WILDER WEATHER:

Laura Ingalls Wilder's Weather Stories and Climate Clues

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PROPOSAL CONTENTS

1. Overview

American author Laura Ingalls Wilder (1867-1957) captivated generations of readers with her *Little House* book series, stories of her life experiences cloaked in fiction. Knowing that Wilder wrote books that are a mix of fact and fiction drives her readers, fans, and scholars to discern which is which. They explore everything from the disease that blinded Mary to the relationships among family members to the backgrounds of the supporting characters. They make pilgrimages to Wilder's historical homesites to lay their own eyes on the terrain and vegetation, to smell the air, to feel the very same floors and walls that Wilder described so intricately.

Wilder chronicled numerous weather and climate events as she and her family moved across the Midwest and Great Plains. Ranging from cryptic to astonishingly accurate, her observations and "word pictures" are the foundation to understanding the weather and climate of her world. *Wilder Weather* investigates these weather and climate events to verify and understand them.

Each piece of evidence and each story clarifies the picture of the weather and climate in Wilder's world. In *Wilder Weather*, readers will absorb the accounts of Wilder, the author, and others combined those with archived weather observations to illuminate the weather and climate events of Wilder's life. The result invites readers to feel Wilder's experiences of the weather and climate and merge them with their own, gleaning wisdom about safety and survival. Readers grasp how they can understand past weather and climate even if some details are missing, much as a person can visualize the artwork of an almost (but not perfectly) complete jigsaw puzzle.

The connections between Wilder's weather and history, climate and place attract readers who are drawn to or nostalgic for the places and times in her stories. Perhaps impacted by hazardous weather events in their childhood, or perhaps noticing that the farms of their childhood can't

sustain the same crops in today's climate, these readers relate their own experiences to Wilder's. Readers will find a both place in history and deeper understanding of weather and climate phenomena in *Wilder Weather* and in their own lives.

Wilder Weather is Dr. Barb Mayes Boustead's story to tell. A meteorologist and Wilder scholar, she is the only person at the intersection of weather, climate, and Laura Ingalls Wilder, with expertise in both the weather data analysis and the deeper stories of the weather in Wilder's books, homes, and life. She has been researching and documenting Wilder's weather for over a decade, and her accumulation of data and stories have a home in the canon of popular books related to Laura Ingalls Wilder, American history, historical weather, climate change, and life in the Great Plains and Midwest. It is her responsibility, her honor, and her contribution to share these stories.

2. Manuscript Specifications

Five chapters are complete. The manuscript will be complete by July 2022 at approximately 80,000 words. Caroline Fraser, the Pulitzer Prize-winning author of *Prairie Fires: The American Dreams of Laura Ingalls Wilder*, has agreed to write the Foreword.

3. Author Biography

Barb Mayes Boustead, Ph.D., is a meteorologist, climatologist, and instructor with the National Weather Service. She is also a recognized Laura Ingalls Wilder expert and has introduced a piece of the *Wilder Weather* puzzle at every LauraPalooza conference since the inaugural event in 2010. Born in Michigan and currently living in Nebraska, her loves of weather and of Laura Ingalls Wilder's books both grew from early elementary age. After reading every book on weather in her local library, she told her mother at age 6 that she wanted to be a meteorologist when she grew up. She read *Little House on the Prairie* at the same age, devouring the entire *Little House* series within a few years.

Dr. Boustead received bachelor's degrees in Meteorology, Geography, and English from Central Michigan University, an M.S. in Meteorology from the Pennsylvania State University, and a Ph.D. in Natural Resources: Climate Assessment and Impacts from the University of Nebraska–Lincoln. Her dissertation, "The Hard Winter of 1880-1881: Climatological Context and Communication via a Laura Ingalls Wilder Narrative," and its subsequent papers are the only academic publications in the intersection of Wilder and weather. Dr. Boustead's weather, climate, and historical expertise are rooted in the Midwest and Great Plains, giving her a unique position in the intersection of weather and climate with Laura Ingalls Wilder's life and stories.

A meteorologist with the National Weather Service since 2002, Dr. Boustead's career roles have included instructor, operational weather forecaster, national climate outreach and partnerships program manager, and central U.S. regional climate program manager. Dr. Boustead is a member, past President, and past Board of Directors member of the Laura Ingalls Wilder Legacy and Research Association, a 501(c)(3) non-profit organization, and a member of the

American Meteorological Society and the National Weather Association. She served as a contributing author on the 4th National Climate Assessment for the Midwest and Northern Plains chapters and is a contributing author on the 5th National Climate Assessment for the Northern Plains. She has published numerous scholarly weather- and climate-related articles and book chapters, as well as general-audience articles in *Weatherwise*, *Fine Lines*, Medium, the website "Beyond Little House," and her own blog, Wilder Weather. She has appeared as a guest on podcasts such as Weather Geeks ("WxGeeks") and Weather Brains, as well as appearing on Wisconsin Public Radio, Michigan Public Radio, and The Weather Channel. Dr. Boustead is active on Twitter and Instagram as @windbarb and on Facebook at @Wilder Weather.

Dr. Boustead has yet to wear a bonnet when she gives presentations about Laura Ingalls Wilder and her weather, but she does own one.

4. Audience Analysis

Laura Ingalls Wilder's *Little House* books are almost a hundred years old, and yet they maintain wide popularity today. The *Little House* series has sold over 60 million copies in over 100 countries. Recent Wilder-related biographies, memoirs, and fiction retellings, published at an accelerating pace in the last few decades, have reinforced continued interest in Laura Ingalls Wilder, likely fueled by the popularity of the 1974-1982 TV series "Little House on the Prairie" and the generation of lifelong fans it created. In the last five years, publishers have released at least 10 nonfiction works related to Laura Ingalls Wilder, three fiction works, and three edited compilations. The Emmy-nominated PBS American Masters series included a feature "Laura Ingalls Wilder: From Prairie to Page" in December 2020.

The generational Laura Ingalls Wilder and "Little House on the Prairie" fans and scholars are a near certainty to purchase and read *Wilder Weather* – they are voracious readers of Wilder biographies and affiliated fiction and memoirs. They will swoop up copies at LauraPalooza and other conferences, at Wilder home sites and museums, and through their favorite online purchasing sites. They are just a subset of the target readers, though.

The target readers of *Wilder Weather* are likely around their mid 30s to mid 60s in age, which is also a peak demographic for nonfiction book readers. The specific Laura Ingalls Wilder connection will draw readers who are predominantly women, while the subjects of weather and history will draw men to the book. Many readers are likely to live in, or have ties or roots in, the central United States.

The wide range of history buffs, weather geeks, and Laura Ingalls Wilder fans share many characteristics. They are likely rooted in place and time, perhaps tradition and nostalgia. They

have some leisure time and may like to travel. They probably go to museums and stop at historical markers. They may be haunted by weather bogeymen – tornadoes that surprised them, blizzards that trapped them, droughts that busted their crops and gardens. They may be casual weather geeks, like one of the 400,000 SKYWARN severe weather spotters across the country. They might be upset that they live in or love a place that others have seen as "flyover country." They want safety and security. They want to make sense of the current world by understanding the past. They want to find someone else who relates to and amplifies their experiences – "Ah, yes, I've seen that! I've felt that!" – and makes them feel seen. They want the value and worth of the central U.S. to shine. They may not seek and pick up a book specifically about climate change, but with a nurturing approach that meets them where they are, they are ready to take a few steps forward in their climate awareness.

5. Competitive Titles

Wilder Weather adds depth to collections of books about Laura Ingalls Wilder, historical weather and climate events, historical disasters, and living in the Great Plains and Midwest. Readers of such books already enjoy a depth of knowledge about the life of Laura Ingalls Wilder, the rich history of the Midwest and Great Plains regions, and historical weather and climate events that shaped those regions. *Wilder Weather*, like these books, is grounded in historical narrative, while introducing scientific concepts and adding clarity to weather events that shaped the lives of Laura Ingalls Wilder and others.

- *The Beautiful Snow: The Ingalls Family, the Railroads, and the Hard Winter of 1880-1881* by Cindy Wilson. Beaver's Pond Press, 2020, 376 pg.

  The Beautiful Snow focuses on the impact of the winter of 1880-1881 on railroad operations and explores the downstream impacts on the Ingalls family and similar families, as well as De Smet and similar communities. The book addresses specific weather events during the Long Winter, relying heavily on newspaper reports and the manuscripts and earlier drafts of Wilder's books, but it does not examine the weather from primary-source or official weather observations, nor does it explore the causes of the weather events; instead, it leads readers toward *Wilder Weather* to fill those gaps. *The Beautiful Snow* and *Wilder Weather* are a delightful and complementary pairing, as my expertise in the science and historical weather resources complements Wilson's expertise in railroad history and newspaper archives.

- *Prairie Fires: The American Dreams of Laura Ingalls Wilder* by Caroline Fraser. Picador, 2018, 656 pg.

  The Pulitzer Prize-winning success of *Prairie Fires* demonstrated the fresh and lively interest in the historical and cultural context surrounding Laura Ingalls Wilder's books and life. *Wilder Weather* fortifies *Prairie Fires* by adding depth to the weather, climate, and environment around Wilder throughout her life. Fraser's book focuses on the political and historical context of Wilder's life and the places she lived in a mainly chronological framework. Like *Prairie Fires*, *Wilder Weather* focuses on the world around Wilder's stories by exploring the weather and climate events around her.

- *Boom Town: The Fantastical Saga of Oklahoma City, Its Chaotic Founding, Its Apocalyptic Weather, Its Purloined Basketball Team, and the Dream of Becoming a World-Class Metropolis* by Sam Anderson. Crown Publishing, 2018, 448 pg.

  Boom Town is a book that could accompany *Wilder Weather* on the bookshelf – a history, rooted in a specific place and time, that connects outside subject areas – including weather – to its core focus on Oklahoma City. The weather and climate of a place are foundational to the people who live there, and they shape the history of that place uniquely and sometimes traumatically. *Boom Town* attracts a similar profile of readers to the target audience for *Wilder Weather*, as both appeal to interest in intersections of history, cultural icons, and weather in the central United States.

- *The World of Laura Ingalls Wilder: The Frontier Landscapes that Inspired the Little House Books* by Marta McDowell. Timber Press, 2017, 390 pg.

  In a similar vein to *Wilder Weather*, *The World of Laura Ingalls Wilder* investigates a component of the setting of Laura Ingalls Wilder's books and life. Readers drawn to *Frontier Landscapes* to learn more about the natural setting around Wilder's homes will find themselves drawn to *Wilder Weather* as they look from the ground to the sky. Both books probe the scientific setting of Wilder's books and life, in different but complementary disciplines, to deepen knowledge about the context of Wilder's books and life.

- *Rain: A Natural and Cultural History* by Cynthia Barnett. Crown Publishing Group, 2015, 355 pg.

  Using rain as the centerline of the book, Barnett pulls together history, scientific knowledge, popular figures, art, literature, and more to merge the cultural, artistic, and scientific concepts of rain. With lyrical passages that highlight the sensations of rain, as well as researched pieces that offer evidence, *Rain* connects weather to common experiences and shared cultural history. *Rain* offers a similar style and delivery to *Wilder Weather* in providing information about a scientific concept from narrative perspectives, leading into climate change subjects as gently as a Seattle drizzle.

- *Pioneer Girl: The Annotated Autobiography* by Pamela Smith Hill, editor. South Dakota Historical Society Press, 2014, 472 pg.

The 2014 release of *Pioneer Girl* tapped a latent interest in Laura Ingalls Wilder and the stories behind her books that exceeded publishers' expectations, as the book required immediate and large reprints (from 15,000 to 150,000 copies!) from a small academic press to meet demand. Hill framed Laura Ingalls Wilder's first-draft "Pioneer Girl" manuscript (available at the Herbert Hoover museum in West Branch, Iowa) with annotations and notes to more fully tell its story. Readers seek this book for its documentation of events described in Wilder's manuscript, leading them to search for additional books and information that also document those events. As they search for more information about the facts documented in the annotations, *Wilder Weather* provides the only supporting information on the weather, climate, and environment that readers seek after *Pioneer Girl* raises their curiosity.

- *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants* by Robin Wall Kimmerer. Milkweed Editions, 2013, 392 pg.

For many readers, it is important to bridge from what they know and understand, through a trusted voice, to reach the subject of climate change. Just as *Braiding Sweetgrass* is "about" the changing vegetation around her, reaching conclusions about climate change as a root cause of disruption to sweetgrass and the traditions around it, *Wilder Weather* is about the weather around Laura Ingalls Wilder and bridges to climate change as a root cause of differences in that weather from Wilder's era to now. Kimmerer imparts wisdom about climate change and its impacts on the world around her by building trust as a narrative voice, beginning with her indigenous roots and the vegetation that was important to her heritage

before leading her readers into the climate and environmental pressures affecting sweetgrass (and the environment more broadly).

- *The Children's Blizzard* by David Laskin. HarperCollins Publishers, 2005, 336 pg.

Years ago, in a personal conversation, the renowned author David Laskin informed a young and enthusiastic me at a book signing at the American Meteorological Society's annual meeting that he had debated whether to write about the 1888 Children's Blizzard or Laura Ingalls Wilder's Long Winter. I told him I was glad he chose as he did! Laskin's foundational work on the Children's Blizzard brought the event into public conscious. While the book's publication is now over 16 years old, it is a topic that resurfaces often, as in Melanie Benjamin's historical fiction of the same name (Delacorte Press, 2021). *Wilder Weather* picks up the story of the Long Winter of 1880-1881 that Laskin left behind. As readers often confuse the two events, the pairing of the two books will round out the story of each one, giving them distinct voices.

6. Marketing Plan and Platform

The old adage is true: everyone likes to talk about the weather. It is, after all, something we all have in common. It turns out that people like to talk about Laura Ingalls Wilder, too, as measured by the recent successes of Caroline Fraser's *Prairie Fires* biography in 2018 (awarded the Pulitzer Prize for nonfiction in 2019) and the PBS American Masters documentary "Laura Ingalls Wilder: Prairie to Page" in 2020 (nominated among the series for an Emmy in 2021). Mobilizing a combination of outlets ranging from social media to traditional media connections to in-person events to personal connections, I will directly reach tens of thousands of potential readers, and that does not include word of mouth and targeted marketing efforts to expand the circle.

Internet and Social Media

I have over 4,600 Twitter followers (@windbarb) and a widespread network of connections on Facebook groups and pages, stemming from special interests in Laura Ingalls Wilder, weather, Midwestern and Great Plains history and communities, and writing. I also have a growing following on my own "Wilder Weather" page, giving me a robust and expanding platform from which to build anticipation for *Wilder Weather* before its release and promote it after publication.

Social media will be a valuable marketing platform for *Wilder Weather* through Twitter reach and Facebook networks. I will tap into the social media communities with the following strategies:

1. Expand content of wilderweather.com to include about-the-author, contact information, and weather resources for Wilder fans sections, as well as book announcement and pre-sale information leading up to book release and purchasing information after release, embedding connections to and among social media sites. Include weather forecast and warning widgets for each home site on the website. Initiate an opt-in newsletter to add direct contacts.

2. Use questions, teasers, and time-sensitive events (i.e. ongoing weather events similar to those Wilder experienced) on Twitter @windbarb and Facebook @Wilder Weather to engage potential readers directly. The strategy has engaged LauraPalooza attendees successfully in the past as they provide input on questions they would like me to answer in presentations at upcoming conferences. The input leads to audience buy-in and intrigue, inviting readers to be a part of the story and find their questions answered in the book. It also provides an avenue for channeling actionable weather safety information to potential readers.

3. Customize announcements and information on Facebook groups and pages in which I am active leading up to publication and ahead of appearances, especially ones that are relevant to the "genre" of particular groups. For example:
    - In the group "Remembering the REAL Laura Ingalls Wilder" (6,900 members), I will post book release images and announcements.

- In the group "South Dakota History of Cities, Towns, places and people who made it great!" (60,000 members), I will announce both publication and speaking engagements in the state.

4. Build Instagram following on currently underutilized @windbarb account, moving it toward becoming the only one of my social media accounts that is specifically an author account. I will post photographs that won't make it into the book or that support the book, such as pictures of weather phenomena, historical documents and equipment, and vistas of the locations in the book. Also, I will post insights on the writing process.

Traditional Media, Publications, and Podcasts

Since 2010, I have presented *Wilder Weather* material at dozens of conferences to thousands of attendees in the fields of meteorology, history, education, and even at LauraPalooza, the conference for research related to Laura Ingalls Wilder. I have published *Wilder Weather*-related work in academic journals, including "The Long Winter of 1880/81" in the *Bulletin of the American Meteorological Society*, one of the top academic journals in meteorology.

These ongoing presentations and publications have built interest in and attention to the topic, resulting in several national-level media features. These include traditional media outlets like *The Weather Channel*, *USA Today*, the *Washington Post*, and state PBS affiliates, as well as the Penn State University-broadcast TV show "WeatherWorld" and other local newspapers.

I have been interviewed on the podcasts "Weather Geeks" (produced by *The Weather Channel*), "Weather Brains," and "Trundlebed Tales," and I have appeared on expert panels

alongside Dean Butler and Alison Arngrim ("Almanzo" and "Nellie" in the 1974-1982 TV series "Little House on the Prairie"). Additionally, my research on the Long Winter has been featured on podcasts "The History Guy" and "Warm Regards." I have been quoted hundreds of times for numerous weather and climate topics by a wide range of print and online media and have been featured in dozens (hundreds?) of recorded and live radio and TV interviews. I have a *Medium* site and a personal blog, and I have guest-blogged for "Little House on the Prairie" and "Beyond Little House."

Capitalizing on the name recognition for both myself and *Wilder Weather* research, I will:

1. Follow through already-extended invitations to contact *USA Today*'s Doyle Rice, PBS outlets in Wisconsin and Michigan, and *The Weather Channel* when *Wilder Weather* is ready for release. I also will reconnect to other TV, radio, and print outlets that have featured my work in the past. I will let them know that I can now expand on the topic that they featured or can speak to other topics featured in *Wilder Weather*.

2. Write articles for digital publications with features and behind-the-scenes looks at *Wilder Weather*, including cut material, personal essays that focus on my perspectives of being the detective in search of weather and climate answers, and highlights to invite readers to the book for further information. Specifically, I will write articles such as:
   - "Top 5 Weather Events in Laura Ingalls Wilder's Life" to tease the prominent weather events (and maybe a "surprise" one that is less well-known),

- "Hail Safety, or How to Not Get Knocked Out By Hailstones" to connect the hazardous weather from Wilder's books to current weather safety information,
- "Meteorologist on the Prairie" to tell some of the story of how a meteorologist came to start researching weather in Wilder's books.

3. Seek guest appearances on podcasts that include ones I have already visited and others that broaden the audience reach to include history buffs, Midwest and Plains enthusiasts, and popular science fans. I will target podcasts such as "Stuff You Missed in History Class," "The Story Collider," and "The History of Literature."

Wilder Connections and Weather Connections

Many of my peers in the Laura Ingalls Wilder community themselves have large platforms, with active potential for re-sharing book information to reach exponentially larger audiences. My personal connection to many in this core group includes recognized leaders like William Anderson, Dr. Pamela Smith Hill, and Nancy Koupal who have authored or edited numerous books on Wilder and conducted primary-source research. I have confirmed blurbs and support from:

- William Anderson (Wilder biographer and historian)
- Dr. Pamela Smith Hill (Wilder biographer)
- Cindy Wilson (author of *The Beautiful Snow*)

Many meteorologists have a strong interest in weather history and, combined with a personal connection to their colleague, are candidates both to read the book and to share it in their own circles. I have networks in meteorology, climatology, and the related field of science communication, and this book will be an example of reaching a specific non-scientist audience to communicate about the scientific subjects of weather and climate. Key high-profile supporters and blurb writers include:

- Dr. Katharine Hayhoe (author of *A Climate for Change* and *Saving Us*, Chief Scientist at the Nature Conservancy, Distinguished Professor/Endowed Chair at Texas Tech University, and winner of the American Geophysical Union's Climate Communication Prize and the National Center for Science Education's Friend of the Planet award)
- Dr. J. Marshall Shepherd (writer, Distinguished Professor at University of Georgia, and TV and podcast host at The Weather Channel)
- Dr. Michael Mann (author of *The Hockey Stick and the Climate Wars*, *The Tantrum that Saved the World*, and others; Distinguished Professor at Penn State University, and winner of the American Geophysical Union's Climate Communication Prize and the National Center for Science Education's Friend of the Planet award)
- Bob Henson (author of *The Thinking Person's Guide to Climate* and writer for Climate Central)

Furthering the successful use of my professional and personal networks to promote my *Wilder Weather* marketing strategy, I will:

1. Present content and promote the book at national conferences like the American Meteorological Society and the National Weather Association, as well as regional conferences in the Midwest and Great Plains, focusing on relevant topic areas like history, weather, and education. Many of the sponsoring organizations of these conferences support book awards for which I will apply, adding professional support and recognition to *Wilder Weather*. I will combine the presentations with on-site book signings.

2. Leverage the network of Laura Ingalls Wilder historical homesites, museums, and libraries, as well as other national and regional historical sites, museums, and libraries, to conduct readings and signings. Because I am physically located in Nebraska, centered among a half-dozen Laura Ingalls Wilder home sites and museums, I can attend a wide range of events at relatively low cost. In a reciprocal relationship, I will draw attendees to the home sites while they advertise appearances, bringing foot traffic that benefit the home sites and museums as well as potential book sales, making the home sites and museums willing hosts of such events.

3. Engage with regional entities like the Center for Great Plains Studies at the University of Nebraska. Publish academic articles in journals like *Middle West Review* and attend the conference of its supporting organization, the Midwestern History Association, to draw attention to *Wilder Weather.* Potential topics include the many weather and climate events and how they impacted the lives of Wilder and others. In a similar vein, I recently

published an invited article, “Little Drought on the Prairie,” in the *Victorian Review* (Johns Hopkins Press).

7. Table of Contents

Prologue

The prologue anchors and orients readers to the places and time span of Laura Ingalls Wilder's life with a brief biography, introducing them to Wilder's world. It provides a conceptual overview of the process of investigating weather and climate events.

Part I: The Long, Hard Winter of 1880-1881: The First Mystery

Chapter 1. Record Keepers and Storytellers

The picture of weather history in the U.S. is filled in from the jigsaw pieces of observations that records keepers and storytellers have taken through the years. This chapter introduces those people and their legacy, with a peek at the tools and rules of their work. Along with the farmer who volunteers every morning, the civil servants tasked with observations several times per day, and the indigenous people who kept counting calendars and winter counts, residents like Wilder herself add letters and journals to the records and tell the weather stories. Readers learn how the many pieces of information fit together to clarify the picture of past weather and climate.

Chapter 2. Hard Winter Reconstruction

This chapter recounts the events of the Hard Winter of 1880-1881, drawing from Wilder's stories in *The Long Winter* and supported (or contradicted) by evidence from weather records. A synthesis of weather records and Wilders' (and others') stories allow a deep plunge into accurately recounting the events of that winter. Pairing the records to Wilder's own words

establishes her credibility as a witness to weather and climate events, and it also identifies potential gaps in her weather narrative.

Chapter 3. Culprits and Chances

Continuing to investigate the "case" of the Hard Winter, this chapter uncovers and explores the weather and climate drivers of the Hard Winter of 1880-1881 as the "means" and "motive" in creating the events of the winter. While Chapter 2 provides what happened, Chapter 3 explores why these weather events happened and why they brought such devastating impacts to the Ingalls family and the town of De Smet. The investigation incorporates the human and societal factors that added to the vulnerability of the Ingalls family and the town of De Smet to the unusually severe winter. Readers put together how several factors can converge to create hardship.

Chapter 4. Context and Comparisons

Building from the "what" of Chapter 2 and the "why" of Chapter 3, Chapter 4 adds clarity to "how bad," delving into how the Hard Winter of 1880-1881 ranks in severity among other winters on record in the Midwest and Great Plains. The method of comparing winter season severity, developed by the author foundationally for comparing the Long Winter to others, is itself a story of records keeping and storytelling. Even winters that rank nearly equal in severity can have widely different impacts in a given place and time. It turns out that the Hard Winter was not the hardest winter, by the numbers, that Wilder endured, which leads readers into the next chapter and section to learn more about the winter that technically ranked as most severe.

Part II: Wilder Weather through the Seasons

Chapter 5. Cold Snaps and Big Snows

Cold is relative, and sometimes relatively cold events in otherwise warm times of year can have a steep cost. Using weather records and Wilder's stories, this chapter invites readers to investigate other cold-weather events in the Little House books, including: the other winter in Wilder's experience that ranks as severe as the Hard Winter, as identified in Chapter 4 (and why its impact doesn't match the Hard Winter in Wilder's stories), the sugar snow in *Little House in the Big Woods*, the ice break-up of Lake Pepin at the beginning of *Little House on the Prairie*, the July 4th freeze in *Farmer Boy*, the "cold and miserable" journey to Burr Oak, Iowa, and the cold snap as Wilder commuted home from the Bouchie ("Brewster") school in *These Happy Golden Years*.

Chapter 6. Rivers, Freshets, and Floods

Through the range of events, readers explore different types of floods – slow-moving compared to fast-rising – and the risks and impacts that they carry. Using weather records and Wilder's words, readers investigate flooding and high-water events in and around the *Little House* books, including: the "freshet" season as in *On the Banks of Plum Creek*, the sudden rising water at a river crossing in *Little House in the Prairie*, the swollen rivers and muddy roads that followed the Hard Winter, and one of the few weather stories where the evidence and Wilder's words do not match up, with Mr. Edwards crossing a swollen river to bring Christmas presents in *Little House on the Prairie*.

Chapter 7. Electric Storms

Some of the most frightening weather strikes in the form of the storms that hit in the warmer seasons – loud thunder, gusty winds, tornadoes, and hurricanes – and the safety measures for these threats have changed through the years. Using weather records and Wilder's words, readers investigate lightning, thunderstorms, and even hurricanes in the *Little House* books, in Wilder's life, and in places important to the Ingalls and Wilder families, including: the ball of fire (ball lightning) in *On the Banks of Plum Creek*, a vividly accounted tornado in *These Happy Golden Years* that happened to have been extensively documented elsewhere, the hail storm in *The First Four Years*, a tornado that struck their Rocky Ridge farmstead in Mansfield, Missouri, in the 1940s, a tornado that destroyed the town of Manchester, South Dakota, in 2004, and Rose Wilder Lane's brushes with the disastrous Long Island Express Hurricane of 1938 and Hurricane Beulah in 1967.

Chapter 8. Prairie Fires

Fires have an important role in prairie ecology, even as they can threaten human-built structures. Using weather records and Wilder's words, readers investigate wildfires in and around the *Little House* books, including: the prairie fire in *Little House on the Prairie* that likely was not as sinister as the family feared, a grass fire that threatened the family in *On the Banks of Plum Creek*, and a prairie fire that encroached on the farmstead of the young Wilder family as drought beset the region in *The First Four Years*.

Chapter 9. Droughts on the Prairie

"Drought" itself is a tricky label to apply, and its definition is not as clear-cut as other weather and climate hazards. Droughts have caused mass migrations of residents through history,

including the Wilder family, which readers also will explore. Using weather records and Wilder's words, readers investigate droughts that affected the Ingalls and Wilder families in and beyond the *Little House* books, including: drought (or was it?) in *On the Banks of Plum Creek*, severe drought in South Dakota in the late 1880s to early 1890s, and the far-reaching effects of drought in the Dust Bowl years of the 1930s.

Chapter 10. Grasshopper Weather

The background weather and climate during the locust infestation connects to the ecology that supported the rise and fall of the locust. Changes in either climate or land use can cause notable, observable impacts, such as the eventual extinction of the Rocky Mountain locust. Using weather records, Wilder's words, and other historical accounts, readers explore the weather aspects, in particular, of the Rocky Mountain locust infestation of the mid-1870s, as described in *On the Banks of Plum Creek*, including the role of both observed and perceived weather and climate in the locust infestation.

Part III: Weather Then, Now, and Future

Chapter 11. Auld Lang Syne

The average weather – that is, the climate – of Wilder's homesites is not the same today as it was in Wilder's days. Wilder's own words demonstrate how humans affect and interact with the climate, with her perspective leaning on the changes that result from planting or clearing trees, plowing, and other land-use changes. Wilder herself knew that human activities can influence the climate of a region, and her words, too, provide evidence of climate and land use past and present. This chapter takes the important step of taking readers from where they may be most

comfortable, rooted in their memories and nostalgia, and leading them toward the current and future climates.

Chapter 12. Records, Stories, and the Future

The records keepers and storytellers pulled together pieces of the weather puzzle to give a picture of the weather of the past, lending credibility to modern understanding of past climate and how the picture is different in the current climate. Readers have put their trust in these records and stories, as well as the picture they have collectively created about past weather. The chapter will pull together the multiple sources of information that support conclusively what scientists know today about climate change and how it will affect lives and livelihoods around those homesite regions. These include changes in what can be farmed or grown, what animals will thrive or move, and what hazards will threaten the homesites, placing the changes in the context of the world around these sites.

Chapter 13. The Ideal Climate

The Wilders sought an "ideal" climate in which to live, one that met their health needs and comfort – a search that will feel familiar to many readers. In fact, throughout the *Little House* books, folks moved locations to address their health, including the "cure for consumption" noted in *By the Shores of Silver Lake*. Ideal climates move as climate changes over time, however, and the ideal climate that the Wilders found in Mansfield, Missouri, is not there anymore. But for the Wilders, in that time and place, they found the comfort of the climate they sought. The chapter suggests where the ideal climate for the Wilders exists now, as climate has changed, and where it

will be in the future, inviting readers to ask what their ideal climate is now and where it might be in the future.

Epilogue (Summary)

The epilogue brings readers to the end of their weather and climate journey through Wilder's eyes. It stokes curiosity by opening the curtains for a peek into the process of investigating weather and climate, and it ends by inviting readers to join the investigation themselves as records keepers, storytellers, and investigators.

Appendix A. Timeline of Weather-Related Events

A timeline of and around Wilder's life specific to key weather events, signposted by other well-known events in Wilder's life, such as the dates of her families' moves.

Appendix B. Weather Almanac for Ingalls and Wilder Homes

A resource for current and past climate information at all known homesites (or, more specifically, at the closest observation stations to those sites). This information will allow easy comparison of past and present climates and also will help guide readers on what kinds of average weather conditions they can expect and types of weather hazards that can occur if they visit the homesites.

Appendix C. Weather Glossary

A glossary for weather and climate terms to support readers' journey learning about weather and climate phenomena in Wilder's books and life.

8. Sample Chapters

Chapter 1. Record Keepers and Storytellers

Chapter 5. Cold Snaps and Big Snows

1. Record Keepers and Storytellers

All that we know about past weather is known because the records-keepers and storytellers recorded it.

Whether it was in a passage of a journal or letter, an official weather observation taken by a trained observer, or a graphical depiction by a Native American storyteller, our weather is archived into history by the records keepers and storytellers who took the time to record the weather. Our climate - the average conditions of our weather in the past, our weather now, and our weather in the future - is drawn by the pencils, paintbrushes, and keyboards of thousands of humans who included weather in their stories and routines. While oral histories have helped fill some gaps, such stories can only fill in the gaps when someone shares them. In other words, whether on video, paper, or some other medium, someone recorded it.

Collectively, the millions of weather observations in history paint a picture of the weather in the background and at the forefront of our lives. The picture will never be complete, or uniform, or sharp and clear everywhere. The observations and records are the tiniest pieces of an enormous jigsaw puzzle, dumped on an expansive table. The pieces are waiting to be sorted, grouped, connected until some part of the picture begins to take shape. With enough pieces joined, we can begin to discern the picture they make. Even with a few gaps and missing pieces, we can see the weather history (climate) patterns emerge, and we can see the bold strokes of big weather events when weather rises to the foreground.

February 1937: "There is snow over everything and the prospect good for more to come."

In a letter dated February 5, 1937, Laura Ingalls Wilder wrote to her daughter, Rose Wilder Lane, about the recent weather, amid an anecdote from "Manly" (Almanzo Wilder, her husband) that she thought may be useful for storytelling in her *Little House* books. Her weather account lacks the precision of an instrument weather observation, but it tells about living with the weather - how it looked and felt, how it fit with life around it. Wilder's letter, dated on February 5, had been written over several days prior to its send date, a common practice in the era of long letters that connected far-flung family and friends. This passage was under the header "Tuesday morning," which would have been February 2 that year.

1937-02-01, Max Temperature 28, Min Temperature 12, Total Precipitation 0.12, Snowfall 1.0

Though decidedly less descriptive, the instrument measurements at nearby Springfield, Missouri, confirm a fresh snowfall on February 1, 1937. Wilder might have thought the prospect for more snow was good, but it materialized as just a trace of snow (visible but not enough to measure) in Springfield on February 3, with no additional measurable snow until February 27.

Wilder's words, combined with the official weather records, tell of a cold and snowy start to February 1937 in southwestern Missouri. The picture comes into clearer focus because we have both the numbers and the images. The evidence provided by both Wilder and the weather observation, when combined, lead to a confident conclusion, even though Wilder's Rocky Ridge farm in Mansfield, Missouri, was around 50 miles from the official observing site in Springfield, Missouri. There will always be missing pieces, and yet we can tell the weather stories with the pieces that we have.

The Backbone of Weather Records

With the livestock checked before the sun peered over the horizon, a farmer walks to his wide-open backyard. In the middle of the space, a white plastic cylinder about the size of a coffee can with layers like a stack of upside-down plates, mounted head high on a metal pole, reflects the first pink of sunrise. The fresh snow squeaks and crunches under his boots as he approaches his final chore before breakfast. He takes a metal stick with a wooden handle hanging from a nail next to the back door, labeled with tenths of an inch instead of fractions like 1/2 and 3/4, and measures the fresh snowfall on a white PVC board about 18” by 24” and marked with small flags so he can find it when the snows are deep. Stooping low to read the ruler closer to eye level, he pokes the ruler through the snow several times, mentally averaging the readings, and then clears the board and sets it back between the flags. He measures again on a second board, also marked with flags, that he does not clear. Then he walks through the backyard and pokes the stick in about ten places, also mentally averaging the readings. The backyard measurements match up to his second board, adding confidence to his numbers for total snow depth. He commits the measurements of both boards to memory, then takes a metal cylinder about 8” in diameter out of the middle of a tripod-like metal support stand, tucks it upright into the crook of his elbow, and trudges back inside.

Shaking off his coat and gloves, he sets down the metal cylinder, then writes his snow measurements on a scrap of paper from a pile that always sits by the back door. He runs the kitchen sink faucet until hot water pours out, then grabs the clear plastic tube that he keeps next to the sink in winter, about two inches in diameter and marked every inch with increments every tenth of an inch. The plastic tube fits inside the metal cylinder in the warm season, when he

doesn't have to melt snow, with a metal funnel that fits over top of both the outer and inner tubes. He fills the tube with precisely 0.50 inches of hot water, then pours it into the metal cylinder. He swirls the metal cylinder until its contents turn from snow to slush to water, using his free hand to take a long pull of hot coffee. When all the ice has turned to water, he pours the liquid through the funnel and back into the smaller, clear plastic tube, setting it flat on his counter. He takes a slim metal ruler, marked in hundredths of an inch, and dips it into the plastic tube until it touches bottom. The water darkens the charcoal-gray metal to black, marking the total liquid. He writes that number down, too, subtracting the half inch he had added to melt the snow. Finally, he clicks a few buttons on a digital temperature readout on the counter to view the maximum temperature, minimum temperature, and current temperature, jotting each of these on his paper, before clearing the memory on the readout to reset it for another day. He sits down at his desktop computer at his desk next to the dining room table, coffee in hand, and logs into a website. He types each reading carefully, checking twice against the numbers he wrote on his scrap of paper. He submits the report and finally can sit down to breakfast.

The farmer is a trained volunteer weather observer in the Cooperative Observer Program, or COOP - one of about 10,000 volunteers who has committed to serve his country by taking daily weather observations at 7:00 AM every day, rain or shine, hot or cold. Established in 1890, COOP observers have kept records of temperature and precipitation that form the backbone of our country's weather history. Many observing sites have passed through generations of family members, often on family farms. Other COOP sites are at wastewater treatment plants, state and national parks and research grounds, city suburbs, and outskirts of small towns - where Americans live, work, play, and grow their food. Observers earn awards for their longevity of service and the quality of their measurements. They form a camaraderie with the National

Weather Service technicians who visit a couple of times per year to inspect and clean their gauges, make repairs, upgrade systems, and check the integrity of the observing site. The technicians make sure that grass, trees, and new buildings are not encroaching on the observing site and changing its climate without the change being recorded.

This farmer's observing location may have been passed down for generations. Before him, his parents or grandparents would have recorded their observations by pen and paper on a form, kept in a notebook and carefully tended. They would have read two glass thermometers - one filled with mercury, one alcohol. The two thermometers were hung in a white, wooden cotton region shelter - a structure about head high and about a cubic yard in volume, with slatted sides to let air flow and a door to access the instruments. While the digital thermometers are more common and preferred today, several observing sites around the country still use the glass thermometers in wooden shelters. Observers read maximum temperature from the mercury thermometer, which pauses at the highest temperature of the day until the observer spins down the mercury to reset it, flinging the thermometer like the spinner of a board game. Then, the observer uses an alcohol thermometer to read the minimum temperature, with an "index," or marker, that the alcohol pushes down to the lowest reading. The observer resets that value by moving the marker back to the current reading, also recording the temperature at observation time from the alcohol thermometer while they reset it.

Precipitation measurements were the same a hundred years ago as they are now, as manual observation remains the most common for daily observations. The inner tube of their cylinder would have been brass instead of plastic, with the same calibrated ruler to measure the liquid. The metal outer tube would have been the same as modern equipment, and snowfall would have been measured with a ruler on the best available surface.

Snowfall readings were and still are taken with a ruler marked in tenths of an inch (while standard rulers are marked in eighths or sixteenths of an inch), to the nearest tenth of an inch, on a standard surface such as a white-painted wood or white polystyrene board dubbed a snow measurement board, or "snow board" for short. Observers are instructed to take ten measurements and average them to give a best estimate of snowfall. Observers clear the board every six hours to minimize the effects of compaction. Snow depth also is measured by a ruler, by a human, over a standard snow measurement board. For snow depth, the snow is not cleared from the board, but rather remains until it melts away. Snow depth is measured to the nearest inch. When the snow falls in relatively still conditions, those measurements are usually fairly consistent, and the snow measurement is more reliable. In windy conditions, those measurements could vary widely, and overall confidence in having one true, representative snowfall measurement is far lower. In addition to the snowfall amount, observers collect the snow in rain gauge cylinders and melt it for a liquid equivalent of the precipitation that fell. Though there are still challenges in windy conditions - snow can be blown over the cylinder rather than falling into it - the liquid equivalent measurements are considered more reliable over time and are more commonly used for climate analysis than their frozen counterparts.

The COOP observers would mail the forms every month to their National Weather Service office, who would check the forms for accuracy and compare to the forms of others for consistent. They would write letters or make phone calls to clear up any illegible or potentially erroneous observations. Then the National Weather Service office would mail the collection of forms from all observers that month to the National Climatic Data Center, now known as the National Centers for Environmental Information. The climatologists there would again quality-control the forms, then carefully file and archive them. Anyone seeking information

about past weather observations could write or call the National Climatic Data Center office and request copies, a painstaking and time-consuming process even with the most careful filing systems.

Today, the National Weather Service office receives digital COOP observer reports nearly instantaneously via the internet. They can quality-control the day's observations right away, then look at the whole month collectively. They still transmit digital forms to the National Centers for Environmental Information at the end of a month, where the digital records still are quality-controlled again and carefully archived. The few observers who still record observations on paper forms still mail those to their National Weather Service office, who quality-controls the data and then mails the paper forms to the National Centers for Environmental Information, where they are keyed and put online for digital access. The data records are much more accessible now, requiring only an internet connection and a bit of knowledge about which website to visit.

Sites close as observers die, become unable to take readings, move, change their land use, or simply grow weary of the daily task of weather observations. The National Weather Service will search for neighbors who may be willing to pick up the duties and live close enough that the station move is negligible in the climate records. Often, though, when a site is closed, the next one is too far away to be considered a continuous record. It has its own starting date, its own history, its own records. The move is a break in the climate records - both sites produce useful data, but a longer record is always preferred to a fragmented one.

First-Order Stations

The COOP observers may be the heartbeat of the modern weather records, but they are not the only sources of data. The U.S. Government keeps climate records around the country at "first-order stations" - the primary weather observation sites near bigger towns and cities that define the climate records and history of the country. They are sprinkled around the country, more or less evenly spaced, though with large gaps in areas of rough terrain and low population. Some of the first-order station records date back to 1870 - or even earlier - while others are just a few decades old. The locations may have been relatively steady for decades to centuries, but the keepers have often changed many times, from Army civilians to government scientists to automated equipment.

U.S. government weather observations began with the establishment of the U.S. Army Signal Corps in 1870. The officials assigned to weather observing sites were almost exclusively men - civilians, often single, many relatively untrained in weather before their service. While some were fortunate to be assigned to more settled and established cities like Boston or Galveston, others were sent to outposts in newer and more outlying locations like Omaha or Dodge City. The observers were charged with taking observations four times per day - every six hours - with no back-up observer providing relief. (There is some speculation that those who were married may have split duties with their wives. There is also some speculation that a few observers at least sometimes took their observations at bedtime and again at morning waking time and manipulated the times of their observations so that they could get a full night of sleep.)

Observers followed procedures to record temperature, precipitation, sometimes snowfall, air pressure, and sky cover, along with any other weather worth documenting in notes. The notes of these observers provided insight into storms, frosts and freezes, hurricanes, meteors, fog, floods, earthquakes, and just about any other phenomenon observed in the sky or on the ground.

They transmitted their observations via telegraph to a central headquarters in Washington, D.C., while keeping the written records locally to pass down to the next observer as they cycled through their staff. From the observations gathered in D.C., early meteorologists gathered and mapped the observations, making the earliest weather analyses and predictions.

Before climatologists knew how important it was that observation sites be consistent, stations moved several times across cities. Before they recognized that rooftops are not the best locations for temperature observations, many official sites in cities found the high points to get out of the shadows of tall buildings. Climatologists today know when these moves occurred and which sites were in substandard locations like rooftops, and they account for these when they construct the long-term climate history of our country. It makes their job more complicated, but not impossible, to trace the moves through the years.

In 1890, the federal government transferred its weather services into its new Department of Agriculture, under the U.S. Weather Bureau. Little changed in the operations of the Weather Bureau, especially related to taking weather observations, as observers continued to take manual observations, telegraph them to the central headquarters, and maintain meticulous written records on site. In 1940, the Weather Bureau moved again, this time to the umbrella of the Department of Commerce. While the workforce of meteorologists increased, especially in the 1940s in the throes of World War II, little changed in the practice of taking observations.

The scope of weather observations shifted dramatically with the emergence of airports in the late 1930s through the 1940s. From the beginning of commercial air travel, weather observations became inextricably linked to airports, a connection that continues to this day. Official observation sites moved from downtown city locations to the outskirts, where the large tracts of land needed for air travel were available. The moves created disconnects between old

weather records and new ones that climatologists spent years untangling, quantifying, and smoothing in later decades when scientists began to understand the importance of continuous climate records.

The federal weather enterprise moved within the Department of Commerce to the newly established National Oceanic and Atmospheric Administration in 1970, along with another name change: the National Weather Service (NWS). These remain the home and the name for the federal weather agency today. With the move to NWS, the workforce moved to becoming more professional. Meteorologists had to meet college degree requirements, and meteorological technicians often moved into NWS after military service, applying their knowledge of both weather and equipment systems to both take observations and tend to the equipment. The duties of observation services in the National Weather Service were, and still are, balanced between the positions of professional meteorologists and those of meteorological technicians, who are often military veterans with weather experience but do not have a college degree to meet the requirements of a federal meteorologist. The number of non-degreed meteorological technicians in today's NWS is dwindling as degreed meteorologists absorb the roles of maintaining observing systems.

With the National Weather Service's Modernization Plan in the 1990s, Automated Surface Observing System (ASOS) stations replaced paid human observers at airports across the country. Many airports at non-first order stations had already started to take automated weather observations, in the Automated Weather Observing System (AWOS) network, as early as 1979. ASOS stations at the first-order locations - the bigger airports - take more readings than AWOS sites, with higher quality equipment and occasional human input. The first ASOS station came online in 1992, with all first-order sites converted by 2004.

Automated weather observations are highly accurate - more so than humans, even, because the automated equipment can detect subtle changes that humans cannot. The observations provide information every few minutes, using precisely calibrated instruments that are checked and maintained routinely and diligently. Instruments can fail or provide false readings, but the error rate is no greater than with human observations. Over time, the small errors smooth out, leaving a reliable record. Temperature, dewpoint temperature (from which we can calculate relative humidity), air pressure, wind speed and direction are recorded by electronic equipment that measures in terms of resistance, conductivity, and interference. The automated observations note the visibility and the cloud ceiling height - that is, the height of the base of the clouds above - as a service to the airports they serve. The liquid equivalent of precipitation is measured with heated tipping buckets and weighing gauges, removing the need for a human eye.

Snowfall remains among the more primitive of weather measurements, as it is still measured by a human at all observation sites, even in this modern era, and even at the automated first-order observation sites. Even in modern observations, snow measurements can be among the least reliable of weather parameters, complicated by melting, blowing and drifting, and the surface on which snow is measured.

Modern weather observation systems provide consistency among observation sites across the country, ensuring that the weather is measured with the same instruments that have the same calibration standards, meeting requirements for the site to be free of obstructions, and reporting at consistent times of day. Combined with the COOP observations, the network of modern first-order observations provides a quality network of weather records - tens of thousands of pieces of evidence every day to support weather and climate stories across the country.

Forts and First Written Records

Before the U.S. Army Signal Service was established, Army outposts - sometimes called "frontier forts" - took some of the first recorded weather observations in the mid to late 1800s. Their efforts, though far less organized than the later Signal Service observations, were the earliest foundations of routine, instrumental weather observations in the United States. The observers usually were the forts' doctors, which was the most scientific occupation in an outpost military fort, and they kept their observations in written journals. Most outpost forts of any size kept records for at least some duration while they were occupied, though there are gaps during times such as battles and engagements, abandonment for a season, or records lost to time. Records exist from 1820 to 1892 for some 450 sites across the continental United States and Alaska. Excavated by modern climatologists, many of the old records from military forts have been collected and keyed into digital formats. The data, from the project dubbed the "19th Century Forts and Voluntary Observers Database," is abbreviated as "FORTS data."

Similar to the early COOP measurements, observers took temperature measurements with mercury and alcohol thermometers, and they measured rainfall in metal cylinders with calibrated rulers. FORTS observations often included wind and air pressure measurements. The jackpot sites even observed snow, and in a few rare instances, they actually measured and reported snowfall, a rarity in 19th century observations. Other sites sometimes included precipitation type, which is at least a step toward clarifying a fuzzy picture of precipitation type when temperatures hovered close to freezing.

COOP observers do not take wind measurements - only the automated observing stations do - but many FORTS sites did report wind direction and speed. Wind direction can be observed

with a wind sock, flag, or vane; 19th century observations were taken manually by an observer who eyed the direction, while modern wind direction is read and recorded digitally. Wind speed, by contrast, has been observed by myriad methods through the decades. Predecessors to modern anemometers required a human to watch and count the number of rotations of a device per minute to glean a wind speed, a dizzying task at fast wind speeds. Wind speeds also have been recorded by the extent and motion of a flag or tree branches in the wind and, where available, the roughness of the sea. In FORTS records, observers often recorded winds using either something like a Beaufort scale of wind force or using a measurement that equated wind to distance, presumably the distance an object may travel on the wind over a defined period of time. The observations lack modern precision, but they do give information on relative wind speeds that is enough to identify windier and calmer days. Combined with wind direction and even temperature and precipitation, we can piece together evidence to find storms and blizzards, cold fronts and warm fronts, wind chills, and hot and dry summer winds.

Barometers have measured air pressure through the years, another important means of piecing together weather conditions. A barometer can be fashioned out of virtually any liquid and slender tube, with many project templates available for curious children and grown-ups to build barometers at home. The aneroid barometer, invented in the 1840s, measured air pressure using a vacuum tube and expanding or contracting surfaces that move a needle on a gauge. This likely would have been the instrument used in 19th century observations, including at FORTS sites. Modern automated weather observation sites house electronic pressure transducers that use highly technical electronics and polymer tubing to measure atmospheric pressure and calibrate it to the altitude at the site.

While modern observers report the highest and lowest temperature in the past 24 hours, plus the temperature at the time of observation, FORTS observers sometimes recorded temperatures at predetermined times instead of (or in addition to) recording the maximum and minimum readings. The temperatures at fixed times are not likely to be precisely the highest and lowest temperatures, though they may be close. At different sites and at different times during their records, the observers reported temperatures at 7 AM and 7 PM local time, or at 8 AM and 5 PM and 11 PM, or 7 AM and 3 PM - in other words, the times of observation were inconsistent from site to site and even through the records at the same site. The 7 AM temperature is near the likeliest time of day for a minimum temperature to occur at most times of year, in the absence of weather that causes the temperature to drop instead of warm through the day. Maximum temperatures are even trickier, as they tend to occur closer to mid-afternoon (2-3 PM) in the winter and closer to late afternoon (4-6 PM) in the summer, meaning that an observation at a fixed time is unlikely to capture the maximum temperature through the year.

Observers took precipitation measurements at least once per day, sometimes more frequently. As in modern observations, the precipitation measurement included the melted equivalent of all precipitation that fell, whether it fell as rain, snow, ice, or a mix. Some observation logs carried a note of precipitation type, and in very rare instances, a measurement or estimate of snowfall was logged. These are indeed rare, though, and the reliability of any snow measurements in the FORTS database is questionable. They do lend confidence to precipitation being in the form of snow, as well as some measure of proportion of amounts, and thus any notes or observations about snowfall are coveted, even if the precision and accuracy are low.

Native American Winter Counts and Counting Calendars

Weather observations in North America began long before European-descended settlers arrived and established their long-term weather records. Many Native American tribes in central North America kept a pictorial calendar of their history, recorded on animal hides in spiral or row patterns and sometimes transferred later to cloth or paper. Their originators referred to these as “winter counts” or “counting calendars” - a means of passing a record of each year. Mostly begun in the 1800s, the calendar recorders may have backfilled their calendars with past events that had been passed along previously through oral histories, in addition to adding new events from the year of their creation forward in time.

Depending on the originating indigenous nation, winter counts and counting calendars used one or two pictures per year, highlighting the most unusual or remarkable event of the year. The events depicted included battles, killings, deaths of significant figures or significant numbers of people, disease outbreaks, hunger, animal (particularly horse) arrivals and departures, astronomical events, and weather or natural catastrophes. One event included universally across every known calendar or count was a vivid Leonid meteor shower in 1833-1834, labeled as some variant of “the stars fell” in many calendars. The presence of this event across all the calendars has allowed them to be dated and catalogued accurately.

Tribes of the Lakota nation kept “winter counts” - that is, a record from the beginning of one winter to the beginning of the next, not just events that occurred during winter. Among Lakota tribes, there are something like a dozen preserved and archived winter counts. Most calendars ceased between the late 1860s and the 1890s as the U.S. government violated treaties and eradicated indigenous customs, breaking apart tribal communities and removing or banning

the tools and practices used to keep the calendars. Among the latest-running calendars, the No Ears Lakota count continued until 1919-1920.

Because the calendars included a range of important events, only the most impactful weather events would warrant inclusion on counting calendars, and even highly impactful weather events could get bumped by significant cultural events. The absence of a weather event on the counting calendar does not indicate that it did not occur or was not important; rather, it indicates that something else was important that year, too.

Among the weather events depicted in the Lakota calendars, many counts for 1825-1826 depict a flood that drowned many camp inhabitants <REF: Stars>. In this event, the Missouri River rose quickly, drowning dozens of lodges of Dakota Indians. Also, the winter of 1865-1866 in several calendars is noted for many horses dying due to snow. In contrast, 1841-1842 is in the Lakota calendars as one of three events: a winter of deep snow, that the Oglalas got drunk and quarreled, or that Feather in his Ear stole many horses from the Crow Indians. At least one of the Lakota counts depicted harsh winter conditions (deep snows or extreme cold) in the winters of 1720-1721 (starvation in the winter), 1722-1723 (deep snow) 1747-1748 (froze to death during the hunt), 1773-1774 (blowing snow), 1777-1778 (intensely cold winter), 1827-1828 (deep snow), and 1852-1853 (deep snow). A count also noted a prairie fire in 1762-1763, at the root of the Brule tribal name.

Indigenous people were the original storytellers of the Midwest and Great Plains. They are the keepers of tradition Indigenous knowledge that continues to support weather and climate awareness in the region <REF: NCA4 TIK>. While many of their stories may have been oral histories that have been lost, their counting calendars provide the only written weather records

that predate European-descended settlement. Humans across cultures are wired to use storytelling to pass knowledge, regardless of how (or if) that knowledge is recorded.

Journals, Letters, and Newspapers

When verified with observations and other records, Wilder's narrative, too, becomes part of the body of evidence of weather and climate in her place and time. She is a part of the legacy of weather and climate observations. At the same time, it is important to remember that Wilder wrote historical fiction, and even though it was strongly based on her life experiences, it was not intended to be a historical record. For that reason, it is critical to evaluate every weather and climate anecdote, comparing it to other observations and records, before including it among the evidence.

For example, Wilder noted the temperature several times in her books, usually to the cold extreme. When she said it was "only twenty degrees below zero" during a Sunday sleigh ride party in *These Happy Golden Years*, was that a literal reading, or was that to distinguish it from the chilling, moody "forty below" conditions earlier that winter, as she taught school for the first time? Was that "forty below" a reading or a guess? After all, the character Almanzo does mention reading the thermometer at "forty below" before he left town. If observations can corroborate one of those temperature readings, readers can gain some confidence in the accuracy of the temperatures elsewhere in the book. If the weather records verify several of the readings, readers, historians, and weather researchers gain not only confidence in the temperatures; they gain a written history of the temperatures in a place with only sparse weather data. They gain signposts that help mark the dates and put the events of Wilder's books into a timeline, just as

they can use events from the books - like Christmas or other well-known dates - to signpost the weather events, too.

Sprinkled among the letters from Wilder to Rose Wilder Lane, her daughter, that have survived to the archives <REF: Hoover Library>, Wilder included occasional mentions of current weather. As both the daughter and the wife of a farmer, as well as an astute observer who had trained herself to use words to help her blind sister, Mary, visualize the world around her she was tuned to weather and its impacts - and her observations were not limited only to the *Little House* series. She kept her weather eye through adulthood.

In another (or same Feb 5 1937?) letter: "In Pa's book is a day by day record of weather for Jan, Feb, March 1886. Would it be of any use to you?"

If only the book had survived, it would certainly have been of use. Pa's book is believed to be lost, perhaps purged from the De Smet Ingalls home after Wilder's sister, Carrie, died in 1941 <REF: Bill A, personal communication>. While official weather observations compose the backbone of our nation's weather records, personal records such as journals and diaries have long helped researchers fill in the gaps between far-flung observing stations, especially in the early weather observing days when few official observing stations existed.

Citizen science remains vital to understanding and observing weather. Today, volunteer observers can purchase an inexpensive rain gauge and participate in the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network via www.cocorahs.org <CITE: CoCoRaHS>, which logs precipitation measurements from thousands of people around the United States. Rather than recording in paper journals that could be buried deep in boxes or lost

to the ages, observers record their precipitation totals on the internet, where they are stored digitally and are accessible to the world.

Maybe January 25, 1938, pg 3: "We have had a rain at last. Two in. of rainfall in one day and several other rainy days besides. The creek rose up and roared! It was a warm rain soaking into the ground. Sunday night it turned cold and all night and all day and night Monday the wind blew from the southwest like the norther we met in Texas. I never before saw a wind like it here. It would freeze the marrow in ones [sic] bones. That night the wind stopped and next morning it was only 4 above zero."

Indeed, January 1938 was a wet month in Springfield. The official records show 3.14 inches of rain through the month. Almost half of that total fell on January 20, with 1.50 inches of rain. Much of the rest fell on January 23-24, with 1.09 inches total for the two days. With a high temperature of 47 °F and low of 40 °F on January 20, it would be a stretch to call it a "warm rain," though. The 23rd was warmer, with a high of 53 °F and a low of 42 °F. The 24th had a mild maximum temperature of 52 °F, but the low temperature of 25 °F and trace of snowfall reported also would not be what most people think of as a "warm" rain.

We can use weather to trace when Wilder wrote the letter to her daughter, as well. She mentioned Sunday and its cold. Sundays in late January 1938 fell on the 23rd and 30th. We already noted that the 23rd and 24th saw mild high temperatures in the 50s, and the low temperature of 25 °F was chilly but not as cold as the feeling Laura conveyed. On the 30th, however, Springfield experienced a high temperature of 58 °F but a low of just 9 °F. On Monday, January 31, the high temperature was just 26 °F, with a low of 3 °F. These temperatures better

match the “freeze the marrow in ones bones” feeling Laura described, indicating that while Laura may have started the letter on January 25, she was adding to the letter several days later.

February 19, 1938: “It has rained steadily for more than a week, 3 in. in one day. The creek is roaring. Water is all over the highways and roads blocked at Ozark and Branson and Hollister. 12 ft. of water over the dam at Powersite. Up to the hotel on Rockaway beach. Snowed a little last night and looks like more rain.”

Wetter-than-average weather continued into February 1938 in Springfield, with a couple tenths of an inch of rain on February 6 and February 10. February 13-18, however, was especially wet. It rained on each of those days, totaling 3.84 inches in just six days. The wettest of those was February 17, with 1.57 inches of rain recorded in Springfield. Laura did not note it, but 6 inches of snow also fell on February 19 in Springfield. The combined rainfall from January-February 1938 of 7.67 inches was the 13th wettest on record in Springfield (1888-2021).

Wilder’s letters make it clear that she took careful note of the weather and its impacts and recognized the importance of the weather around her to her life. But her words are not the only ones written about weather in the Great Plains and Midwest in the late 1800s. Other residents of the time and place kept journals, penned letters, written town histories, and contributed newspaper highlights. De Smet, Dakota Territory (South Dakota), supported newspapers - the *De Smet Leader/De Smet News* - beginning in 1883. Newspaper clippings are rife with weather notes, though again, sometimes their accuracy needs to be verified with other data to tell the complete story:

"*The eastern and southern portions of the territory were submerged in snow and sleet week before last. Trains were blocked, boats driven to the banks, cattle frozen to death, and various other damage done. In this portion of the territory, while we had severe winds, no snow nor rain fell.*" - Ft. Pierre (SD) Weekly Signal, October 27, 1880

"*Light flurries of snow have been prevalent lately*." - Brookings County (SD) Press, November 18, 1880

"*Snowing hard again this morning.*" - The Weekly Signal, Pierre (SD), February 5, 1881

"*Since last Saturday morning the weather has been very fine, and under the influence of the sun considerable of our snow has disappeared, and should the present weather continue it will not be very long before our farmers can commence seeding.*" - The Egan Express, Moody County (SD), March 10, 1880

Wilder's books and letters add to the pile of tiny pieces of evidence that help complete the weather picture around her. As with any evidence, the experts - historians, meteorologists, climatologists, and others - must connect her words with the observations and words of other weather witnesses around her to clarify the picture of the weather and climate events. In some cases, the picture is not clear. Sometimes, there are more gaps than pieces, and the holes left behind shake our confidence in accurately retelling what happened in the weather in that time and place. Sometimes, the pieces of evidence conflict with each other, leaving us to untangle a reliable account and shaking our confidence that we will ever know for certain what happened.

But in many cases, when Wilder's words, the official observations, and accounts from other people all converge and tell the same story, we are left with high confidence in the true story of the weather around Wilder, in her place and in her time.

The evidence available from the wealth of historical weather data to complete the story of the Ingalls and Wilder families is scant and varies among the home sites. The Ingalls family pushed the edge of regions settled by non-Indigenous people and often lived in locations for just a year or two at a time. The first-order stations were widely scattered and just beginning to take observations, and most of their home sites did not have nearby COOP observers until well into Wilder's adulthood. FORTS observations were hit-or-miss in the years they took observations, as well as the weather parameters they observed. In some cases, the nearest observations were dozens to even hundreds of miles away. Even so, the weather records begin to fill in the gaps of weather information - to give pieces of the complete picture. The combination of all the available records add bigger-picture context and background to the weather stories in Wilder's books and life. By putting together as many of these pieces of evidence - pieces of the puzzle - as possible, the puzzle picture clarifies, and the truth behind the weather stories emerges.

5. Cold Snaps and Big Snows

In the northern climates where the Ingalls family spent most of Wilder's childhood, cold was inescapable, inevitable, and nearly intolerable. In the winters, their houses were not the cozy 70-75 degrees that many home thermostats keep today. At 70-75 degrees, most people are pretty comfortable in street clothes. At 65-70 degrees, they might feel better with a lap blanket. At 60-65 degrees, their feet may crave the comfort of slippers, and the lap blanket is pulled a little tighter around their waist, a little higher on their body.

Most people are not really comfortable, by day, in a house that is 60 degrees or cooler. They add layers of clothes and socks and try to cover up under blankets. If their hands are exposed to type on a computer, or knit, or write a letter, their fingers become chilled and stiff. On really cold days, when the temperature in the house is at the thermostat setting of blankets and slippers, ice creeps up the window panes, and condensation freezes around the frames, and it is not so distant to imagine drawing pictures on the frosted glass pane as Laura and Mary did in *Little House in the Big Woods*.

The inside of the Ingalls' home was so cold in the winters that water inside froze at night and had to be thawed in the morning. At times, they could see their breath indoors, indicating that the indoors temperature was around 45-50 degrees or colder. The kitchen stove might as well have been a candle compared to the vast cold encroaching on the house in the heart of winter. It simply could not keep the cold at bay.

For months during the longer winters, not just days, the Ingalls family home was frozen inside and out, an ice palace that did little more than block the wind from entering and the snow from falling on their heads. Some of their homes didn't even block the snow all that well. The family balanced on the edge of freezing throughout the Hard Winter, but they survived through

cold in other winters, too. They endured unimaginable cold with no relief, no warming stations, no break from the unending knot in their stomachs that accompanies a prolonged fight against bitter temperatures.

Chills crept in during the warm seasons, too. Cold can be absolute; a temperature of 40 degrees below zero is cold to any human's skin. Cold also can be relative. In the midst of a warm summer, temperatures in the 50s drive most of us to add a sweater or jacket, while we might shed the same sweater or jacket with temperatures in the 50s in January. A just-freezing temperature has different effects in January than it would in June.

July Freeze

"I never saw the corn grow so slowly," Father worried. He plowed the field again, and again Almanzo helped Royal to hoe the corn. But the little shoots stood still. On the first of July they were only four inches high. They seemed to feel that danger threatened them, and to be afraid to grow.

In *Farmer Boy*, the one book among the *Little House* series focused on Almanzo Wilder and his family, weather is the antagonist in just one event, on the heels of what Wilder describes as a seemingly cool start to summer. Corn growth lags Father's expectations, and his concern for the crop mounts. On the morning of July 4, the Wilder parents rouse their children to pour buckets of water over the corn, hoping to save it from a freeze in the pre-dawn hours. They labor for hours, watering about half the field before dawn, at Father's insistence that any plant not watered during the freezing temperatures would die when the sun touched it.

Could there have been a July 4th freeze in upstate New York during Almanzo Wilder's childhood? Would watering the corn save it, and would letting the sun touch a frosted plant kill it?

Even in the cool and snowy climate of upstate New York, and even in the colder climate of the mid to late 1800s, true freeze conditions in July are exceedingly rare. Among nearby long-term weather stations in Burlington, Vermont, Rochester, New York, and Buffalo, New York, records extend as far back as 1872, with no freezes noted in the month of July. But temperatures do fall into the upper 30s in July rarely in upstate New York and Vermont - less frequently in the modern climate than in decades past, but still in the range of possibilities. The temperature fell to 39 degrees at Burlington, Vermont, on July 6, 1962, and it has fallen into the 30s at Jamestown, New York, eight times since the 1920s. Those temperatures in the upper 30s could come with frost in low-lying areas on calm, clear nights. Up in the higher terrain of the Adirondack Mountains in eastern New York, temperatures at places like Saranac Lake and Newcomb fall into the 30s more frequently, and there are a few sub-freezing July readings on record. These are not representative of Malone, though, because they are so much higher in elevation.

The scant available observations available show that July in all of the years from 1866 to 1869 - close to the age of Almanzo's character in *Farmer Boy* - was mild, with temperatures as low as the 50s to 60s. Looking back just a little farther, though, draws in the summer of 1859. On the morning of July 4, 1859, temperatures at 7:00 AM were as cold as 48 °F in Burlington, Vermont, 52 °F in Rochester, New York, and 39 °F at Mount Morris (south of Rochester and east of Buffalo), New York. Though these temperatures also seem far from freezing, the weather observation at Mount Morris included the note "a frost in the lowlands!!" <REF: Rockland

Genealogy>. The diary of Nathaniel Arbuckle in rural Delaware County, in southeast New York, also noted the frost: "*This is the Glorious old fo[u]rth the Cannon is moaning all around us we had quite a smart frost last night Something I niver saw before on the fo[u]rth*" <REF: Arbuckle x2>. Delaware County and Mount Morris both are located well south of Malone. Delaware County is nestled in the Adirondack Mountains, but Mount Morris is not in the higher elevation - it is in a river valley.

The chill of the morning of July 4, 1859, found its way into newspapers and journals from New York to Kentucky.

From Rockland Co., NY (just north of New York City in southeast New York): "*A clear and bright sky graces the dawn. Cool weather. People wear overcoats and farmers hoe corn while wearing heavy clothing."* July 4, 1859

From Athol, Massachusetts: Monument "*dedicated on a bitter cold July 4, 1859. The event was well noted in local papers and the town's history…*"

From Bradford County, Pennsylvania (north central part of the state): "*July 4 1859 snow flurries Heavy or killing frost each month*"

From Pleasant Grove, Indiana: "*July 4, 1859, frost*"

From History of Kentucky: "*July 4, 1859, was so cold and inclement that picnic parties were compelled to return home for heavy wrappings*."

Given the observations from the region surrounding Malone, it is not a stretch to conclude that a frost or even a freeze occurred in Malone in the early morning of July 4, 1859. Almanzo would have been either an infant or a toddler, and either way, he likely had little or no recollection of the event himself. His parents and three older siblings, however, would have recalled the summer freeze and likely would have retold the story to him as a part of their family history.

In *Farmer Boy*, the Wilder parents, Father and Mother, rouse their children in the pre-dawn hours of the Fourth of July to rescue their crops. To combat the freezing air, Father, Mother, and the four children (Royal, Eliza Jane, Alice, and Almanzo) pour buckets of water on the corn plant stubs, racing to beat sunlight before it would touch the plants and ruin them. While the race builds narrative suspense, it turns out to have been biologically unnecessary. The practice they applied mixed rescue measures that are scientifically supported in modern knowledge with some folklore, resulting in steps that may have helped as well as ones that may have worsened the effects of a freeze on their plants.

Modern farmers and growers have a few measures available to mitigate the damage of an untimely freeze. Without the option to move plants to a warm place to protect them or to put a large cover over a field of crops, they must bring some measures of protection to the fields. Water is still one of the methods of choice, but the key is not to apply it just once. Rather, it is important to apply the water continually. As water freezes, it releases a small amount of heat energy, known as latent heat. The tiny amount of heat can be enough to keep the temperature at

32 °F very close to the plant, but there are some boundaries on the method. It only works as long as the temperatures are around 23-24 °F or greater and only if the winds are relatively light, allowing the latent heat released to remain close to the plant itself. Additionally, water must be applied continuously so that it can continuously freeze and release heat, all the way until temperatures rise above freezing. Many famous pictures of freezes in citrus-growing regions show trees laden with icicles and coated with ice; the icing is a result of spraying water to offset the freeze.

Farmers have other methods, as well, to offset a potential freeze. If the freeze occurs on a calm, still morning, the subfreezing temperatures may be confined very close to the ground, in a process known as radiational cooling. Large fans that move the air and allow it to mix with warmer air just above the ground can allow temperatures to stay above freezing at plant level. Likewise, during calm-wind freezes, growers can light fires in pits distributed through their orchards and fields. The fires themselves provide warming around them, and the fire can also create air movement near it, which can be a method to move air in places where setting up and powering a fan is not practical.

Regrettably, few of these methods were known or available to the Wilder family in the 1850s, and Father's method to apply just one bucket to each corn stalk may have caused more damage than it saved. The tiny amount of latent heat released on the initial freezing of water would not last until the day's warming brought temperatures above freezing. Also, as water evaporates off the ice (because it isn't arriving in a continuous sprinkle), the temperature near the ice falls colder than the air temperature. Rather than stopping at dawn, the Wilder family would have needed to keep pouring buckets over and over right through dawn and until the temperatures rose

above freezing and the ice began melting on its own. His best fortune might have been that temperatures were only a little below freezing.

"Sugar Snow" and Maple Syrup

"It's a sugar snow," [Pa] said.
Laura put her tongue quickly to a little bit of the white snow that lay in a fold of his sleeve. It was nothing but wet on her tongue, like any snow. She was glad that nobody had seen her taste it.[1]

While much of the forest in the Big Woods of Wisconsin had been cleared for farmland by the time Wilder was born, patches of forested land remained and still remain along the Mississippi River valley. The mixed forests include deciduous trees like sugar maples, as well as elm and oak <REF: WI Biome map>. The sugar maples provided an abundant, if labor-intensive, source of sugar for farmers, including the Ingalls extended family during Wilder's time in Wisconsin (1867-1869 and 1871-1874).

In *Little House in the Big Woods*, Pa rushes to help his parents, Grandma and Grandpa Ingalls, tap and process maple sugar during a late-season sap run induced the "sugar snow" - a light snow and cold snap in the midst of spring. A week of labor culminates in a vibrant sugaring-off party at the grandparents' home, with dancing, fiddling, and lots of maple-sweetened treats. Young readers learn that pouring warmed maple syrup into a pan of snow results in candy, inspiring many at-home maple candy-making attempts. Readers ask if

a “sugar snow” is a real phenomenon and whether it is possible to trace when this possible “sugar snow” occurred.

After enduring a frozen winter, sap beings to run in maple trees as temperatures during the day rise above freezing, while still falling below freezing at night. The freeze and thaw cycles create daily cycles of positive and negative pressure inside the stem of the maple trees <REF: Cornell; WUSTL>. Consider a mostly squeezed ketchup bottle deep in the refrigerator. Its sides are collapsed inward, and it is hard to squeeze out the last bit of ketchup. If you apply pressure to the thin sides of the bottle, rounding out the shape of the bottle to its original form as the space inside of it expands to its original volume, and then let go, you often get a rush of ketchup expelled from the opening. The positive pressure of returning the bottle to its original shape draws the ketchup upward in the bottle; releasing the sides creates negative pressure that sends the contents downward as the space inside collapses. In trees, the daytime warming and thawing allow gases in the tree to expand in the stem. Sap flows upward through the trunk and branches to fill the space. If tapped, the tree will leak sap through the hole, dripping slowly into a container. At night, the gases in the stem compress as the water in the stem freezes, and sap retreats toward the roots.

Sap flow is maximized during the time of year when high temperatures are mostly above freezing and low temperatures are mostly below freezing - truly the midst of the transition from winter to spring. At the nearest weather observing site to Pepin, in La Crosse, Wisconsin, from 1872-1900, high temperatures, on average, started to cross the freezing mark around February 27-29, and low temperatures started to exceed freezing, on average, around April 5-6. The length of actual overlap of these ideal conditions in any given year can fluctuate wildly, though. Also, there is not a smooth beginning and end point to the season

during which high temperatures are above freezing and low temperatures below freezing. As spring overtakes winter, gaps of several days to a week or more in between freezing nights can occur. Sap run seasons are optimal when below-freezing lows are more or less consecutive, while high temperatures remain above freezing. <REF: GDD sap>

Sap collection typically ends when trees reach bud break stage, which occurs around when the location has hit 54 growing degree days. One growing degree day, with a base of 50 °F, is accumulated when the average daily temperature (maximum + minimum / 2) is one degree above 50 °F. In the late 1800s, the average date of bud break, or reaching 54 growing degree days, was April 23; by the early 21st century, it had slid all the way up to April 16.

In *Little House in the Big Woods*, Laura describes a rather typical-sounding winter thaw, with snow cover receding, ice melting, and bare ground expanding. Just as little-girl Laura is ready to play outside, a nighttime snow blankets the ground once again. Pa calls it a "sugar snow" and races away to Grandpa's and Grandma's house — his parents — to help with the maple sugar. Laura's five-year-old mind tastes the snow itself; determining it was not at all sugary, she asks why it was a sugar snow. Not until he returns that evening from his work does Pa have time to explain the maple sugaring process to Laura and Mary. He correctly asserts:

"It's called a sugar snow, because a snow this time of year means that men can make more sugar. You see, this little cold spell and the snow will hold back the leafing of the trees, and that makes a longer run of sap."

The labor-intensive process included racing around the tapped trees to empty buckets into larger collection barrel, taking that to an even larger kettle over a fire to boil down the sap

and concentrate its sugars. Depending on the temperature to which it was cooked, the sap would cool into syrup or granulated sugar.

Indeed, as Pa described, maple trees produce sap longer if the period of above-freezing daytime temperatures and below-freezing nighttime temperatures is prolonged. The snow, while not itself causing the sap to run, was a symptom that the cooler nighttime temperatures were not yet done for the season and that sap would continue to run in the maple trees.

Laura did not make note of when the sugaring-off dance at Grandma and Grandpa's house occurred. By the sequence of her *Pioneer Girl* manuscript, which itself contained anachronisms, Laura would have been about 4 years old, placing it in 1871. The Ingalls family, however, was just returning from Kansas in 1871 and likely was not back yet in time for the spring thaw. It is also unlikely that the dance occurred in 1874, when the Ingalls family departed Pepin. This leaves the winters of 1872 and 1873 as candidates for a "sugar snow," or late spring snow that followed a thaw. Records indicate potential snows in the spring of both years. If the dance occurred in 1872, it likely followed a turn to cold temperatures and likely snowfall around March 31. On that day, with a high temperature of just 35 °F, a low of 28 °F, and 0.50 inches of liquid-equivalent precipitation in Madison, Wisconsin, it is possible that several inches of snow fell. Through the week before it, temperatures had risen into mid 30s to around 40 degrees by day, with lows in the 20s to 32 °F. That weather would support sap flow, and a snowfall could have contributed to cooler temperatures until the snow cover melted. The sugaring weather would not last much longer, as temperatures were above freezing for several mornings in a row beginning on April 6.

If the sugar snow occurred in 1873, a candidate date is harder to discern. On several dates in late March, cold temperatures and precipitation were observed at one of the three nearby

observing sites, but none at all three. At La Crosse, temperatures on March 24-25 fell from 32 °F to 13 °F, with a total of 0.07 inches of precipitation through the two days that would translate to likely less than 2 inches of snow and more likely closer to an inch. Cold temperatures and very light precipitation also occurred at Minneapolis/St. Paul on March 24-25, with 0.07 inches of precipitation and temperatures well below freezing. Additionally, on March 28, with a high temperature of 36 °F and a low of 21 °F, 0.60 inches of precipitation fell, which could have fallen as rain, snow, or a rain-snow mix. Of the three sites, Minneapolis/St. Paul was the only one that recorded precipitation on March 26-29. A little farther east, in Madison, temperatures on March 26 only rose to 23 °F, with a low of 5 °F; the 0.30 inches of precipitation would have fallen as snow, likely around 3 to 5 inches. Looking at April 8-9, with high temperatures of 34-39 °F and low temperatures of 25-30 °F at the three nearby sites, it is a little difficult to determine if the 0.16-0.30 inches of precipitation fell as rain, a rain-snow mix, or snow.

Given the evidence for both 1872 and 1873, we can deduce that the “sugar snow” and run of sap most likely occurred in 1872. In addition to the potential snow around March 31, temperatures above freezing by day and below freezing by night lingered for a week into April, which was not matched in 1873. The longer duration of the optimum temperatures would have supported a prolonged sap run, filling Grandpa and Grandma’s buckets for a week into April. Perhaps the sugaring-off dance occurred on Friday, April 5, or Saturday, April 6, near the tail end of the sap run.

For those who live in cold northern climates like Wisconsin, late-winter and early-spring cold snaps can provide many benefits, even if they do delay the pleasant warm season.

“Cold Miserable”

“It was a cold miserable little journey and we were glad when we drove into Burr Oak…” - Wilder, Pioneer Girl manuscript <REF: PG>

Wilder left readers with so little information about her family’s time in Burr Oak, relegating it to a short chapter of her *Pioneer Girl* manuscript and no words at all in the *Little House* book series. The period was marred by sadness and strife, and the only mention of weather is moody and cold.

Escaping harsh conditions that drove them out of farming near Walnut Grove, the Ingalls family decided to join family friends, the Masters family, to co-manage a store and hotel in Burr Oak, Iowa. They stopped near Zumbro Falls, Minnesota, on their way, to lay over for a visit with relatives, the family of Peter and Eliza Ingalls. On their arrival, the already weak 8-month-old Charles Frederick “Freddie,” Wilder’s baby brother, fell ill. Freddie Ingalls died on August 27, 1876. The heartbroken family buried him in South Troy, Minnesota, and left a short time later to finish their journey to Burr Oak.

The months of August and September were wet at the closest observing sites in Cresco, Monticello, Dubuque, and Independence, Iowa, via FORTS data <REF: Forts>. Within that wet period, September 4-14 was especially wet, with four and a half to seven and a half inches of rain among the four sites. Measurable rain fell on all but a few days of the 11-day period at the sites. Temperatures during that week remained in the 50s to 60s for both high and low temperatures at the sites closest to Burr Oak, with little rise and fall between high and low temperatures (known as “diurnal range”), an indication that skies likely were cloudy even when it was not raining. The

dreary, cold, wet weather all but certainly matched the dark, dampened moods of the family members.

The Other Hard Winter

In Chapter 4, we learned that the Hard Winter was not the only extreme winter of Wilder's childhood. The severity of the Hard Winter of 1880-1881 was driven by the abundant snowfall and prolonged duration. The other "hard winter" of Wilder's childhood ranks as extreme due to record cold temperatures, and that is the winter of 1874-1875, in a swath extending across Minnesota and Wisconsin. In that winter, the Ingalls family was nestled on the banks of Plum Creek. While Wilder mentions a couple of snows and blizzards in *On the Banks of Plum Creek*, she did not write about an extremely cold and harsh winter. How can one extreme winter warrant its own book, while the other barely gets a mention?

The winter of 1874-1875 fell in the midst of the Rocky Mountain locust plague. While the winter of 1874-1875 ranks as being at least as severe as the Hard Winter, more of its severity came from very cold temperatures, compared to the snow-driven severity in 1880-1881. The narrative arc Laura used in *On the Banks of Plum Creek* to describe "grasshopper weather" included mild winters in between the hot and dry summers, even though weather records decisively indicate that was not the case in Minnesota and surrounding parts of the upper Midwest and northern Plains. While Wilder does not include a hard winter between the grasshopper summers, she does build to a more severe winter near the end of *On the Banks of Plum Creek*. It is plausible that the experiences of the Ingalls family during the "other" hard

winter are relayed here and elsewhere throughout the book, out of order like pictures rearranged in a scrapbook to be more pleasing to the eye rather than in chronological order.

In one such story, Pa and Ma are away in town when a blizzard strikes. Laura, home alone with Mary and Carrie, is frightened by stories of children at home not having enough fuel to outlast a blizzard and freezing to death. At Laura's urging, she and Mary bring in an entire pile of cut wood, finishing just in time for Pa and Ma to reach home. Pa built their wood-frame home in the spring of 1875 <REF: PG pg 73>, which is the backdrop for the woodpile story. While a heavy snowstorm or blizzard can strike at any time of year, it is more likely to have caught the Ingalls family by surprise if it was not in the heart of winter - that is, in either the fall or the spring. For example, on October 25-26, 1875, temperatures at Minneapolis/St. Paul fell from the 40s to around 30 degrees. During that time, 1.04 inches of liquid equivalent (rain and snow melted down together) of precipitation fell. No record remains of whether — or how much — of that fell as rain or snow, but the record from Fort Snelling does indicate mixed precipitation on October 25 and snow on October 26, along with winds switching from southerly to northwesterly and increasing in speed as a cold front passed through the area. Such an event, with temperatures falling, precipitation changing to snow, and winds becoming northwesterly and increasing, could be the kind that startles a family, even if it is not an instant blizzard when it starts.

Though their home lay only a mile or two from town, being caught in the weather while on a trip to town becomes something of a motif, as Pa is caught again returning home from town just before Christmas. Chillingly, he does not make it home in *On the Banks of Plum Creek*, riding out the storm in a sheltered snowbank after losing his way. Earlier book drafts <PG pg 73> relayed the story of an unnamed man caught outside in a blizzard who perished, then assigned the story to a neighbor character, and only in later drafts attributed the event to Pa, who survives,

rather than attributing the story to a less familiar person who dies of exposure. Thus, it is plausible that the story did not occur, or at least not to Pa, and was added to demonstrate what *could* happen in the extreme winter conditions rather than an event that did happen.

If Pa truly had been caught out in a storm that lasted three to four days, it would have been fortunate (or miraculous) that Pa survived at all, as many settlers in the central to northern Great Plains froze to death after being caught outside in blizzards. Though he would have been sheltered from the wind, he was still exposed to the cold, and he also was still and not moving his muscles. Even with a new buffalo coat, he likely would have experienced hypothermia within hours and could have died after several hours. His chances of surviving several days without warmth or movement would have been exceedingly low after a day. <REF: Thanks to several colleagues of W.C. Staub>

Was there a Christmastime blizzard that could have caught Pa or a man like him out in the open? Weather observations from Minneapolis/St. Paul do support the potential for a significant snow storm on December 16, 1874, with plunging temperatures from December 15-17, along with a half inch of liquid equivalent of precipitation that likely translated to 6-8 inches of fresh snow. Because the temperatures reached as high as 48 degrees on the 15th, it is possible that residents like Pa were tricked into thinking it was a nicer day, before the cold temperatures and snow arrived. Fort Snelling, located in the Minneapolis/St. Paul area, kept weather records during the era that include wind reports. Winds were reported by direction and by force - the Beaufort force equivalent. The winds increased from force 4 to force 6 on the 15th, with a direction out of the south. Force 4 winds are equivalent to around 13 to 18 mph of sustained wind speed, likely with higher gusts, while force 6 winds are equivalent to roughly 26 to 31 mph sustained. Winds came around to northwesterly on the 16th as temperatures fell, with speeds at

force 2 to force 4 through the day. Though a little less likely, another light snow did fall from December 22-24, 1874, with a total of just 0.08 inches of liquid equivalent of precipitation that may have translated to 1-2 inches of snow. Fort Snelling data indicate winds on December 23 of force 4 to force 6 out of the west to southwest, relatively strong compared to surrounding days.

Not to be outdone, a Christmas Eve snow also fell in 1875. Temperatures dropped through the day and into Christmas Day, and the 0.57 inches of liquid equivalent of precipitation likely fell as another 6 to 9 inches of snowfall. Winds at Fort Snelling rose to force 4 to force 6 out of the west on December 24th. Feasibly, either of the snow events in mid-December 1874 or Christmas Eve 1875 could have been one in which Pa or settlers like him were caught in the open and forced to endure the storm outdoors. These one-day storms would have been survivable, and it is far more likely that a person would survive a span of hours in a snowbank than three or four days, as Laura's story would tell.

The winter of 1874-1875, as cold as it was, simply did not have the same impact on the Ingalls family as the Hard Winter of 1880-1881. We can only speculate as to the reasons why it was not a stronger piece of the family narrative. Perhaps the impact of the locusts sandwiching the winter in both summers of 1874 and 1875 simply overshadowed that of the winter, delivering a greater blow to the family and its stability. Perhaps including a hard winter did not fit the narrative arc of the grasshoppers, "grasshopper weather," and their impact. Perhaps the severe and unusual snowfall of the Hard Winter was more memorable than a winter more characterized by severe and unusual cold temperatures. Or, as hard as it is to imagine after the losses of the first locust infestation, perhaps the family was not as vulnerable to a hard winter while they lived near Walnut Grove. They may have had enough fuel, with a more abundant supply of wood from trees near Plum Creek. The town itself was longer established, and thus, neighbors likely had

more resources, unlike the first-year settlers that populated De Smet during its Hard Winter. Whatever the reasons, the family was not impacted enough to warrant more than a few chapters of stories about enduring winter conditions.

A Cold Ride

Like many teenage girls in the era, Wilder became a schoolteacher while still a student herself. In *These Happy Golden Years*, Laura's first teaching job was plagued by cold weather, an unwelcoming boarding host, and the classroom management struggles that commonly faced first-time teachers in the one-room schoolhouse days. At the pinnacle of her eight-week job, her future husband, Almanzo, takes her home through dangerously cold temperatures. Fresh off of telling Almanzo that she's only interested in his rides home and him, Laura is shocked when he shows up at her doorstep, right on time, on a bitterly cold Friday. She bundles up at the Bouchie (Brewster, in the book) house, where her host is concerned for her safety. After witnessing Mrs. Bouchie threaten Mr. Bouchie with a knife just days earlier, Laura has no intent to stay in their house any longer than she must – the danger of a potentially mentally unstable woman with a knife must have outweighed the danger of the cold in her mind. If Almanzo was going home, then she was certain that she was going with him.

To understand the degree of cold weather during this cold ride, we first must correctly identify at least the months during which Laura was a teacher at the Bouchie school (literarily known as the Brewster school). Following the timeline of Laura's books literally, the teaching episode would have taken place from late December of 1882 through late February of 1883. However, research <REF: PG, PF> indicates that Laura worked her first job as a teacher from

mid-December 1883 through mid-February 1884, a full year later; her teaching certificate was signed in December 1883. <IMG: reproduction of teaching certificate>

Maybe it doesn't even matter. Both winters were bitterly cold. In fact, almost every winter in the 1880s was colder than the long-term average in South Dakota and surrounding areas. At nearby Huron, South Dakota (with records from 1881-1882 to today), 4 of the coldest 10 winters on record and 5 of the coldest 15 winters are from the 1880s, and that's not including 1880-1881. The winter of 1882-83 was the 10th coldest on record in Huron, and the winter of 1883-84 was 14th coldest. If that wasn't enough, three of the next four winters in Huron also were among the top ten coldest, including the coldest winter on record in 1886-87. Both winters had periods where the high temperature for the day did not rise above 0 °F and low temperatures were in the -20 to -30 °F range.

Accepting the evidence that Laura did teach in December 1883 through February 1884 as the winter of the Bouchie school, then when did the cold ride most likely occur?

Almanzo always picked Laura up on Fridays, narrowing the search to just the Fridays from December 1883 through February 1884. Looking for the coldest of these, Friday, January 4, 1884, immediately stands out. The high temperature in Huron was a mere -14 °F that day, with a low temperature of -38 °F reported. The low temperature plunged again to -35 °F the next morning. We can conclude from the data that the temperature on that date was cold from morning to night. No other Friday between December 10, 1883, and the end of February 1884 was nearly as cold. (Friday, February 8, 1884, was the next coldest, with a high of 0 °F and a low of -24 °F.)

Notice that none of the temperatures are "40 below," though 38 below is certainly close. Wilder used that expression extensively in *The Long Winter,* and it rears its head again with this

scene in the early chapters of *These Happy Golden Years*. The reading at Huron was so close to "40 below" that it isn't out of the question that the temperature fell to that reading in DeSmet. The problem is that Laura and the rest of the DeSmet residents might not know if it had. Mercury freezes (becomes solid) at -37.89 °F. Almanzo mentioned that the thermometer in town froze, which would happen before it hits -40 °F. If a mercury thermometer is all that an observer had, then 38 °F is the coldest reading the observer could measure. While it is likely that the thermometer in De Smet was mercury only, the observing site in Huron likely had an alcohol thermometer paired with a mercury thermometer. Huron recorded a temperature of -43 °F on January 8, 1887, which indicates it did have a thermometer at least by that date that would not freeze like mercury. That reading of -43 °F remains tied for the coldest temperature on record in Huron, matched on January 12, 1912.

Back to the weather on January 4, 1884. Let's assume that the highest temperature occurred somewhere around midday or early afternoon, which is a pretty common daily temperature pattern in the winter in South Dakota. Likely the temperature already was falling as Laura and Almanzo began their ride and continued to fall throughout their trip. The coldest temperature probably happened overnight, which means that we can probably estimate that the temperature was around -20 to -25 °F for a good part of their trip. Observations taken at military forts around South Dakota indicate winds were of moderate force and were out of the northwest on January 4, 1884. She likely was heading home with a crosswind, with wind speeds around 15 to 25 mph. The wind chill for that combination would be -48 to -55 °F, which is cold enough to cause frostbite in a mere 5 to 10 minutes on unprotected flesh. Laura and Almanzo were well bundled, but this does give us an idea of just how cold that ride felt. Adding in the additional (roughly) 10 to 15 mph travel speed of the horses only increases the wind chill factor. Imagine

the temperature and wind already described… and imagine riding in a convertible in such cold. The effective wind chill, combining ambient wind speed and travel speed, could have been easily in the range of -55 to -65 °F. With all of the stops, the ride probably took an hour and a half, at least, give or take.

The horses start at a plucky pace, but like the cattle in *The Long Winter*, ice forms over their noses. Almanzo must stop them every couple of miles to clear their breathing. It benefits horses and humans alike to keep the pace as swift as possible, but progress on this trip is hampered. Almanzo, who surely was cold himself, asks Laura questions every few minutes to make sure that she is still conscious and coherent. We don't know what he could have done if she had stopped replying, but it does show his tenderness that he continued to check on her condition throughout the trip. Laura is shockingly cold at first. Then, she begins to drift into a world where she doesn't feel the cold quite as much.

Hypothermia is sneaky. Many of us, surely, have been very cold. We shiver so hard that it hurts. Our fingertips and toes go tingly or even numb. Our gut muscles tighten. The line is crossed from cold to hypothermia when shivering stops. A person enters an eerily warm place where the cold doesn't matter, becoming dreamy and removed from the harsh elements. Eventually, a hypothermic person will fall asleep as the body shuts down, and if not warmed, will die.

The cold that Laura felt in this chapter was not only uncomfortable, like her bitterly cold sleeping room at the Bouchie house. It was dangerous, deadly. Almanzo knew that Laura was dangerously cold – that she was hypothermic. He was in a race against time that was slowly freezing Laura to death, battling against horses that also were nearly freezing. But he won. He got her home to her family, where she could be warmed back to life. Safe in the arms of her

family, she is warmed from the outside in and the inside out, by fresh clothes, blankets, a seat next to the fire, and a cup of tea. She feels like she will never get warm again (perhaps a familiar sensation after the Hard Winter), but she does. The temperatures outside begin to recover, she catches a good night of sleep, and as Ma would say (and Laura does say), "All's well that ends well."

On the ride back to the Bouchie house, Laura asks Almanzo why he took such a risk to get her, especially after she had given him the cold shoulder just a week before. Of course, he planned to make the trip even after Laura's dismissal, and her naivety does not comprehend his romantic motive. The cold nearly deterred him, but his friend, Cap Garland, goaded Almanzo into making the trip.

Almanzo was persistent.

Laura was lucky.

Every cold winter, cold snap, or even cold summer in Wilder's experience had one thing in common: they ended. The darkest hour is just before dawn. Then even the darkest nights always end, and the sun always rises again. The coldest winters always end, and spring always arrives, bringing welcome daylight and warmth, greening and thaws. Spring arrived, bringing its own set of dangers, as no season is immune from hazardous weather.