Water Use in Agriculture

More than 800 significant crops are grown in the WRB by some OSU estimates. Two crops stand out in terms of land area—grass seed, which is grown on about one-third of farmland, and pasture, which accounts for one-sixth of farmland.[15] No other crop is grown on more than 5 percent of the Basin's acreage. Crop choices have changed in the Basin and are likely to continue to do so. Nursery crops have become more important, and, as of 2016, significant new hazelnut acreage is being planted.

In Oregon, as elsewhere in the western U.S., agriculture is the largest out-of-stream human use of water, accounting for about 80 percent of out-of-stream use. Unlike many parts of the western U.S., however, most WRB farmland is not irrigated. A majority of the 1.5 million acres of farmland in the WRB rely directly on precipitation, rather than irrigation. Most of the major crops are grown both with and without irrigation. Exceptions include corn, which is always irrigated, and winter wheat, which is almost never irrigated. About a quarter of grass seed is irrigated, as is 10 to 20 percent of pasture.

About one-third of WRB farmland has irrigation water rights. Slightly more than half of these are surface-water rights; the rest are groundwater rights. Growth in the acreage of farmland with irrigation water rights began in the 1940s and leveled off in the 1990s (Figure 32, p. 36). The location of farmlands with irrigation water rights (both surface and groundwater) is shown in Figure 33 (p. 37).

Irrigation practices in the WRB are unusual, compared to other irrigated areas in the West, in that in any given year only about two-thirds of irrigation water rights are utilized. Of the total acres with water rights, only 60 percent or less are irrigated in a given year. See Figure 32.

Over the past 20 years, irrigated acreage in the WRB has been flat. The area irrigated varies from year to year, but averages less than 300,000 acres, or 20 percent of the region's farmland (Figure 32). This stability is not surprising, given the dominance of grass seed and pasture. No other crop is planted on enough acreage to have a significant effect on overall crop water use.

Crop choice

On a parcel of land with an irrigation water right, the choice of crop and whether to irrigate is based on several factors (see Appendix). Some factors do not vary from year to year (e.g., soil type, elevation, and average precipitation and temperature). Other factors are unpredictable, such as crop prices, costs of fertilizer and energy, and spring rains. As a result, the number of acres planted to a given crop and the number of irrigated acres varies slightly from year to year.

Our modeling of crop choice and irrigation decisions is based on established economic theory, empirical data, and a detailed farmer survey conducted in the WRB (see Appendix). Although the model allows acres planted to most crops to fluctuate from year to year, land planted to tree crops (Christmas trees), orchards, and vineyards is not allowed to vary.

Given the WRB's strong climatic advantages for growing seed crops (see Chastain at http://cropandsoil.oregonstate.edu/system/files/u528/Climate%20Soils%20and%20Seed%20Production.pdf), the most likely future scenario is for grass seed and pasture to continue to dominate acreage, with other crops entering and exiting the crop mix. The projected pattern of crop mix for all agriculture, and for irrigated lands specifically, is shown in Figures 34 (p. 38) and 35 (p. 39).

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[15] The dominance of grass seed on an acreage basis has been relatively constant for more than 50 years (Fisher, 1972).

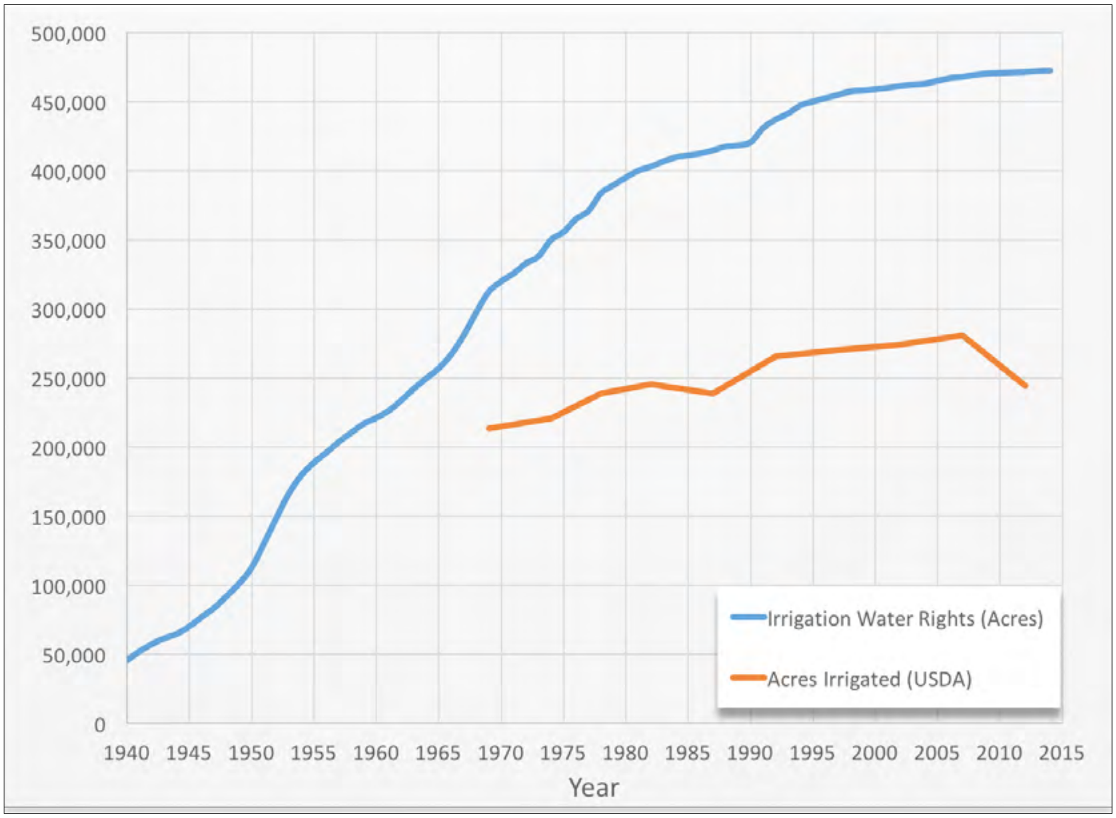

Figure 32. Historical trends in irrigation water rights and irrigated acres.

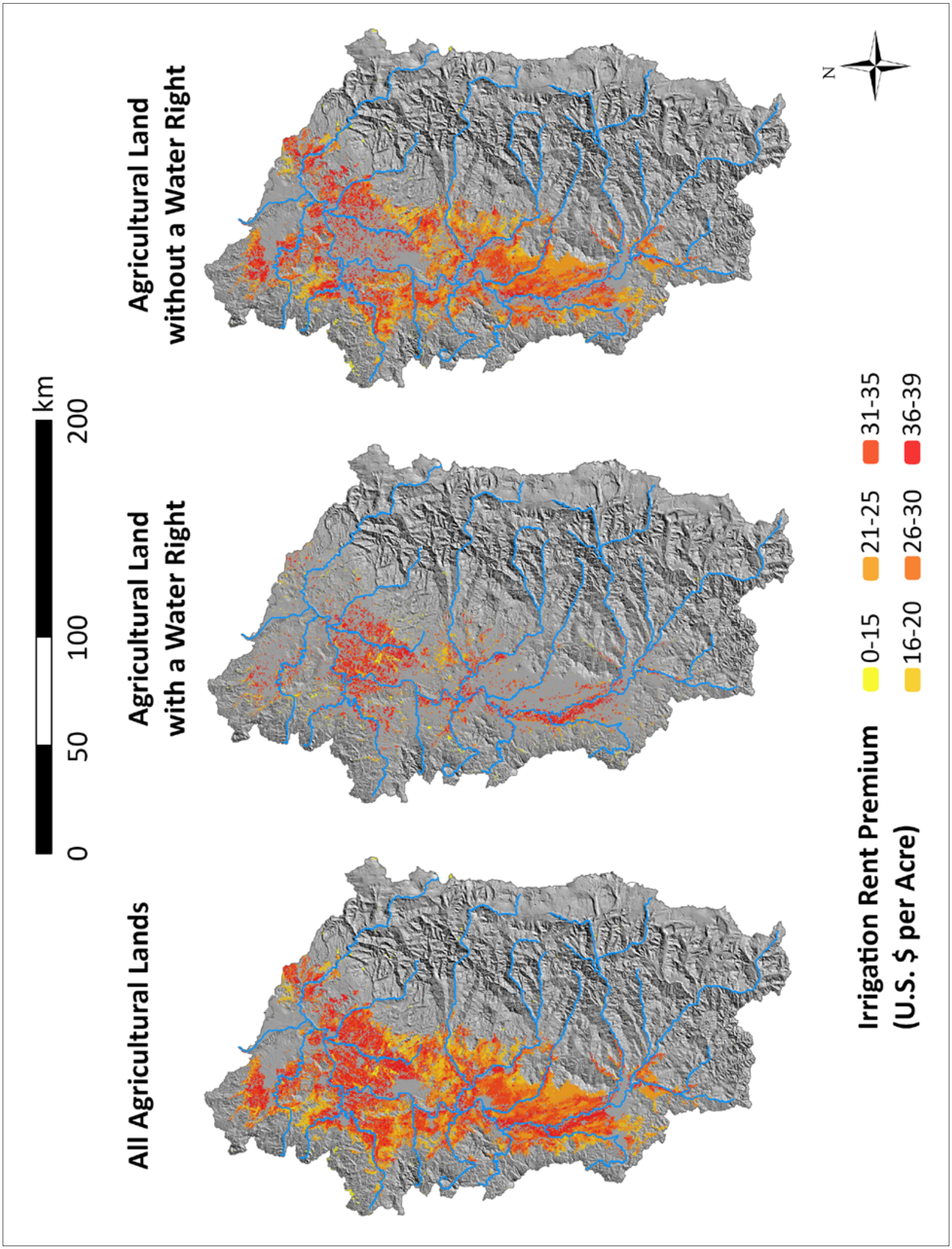

Figure 33. Farmland with irrigation water rights and irrigation rent premium.

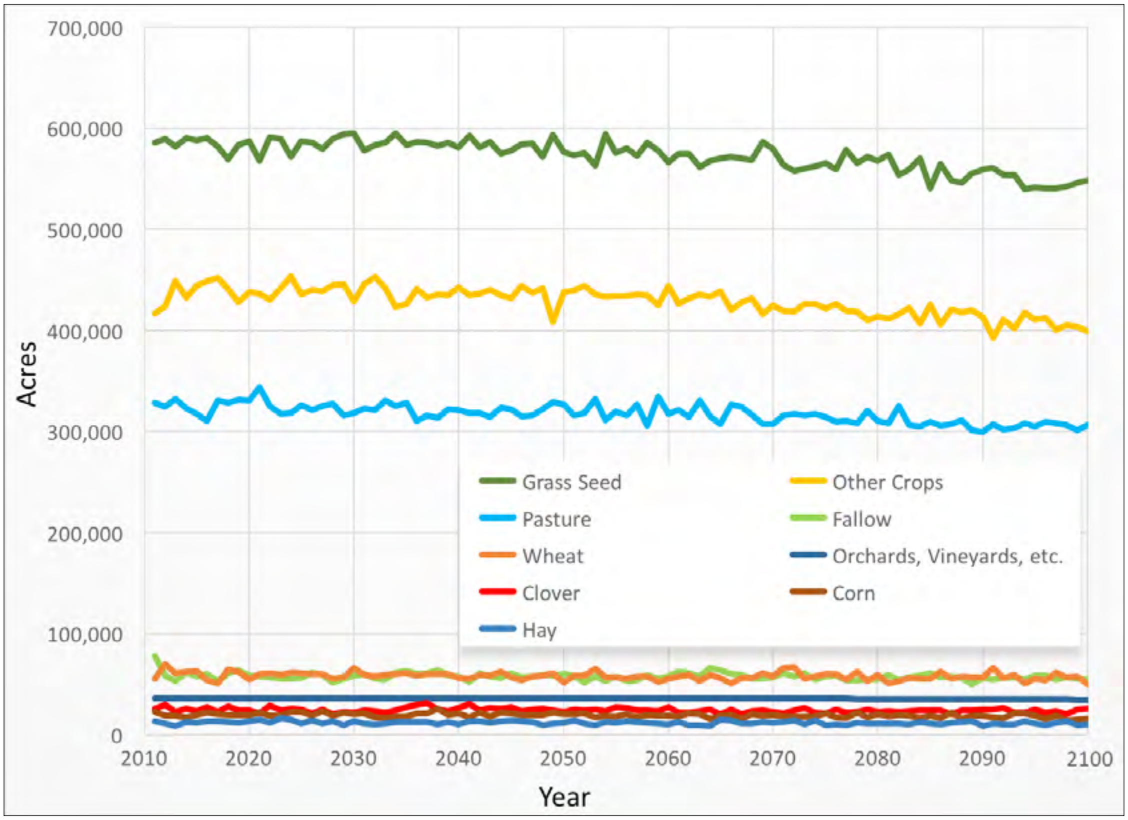

Figure 34. Cropping pattern, all agriculture.

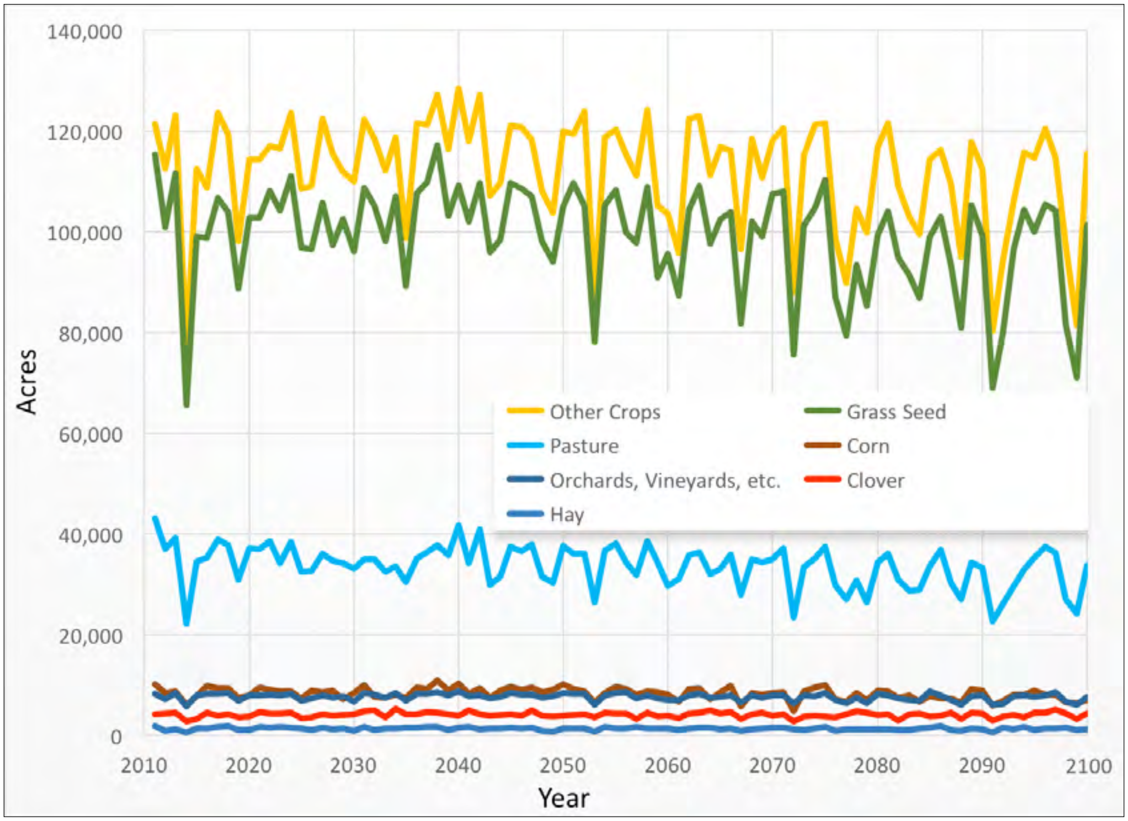

Figure 35. Irrigated cropping pattern.

Total farmland and irrigated acreage

For the reference scenario, the WW2100 model shows a slight downward trend from 2010 to 2100 in total farmland and irrigable acres (Figure 36, p. 41). The decline is about 7 percent for farmland overall and about 5 percent for irrigated lands. In comparison, the high population growth scenario produces a 14 percent decline in total farmland, and the "relaxed" urban expansion scenario generates a 9 percent reduction.

Additional analyses could be undertaken with the WW2100 model. For example, changes in relative crop prices could be introduced in an alternative scenario. Modified cropping patterns could provide insights about how a shift toward more water-intensive crops would affect water use.

Irrigation water use

The amount of water required for irrigation is expected to be relatively stable, with a slight decline in both surface and groundwater irrigation. The projected decline is due to land-use change resulting from urban expansion and the corresponding loss of irrigated acreage.

Even if new crops enter the crop mix, they are unlikely to have more than a small effect on average ET basin-wide. To produce a significant change, multiple new crops would have to have extremely high or low ET and displace current crops on a large number of acres.

One important question is whether climate change will increase irrigation water demand due to the effects of warmer temperatures on crop ET. At a given crop development stage, higher daytime temperatures lead to higher ET. However, our model indicates that warmer springtime temperatures will allow farmers to plant earlier, irrigate earlier, and harvest earlier. Thus, more plant growth will take place during months with relatively cooler temperatures, more precipitation, and higher levels of soil moisture. As a result, the positive effect of warmer temperatures on ET may be offset by the opposite effect from earlier planting, thus reducing, rather than increasing, irrigation.

What results are indicated by our model? The model simulates daily crop water demand from planting to harvest. As a result, it can capture the direct and indirect ways that climate change will affect crop water use and irrigation demand. Even in the high climate change scenario, the model shows only a 2 percent increase in maximum ET from 2010 to 2100.

There is, of course, the potential for expansion of irrigation onto currently unirrigated lands. However, "live flow" surface-water sources are already fully appropriated in the Basin. Moreover, some parts of the Basin have seen declining groundwater levels and face limitations on groundwater withdrawals. One area in southeastern Washington County has been designated a "critical" groundwater area (Herrera et al., 2014).

The projected reduction in irrigation does not take account of the possible addition of irrigation water rights from federal reservoirs. To date, farmers have contracted for only 80,000 acre-feet, or about 5 percent of this stored water. The potential for use of federally stored water is discussed below (see "Stored water," page 42).

Change in irrigation season

The seasonal pattern of irrigation corresponds to plant water needs for growth and development. It also reflects the typical reduction in precipitation from spring into summer.

Our model indicates that warmer temperatures will cause planting and harvest dates to shift earlier in the year.[16] Thus, as indicated in Figure 37 (p. 41), patterns of irrigation water use will shift about 2 weeks earlier by late in the 21st century.

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[16] In principle, a shift to earlier planting and harvest dates could raise the possibility of a second crop ("double-cropping"). Some sequential cropping already occurs in the WRB. For a second crop to be attractive to farmers, it must be profitable. Compared to spring-planted crops, irrigation costs would be higher for an emergent crop in August and September, when rainfall is lowest and temperatures are highest, thus reducing the likelihood that a second crop would be profitable.

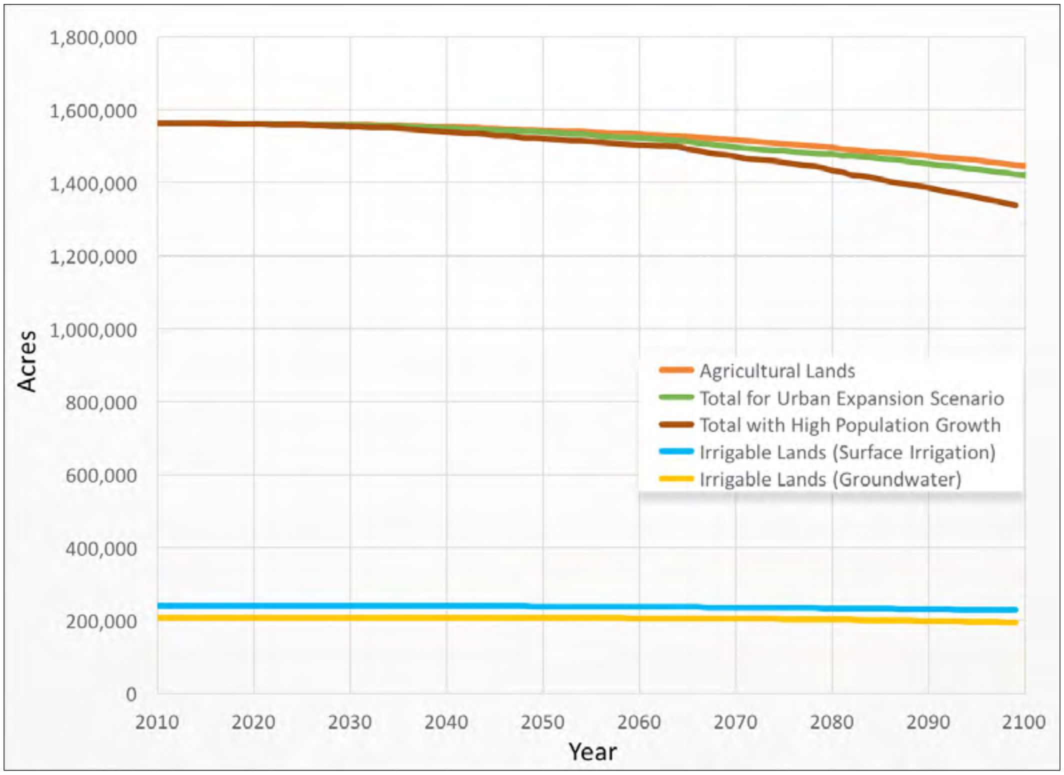

Figure 36. Irrigable and nonirrigable agricultural lands.

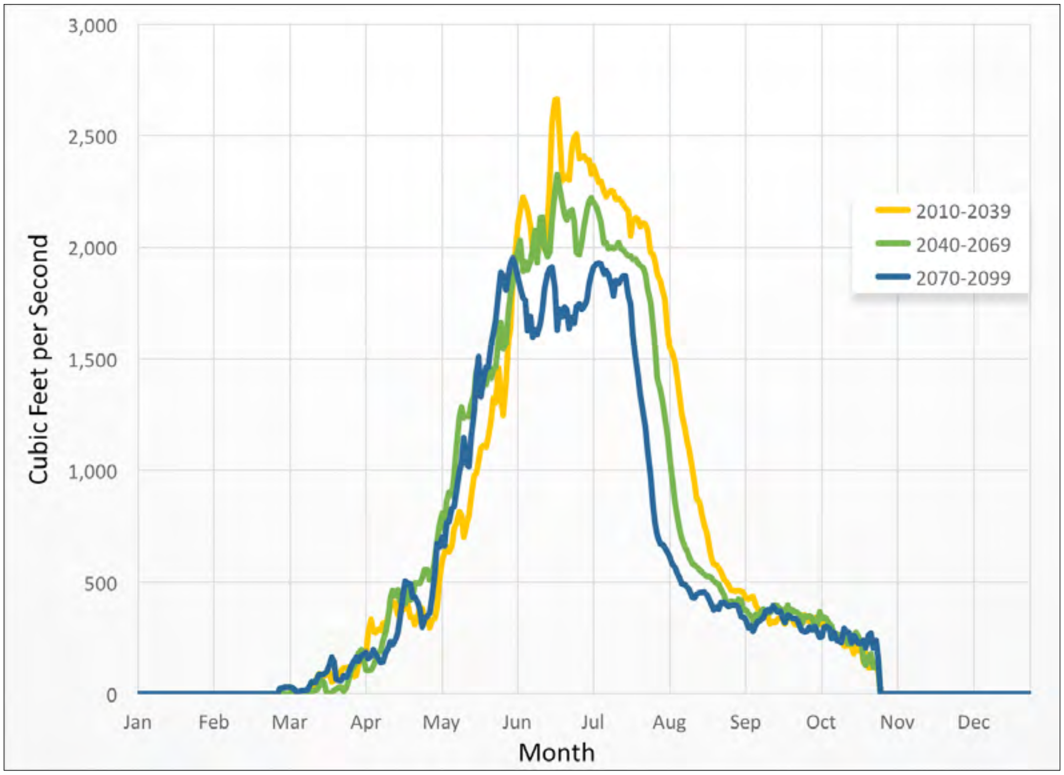

Figure 37. Irrigation withdrawals.

Agricultural water supply and demand in alternative scenarios

Water use in agriculture may vary from the levels suggested by the reference scenario. If changes in prices, crops, or technology make irrigation more profitable, the share of irrigation water rights that goes unused each year could decline. An increase in contracts for stored water from reservoirs might also result in increased irrigation. Conversely, higher energy costs could make irrigation less attractive, or lower density urban expansion could displace more irrigated farmlands.

Stored water

The potential for using some of the 1.6 million acre-feet of water stored in federal reservoirs for new irrigation has been a topic of interest since the 1990s. Farmers may apply for a contract to use this water, provided that the water can be diverted downstream and transported to a farmer's field for irrigation purposes. Both an Oregon water right and a contract with the U.S. Bureau of Reclamation (USBR) are required. Currently, contracts cover only about 80,000 acre-feet of stored water. The amount authorized for potential use under such contracts is currently limited by Biological Opinions under the Endangered Species Act (USFSW, 2008) to a maximum of 95,000 acre-feet, as discussed in the Appendix, Section 6.

To evaluate this potential, a scenario was developed that makes new contracted water available for irrigation on lands that currently do not have irrigation water rights. The model introduces an annual probability of acquiring a water right for stored water, where the probability is a function of the marginal value of irrigation (which varies by soil class) and the cost of conveyance to the field in question.

Estimated conveyance costs (infrastructure and pumping) are based on distance and lift from the nearest point on the relevant river. (See Appendix for details.) Conveyance costs are high for moving water to a farmer's field, and economic returns to doing so are relatively low. Thus, the addition of irrigated lands is limited to those areas in close proximity to streams below federal reservoirs. Estimated conveyance costs for agricultural lands, and the areas that are able to profitably adopt new irrigation water rights, are shown in Figure 38 (p. 43) and Figure 39 (p. 44). The model indicates that only 7,200 additional acres are likely to add irrigation water rights from stored water. This acreage is more than offset by the reduction in surface-irrigated acres resulting from urban expansion under the reference scenario. As a result, total irrigated acreage would change only slightly.

If we modify the scenario to reflect optimistic assumptions about the costs of conveyance, and if we eliminate the price irrigators must pay to the USBR for water contracts, the number of irrigated acres would increase by 27,400, representing about 55,000 acre-feet of stored water.

Profitability of irrigation

In one scenario (high irrigation), an increase in the profitability of irrigation reduces by half the number of acres that go unirrigated in a typical year. This change would increase irrigated acres by 86,000, or 32 percent. Because of this increase in demand, competition among irrigators would be expected to increase somewhat, with a modest increase in the frequency of irrigation shutoffs (see "Water scarcity in agriculture," page 45).

Fallow

All agriculture in the WRB uses significant amounts of water. Since 80 percent of agricultural land is not irrigated in a given year, the amount of water used in rainfed farming is important, since its use by crops makes it unavailable for irrigation or other uses. In fact, total annual ET per acre for non-irrigated crops is, on average, slightly higher than that of irrigated crops, likely owing to crop choice and ET associated with winter groundcover.

However, a decline in rainfed farming would not necessarily result in an increase in streamflows and water available for other uses. The reason is that fallowed land will have vegetation on it. The ET for this vegetation is not significantly different on average, in our analysis, from that of crops such as grass seed and pasture. Even when all agricultural land is constrained to be fallowed, the total ET for agriculture in our model does not change significantly.

If ET did decline with increased land fallowing, streamflows would increase slightly. However, some of the moisture that would have been consumed by a crop would remain in the ground for a period of time. For this reason, it might not contribute additional water to surface flows at the time water is needed.

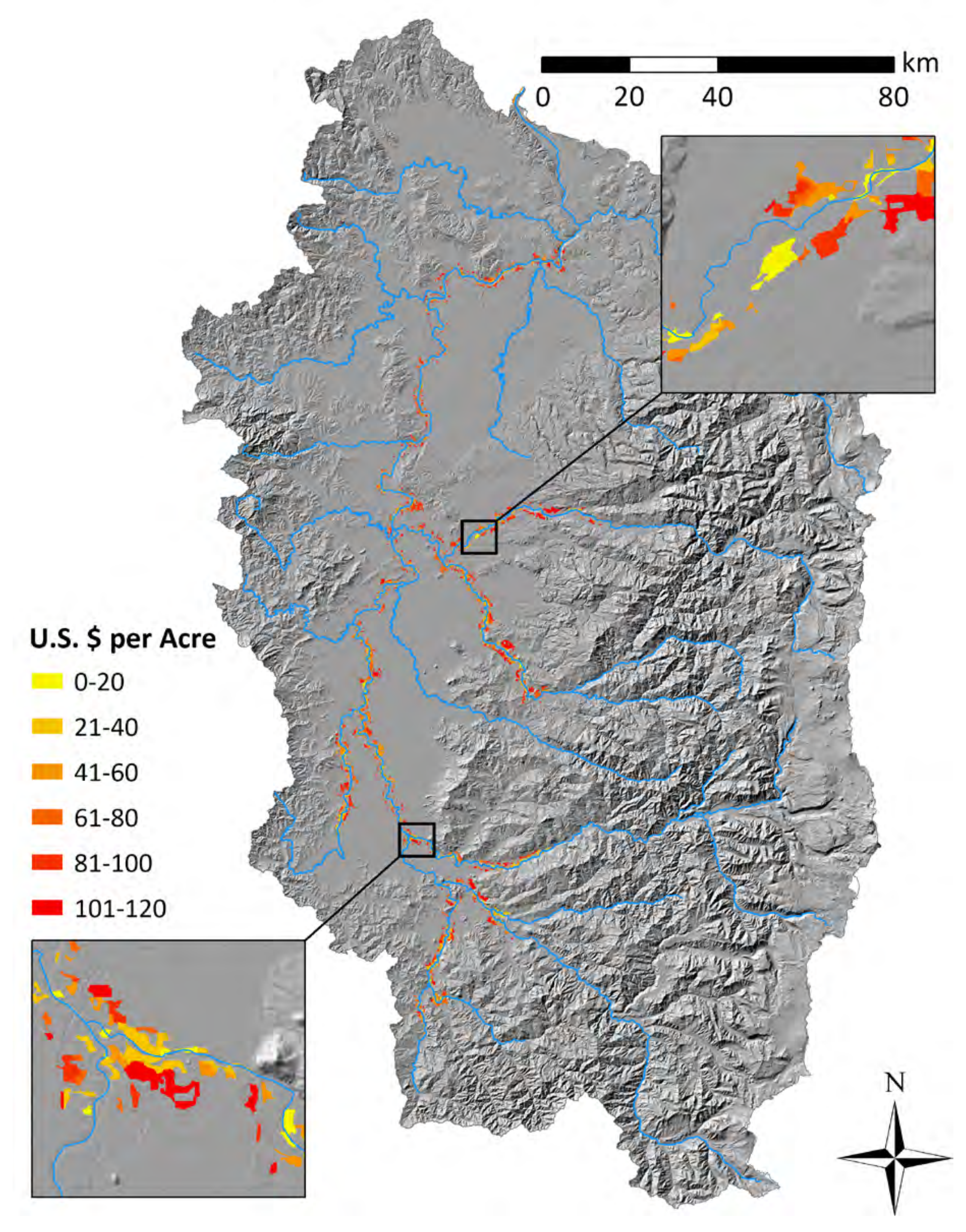

Figure 38. Irrigation conveyance costs.

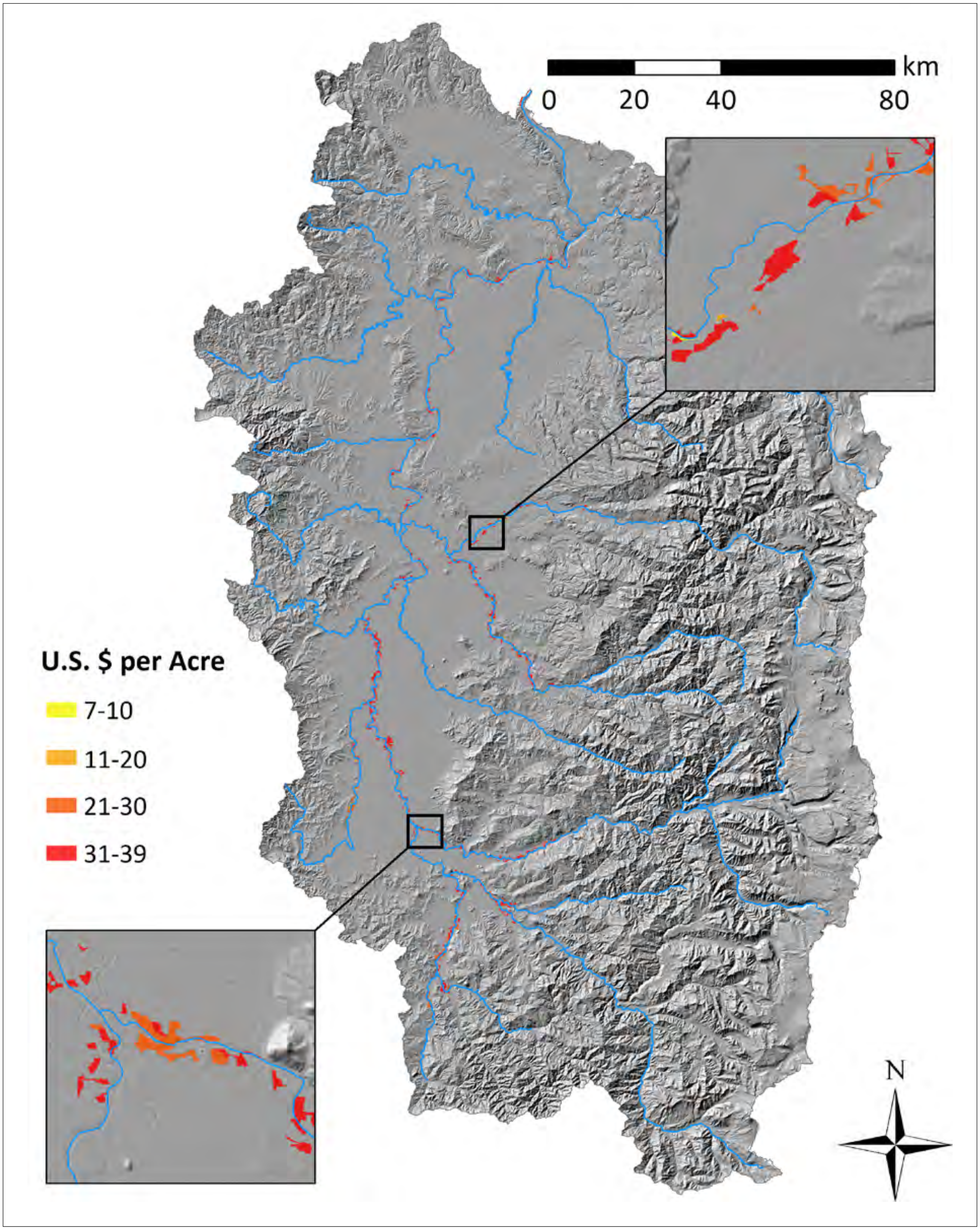

Figure 39. Additional surface-water irrigation from stored reservoir water, based on irrigation rent premium.

Water scarcity in agriculture

The demand for water for irrigation (and hence the potential for scarcity) depends on the economic returns to that activity. Economic returns to farming (annual profits or "farmland rents") are indicated by farmland prices. Thus, the economic value of irrigation is indicated by the difference between the value of farmland with water rights and similar farmland without water rights (an amount known as the "irrigation premium"). As the irrigation premium increases, demand for irrigation water also increases.

Based on data for land values and rental contracts among farmers, the average annual profits or returns to farmland have been estimated for various land types in the Basin (see Appendix). Irrigation premiums are included in the model (Figures 40, p. 46; 41, p. 47; and 42, p. 48). These figures do not include returns to labor, capital, or management.

Water scarcity also depends on whether a farmer possesses a water right and whether that water right has "priority" over other water rights that may compete for the same water. Under Oregon water law, irrigation water rights are based on the seniority system common to most western states, known as "the prior appropriations doctrine." Irrigation water rights are tied to a specific parcel of land on which the water can be put to a "beneficial use." Each water right has a priority date corresponding to the first use of water on that land. The most senior water rights predate 1900. See the Appendix, Section 6, for more details on water rights.

In a time of water shortage, a senior water right holder (a person having a right with an older priority date) can "make a call," requiring relatively junior water right holders to stop diverting water from a common stream so that the remaining water will reach the diversion point for the senior user.

A junior water right holder who is "regulated off" usually cannot irrigate for the remainder of the year. If crops have been planted that require irrigation, the loss of irrigation leads to economic losses that exceed what would have been gained by completing the irrigation season. For example, costs for planting, fertilizing, and partially irrigating the field will already have been incurred.

A direct indicator of water scarcity, therefore, is the number of irrigation shutoffs and associated value of economic losses. Because we have modeled nearly all 15,000 of the irrigation water rights in the Basin, our simulations indicate how many irrigated acres are expected to be shut off each year, and we are able to see how those numbers change over time and vary among scenarios.

Looking at annual shutoffs over time (using the 2010–2020 period as the baseline), we see a decrease in irrigation shutoffs of 10 to 30 percent under both the reference scenario and the high climate change scenario (Figure 43, p. 48). For the two scenarios that assume greater utilization of irrigation water rights (high irrigation and a worst-case scenario), the number of shutoffs is higher, but still declines over the 2020–2100 period.

The levels of irrigation shutoffs in the model are somewhat higher than those documented by the Oregon Water Resources Department (OWRD) in recent years, where 10 to 20 shutoffs per year are typical. This difference may be due to limitations in the model's ability to fully represent the stream network and its connections with individual water rights, especially for small streams.

The apparent reduction in water scarcity (irrigation shutoffs) is an indirect result of climate change. Warmer temperatures early in the year will lead farmers to plant earlier. As a result, more crop growth will take place during months with relatively high precipitation and adequate water, decreasing the need for irrigation. Early planting and warmer temperatures will also result in earlier harvest and cessation of irrigation. Many irrigation shutoffs occur in late July and early August, but in the future many farmers will have completed irrigation by that time. A small portion of the decline in irrigation shutoffs is likely due to the displacement of irrigated lands by urban expansion.

Oregon has a large number of in-stream water rights that have not yet been implemented. If all of these water rights are implemented, the level of irrigation shutoffs is projected to be about 5 percent higher than in the reference scenario. The following section discusses in-stream water rights in detail.

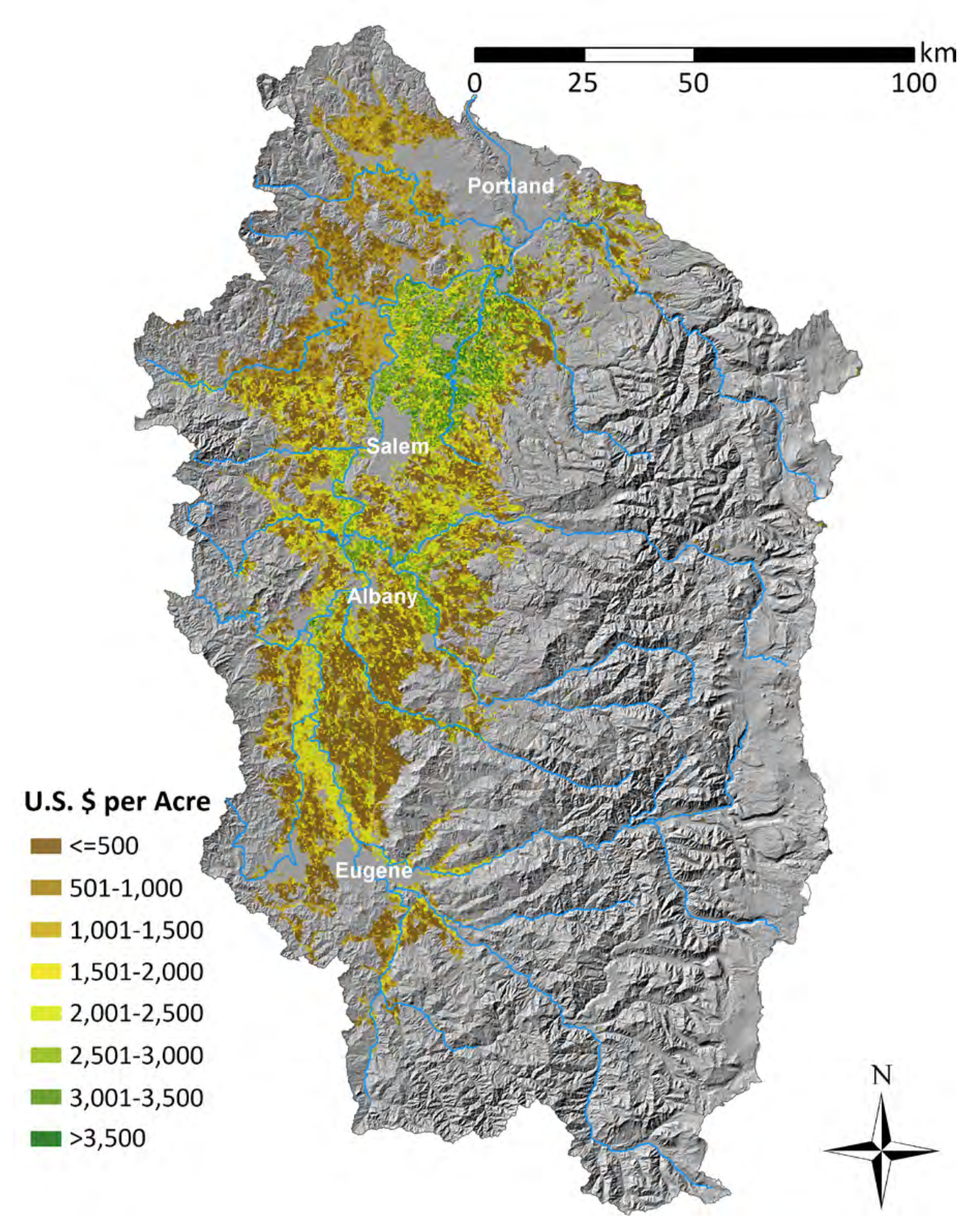

Figure 40. Agricultural land values.

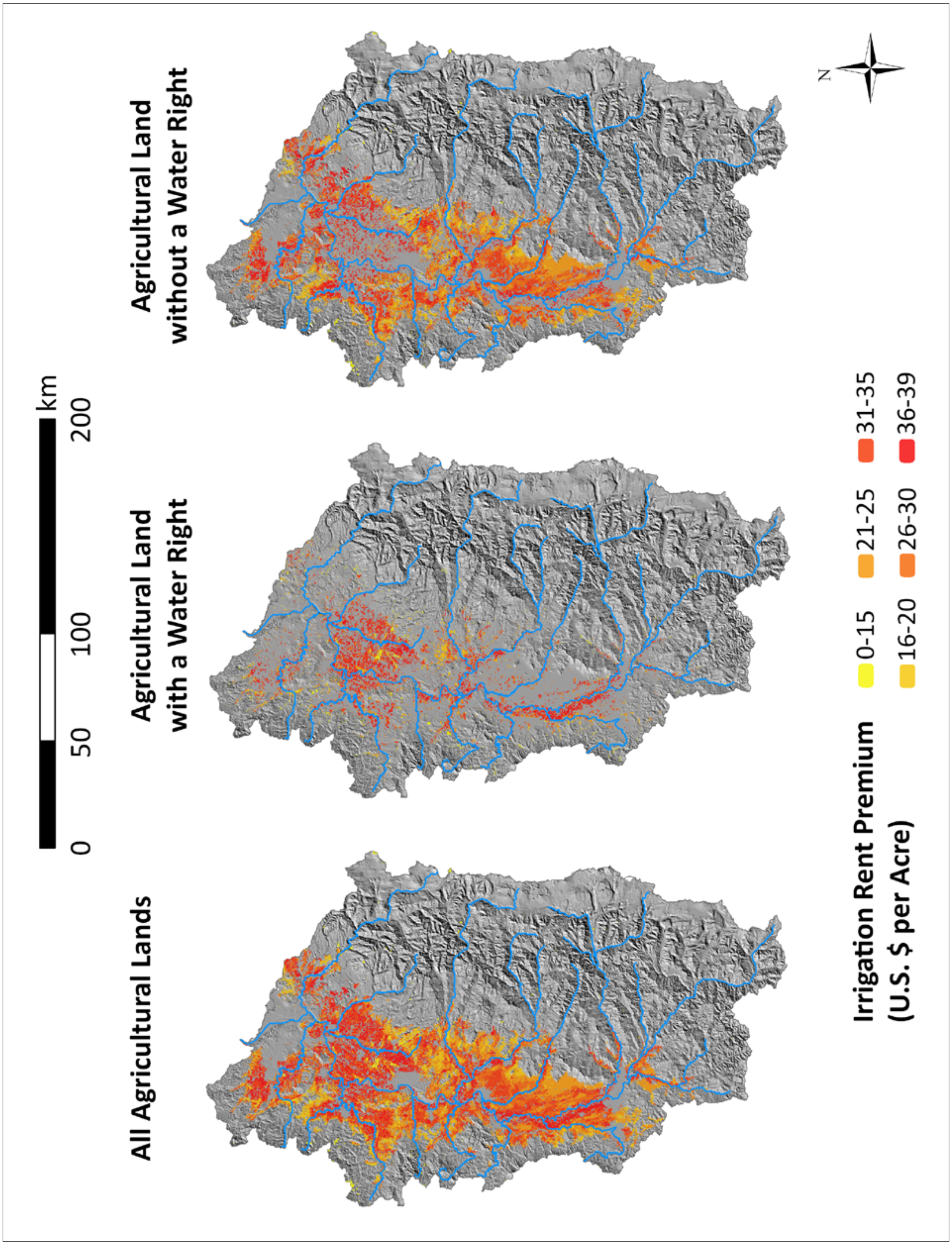

Figure 41. Expected irrigation premium.

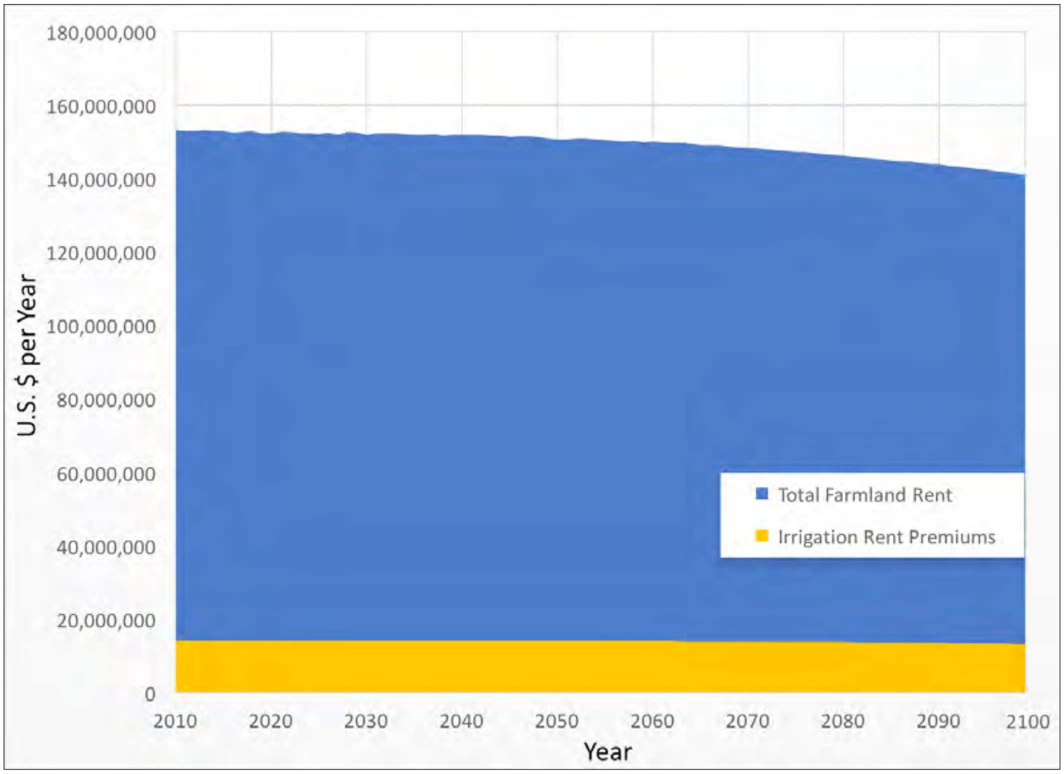

Figure 42. Farmland rent and irrigation premium.

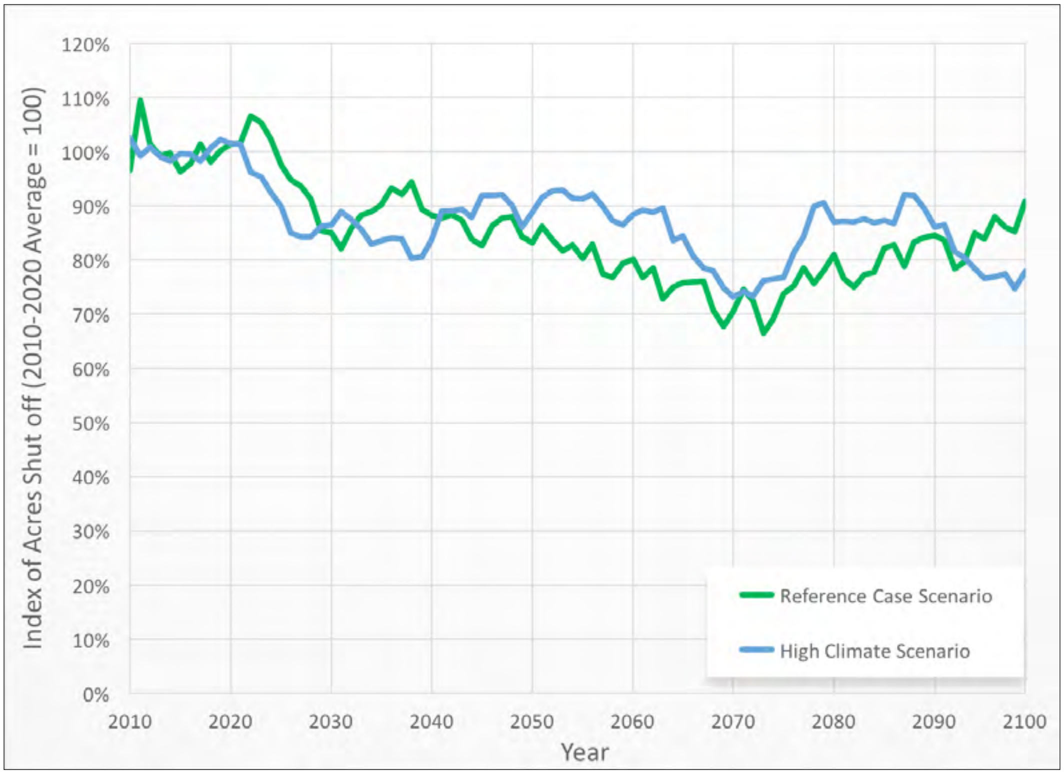

Figure 43. Irrigation shutoffs, two scenarios.