilization			x	x	x	x						
Weed management					x	x						
Arthropod management				x	x	x						
Disease management*												
Vertebrate management			x	x	x	x	x	x				
Harvest						x	x	x				
Post harvest								x	x	x		

x = Pest-management-related worker activities occur at this time, which includes manual labor, machine labor, and aerial applications.

[1]Includes plowing, drying, tilling, and leveling.

* no management takes place

Appendix 4: Pest Monitoring and Management Timelines

Table 4A: Pest Monitoring and Management Timeline: Weeds

North management

Weeds	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Weeds			x	x	x	x						

x = Monitor and manage; the pest or symptoms are present in the field at this time; control actions taken when the pest or symptoms are not present in the field

South management

Weeds	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Weeds				x	x	x						

x = Monitor and manage; the pest or symptoms are present in the field at this time; control actions taken when the pest or symptoms are not present in the field

Table 4B: Pest Monitoring and Management Timeline: Arthropods

North management

Arthropod Pests	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Armyworms*												
Midges					x	x	x					

x = Monitor and manage; the pest or symptoms are present in the field at this time; control actions taken when the pest or symptoms are not present in the field
*observed but stated as a non-issue

South management

Arthropod Pests	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Armyworms*												
Midges				x	x	x	x					

x = Monitor and manage; the pest or symptoms are present in the field at this time; control actions taken when the pest or symptoms are not present in the field
*observed but stated as a non-issue

Table 4C: Pest Monitoring and Management Timeline: Vertebrates

North and South management

Vertebrate Pests	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blackbirds			x	x	x	x	x	x				
Other birds			x	x	x	x	x	x				

x = Monitor and manage; the pest or symptoms are present in the field at this time; control actions taken when the pest or symptoms are not present in the field

Table 4D: Pest Monitoring and Management Timelines: Diseases

North Management

Diseases	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Algae			x	x	x	x						
Rots*												
Red root			x	x	x	x	x	x	x	x		

x = Monitor and manage; the pest or symptoms are present in the field at this time; control actions taken when the pest or symptoms are not present in the field
*stated as an issue but no management timeline

South management

Diseases	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Algae			x	x	x	x						
Rots*												
Red root**												

x = Monitor and manage; the pest or symptoms are present in the field at this time; control actions taken when the pest or symptoms are not present in the field
*stated as an issue but no management timeline
**For CA south diseases, red root may be an issue but uncertain as it has not been explicitly investigated

Appendix 5: Efficacy of Weed Management Tools Used in California Wild Rice Production

Weed Chemical Management Tools

Efficacy of chemical weed management tools. Rating system: Excellent (greater than 90% control), Good (80-90% control), Fair (60-80% control), Poor/Not effective (less than 60% control).

Active Ingredient	Trade Name	MOA	Overall Rating	Weed Ratings: Annual Grasses	Weed Ratings: Annual Broadleaves or Sedges	Weed Ratings: Perennials	Comments
carfentrazone-ethyl	SHARK H2O	14	If timing right, good	n/a, poor	Poor, good on ducksalad	Good on young plants	Timing is critical (young is best)
glyphosate*, potassium salt	ROUNDUP POWERMAX	9	Fair				Used primarily on Tulle (field edges), not in field
glyphosate*, isopropylamine salt	CREDIT 41 EXTRA NON-SELECTIVE HERBICIDE	9	Fair				Used primarily on Tulle (field edges), not in field

MOA = mode of action
*Glyphosate not used during harvest

Weed Non-chemical Management Tools

Efficacy of non-chemical weed management tools. Rating system: Excellent (greater than 90% control), Good (80-90% control), Fair (60-80% control), Poor/Not effective (less than 60% control).

Non-chemical Management Practices	Ratings*	Notes
Deep water	Good	
Pre-plant Tillage	Good	Good on all except plantain, a bit on tulle
Crop rotation	Good	Helps dry out tubers of perennials, allows for wild rice chemical rotation utilization
Fallow	Good	Could be a till/fallow, many ways to implement. Effective on many weeds, except for sedges

Appendix 6: Efficacy of Algae and Nostoc Management Tools Used in California Wild Rice Production

Algae and Nostoc Chemical Management Tools

Efficacy of chemical algae and Nostoc management tools. Rating system: Excellent (greater than 90%

Active Ingredients	Example Trade Name	Mode of Action	Algae Ratings	Comments
copper sulfate (pentahydrate)	COPPER SULFATE CRYSTALS	-	Excellent	Expensive, works well but concerns of soil buildup. Used sparingly (kills midge and shrimp too)

control), Good (80-90% control), Fair (60-80% control), Poor/Not effective (less than 60% control).

Algae and Nostoc Non-chemical Management Tools

Efficacy of non-chemical algae and Nostoc management tools. Rating system: Excellent (greater than 90% control), Good (80-90% control), Fair (60-80% control), Poor/Not effective (less than 60% control).

Non-chemical Management Practices	Ratings	Comments
Circulating Water	Excellent	If water available, water boxes in proper sequence
Drain	Excellent	As long as plants standing

Appendix 7: Efficacy of Arthropod Management Tools Used in California Wild Rice Production

Arthropod Chemical Management Tools

Efficacy of chemical arthropod management tools. Rating system: Excellent (greater than 90% control), Good (80-90% control), Fair (60-80% control), Poor/Not effective (less than 60% control).MOA = mode of action; – = no information

Active Ingredient	Example Trade Name	MOA	Arthropod Ratings: Armyworms	Arthropod Ratings: Midges	Arthropod Ratings: Rice Leafminer	Arthropod Ratings: Rice Water Weevil	Comments
lambda-cyhalothrin	LAMBDA-CY EC INSECTICIDE-RUP	3A		Excellent			
malathion	GOWAN MALATHION 8	1B		Excellent			
magnesium phosphide	DEGESCH FUMI-STRIP	–					Not known, used more as fumigants post-harvest
phosphine	ECO2FUME	24A					Not known, used more as fumigants post-harvest
Zeta-cypermethrin	MUSTANG INSECTICIDE	3A		Unsure			Unknown, not really used but for in-season control of sucking pests

Arthropod Non-chemical Management Tools

Efficacy of non-chemical arthropod management tools. Rating system: Excellent (greater than 90% control),

Non-chemical Management Practices	Ratings	Comments
Planting timing	Good	Earlier is better

Good (80-90% control), Fair (60-80% control), Poor/Not effective (less than 60% control).

Appendix 8: Efficacy of Disease Management Tools Used in California Wild Rice Production

Disease Chemical Management Tools

No fungicides are used for wild rice disease management.

Disease Non-chemical Management Tools

Efficacy of non-chemical disease management tools. Rating system: Excellent (greater than 90% control), Good (80-90% control), Fair (60-80% control), Poor/Not effective (less than 60% control).

Non-chemical Management Practices	Ratings	Notes
Crop rotation	Excellent	Specifically used to manage red root
Cover crop	Good	

Appendix 9: Efficacy of Vertebrate Management Tools Used in California Wild Rice Production

Vertebrate Chemical Management Tools

Efficacy of chemical vertebrate management tools. Rating system: Excellent (greater than 90% control), Good (80-90% control), Fair (60-80% control), Poor/Not effective (less than 60% control).

Active Ingredients	Example Trade Name	MOA	Vertebrate Ratings: Blackbirds	Vertebrate Ratings: Other Birds	Comments
Magnesium phosphide	DEGESCH FUMI-STRIP	–			For storage rice pests, post-harvest
Methyl anthranilate	AVEX BIRD REPELLENT	–			Not familiar, unused
phosphine	ECO2FUME	24A			For storage rice pests, post-harvest, foliar nutrition

– = no information

Vertebrate Non-chemical Management Tools

Efficacy of non-chemical vertebrate management tools. Rating system: Excellent (greater than 90% control), Good (80-90% control), Fair (60-80% control), Poor/Not effective (less than 60% control).

Non-chemical Management Practices*	Ratings	Comments
RC Planes	Good	
Audio deterrent	Good	Bird cannons, bangers, etc
Vehicle patrols	Good	
Reflective tape	Fair-poor	Typically paired with bamboo stakes
Tube men inflatables	Good	Expensive
Predator boxes	Fair-poor	

*Timing is important for many of these managements to be effective
Note: it is believed a trap crop would be ineffective as birds love wild rice