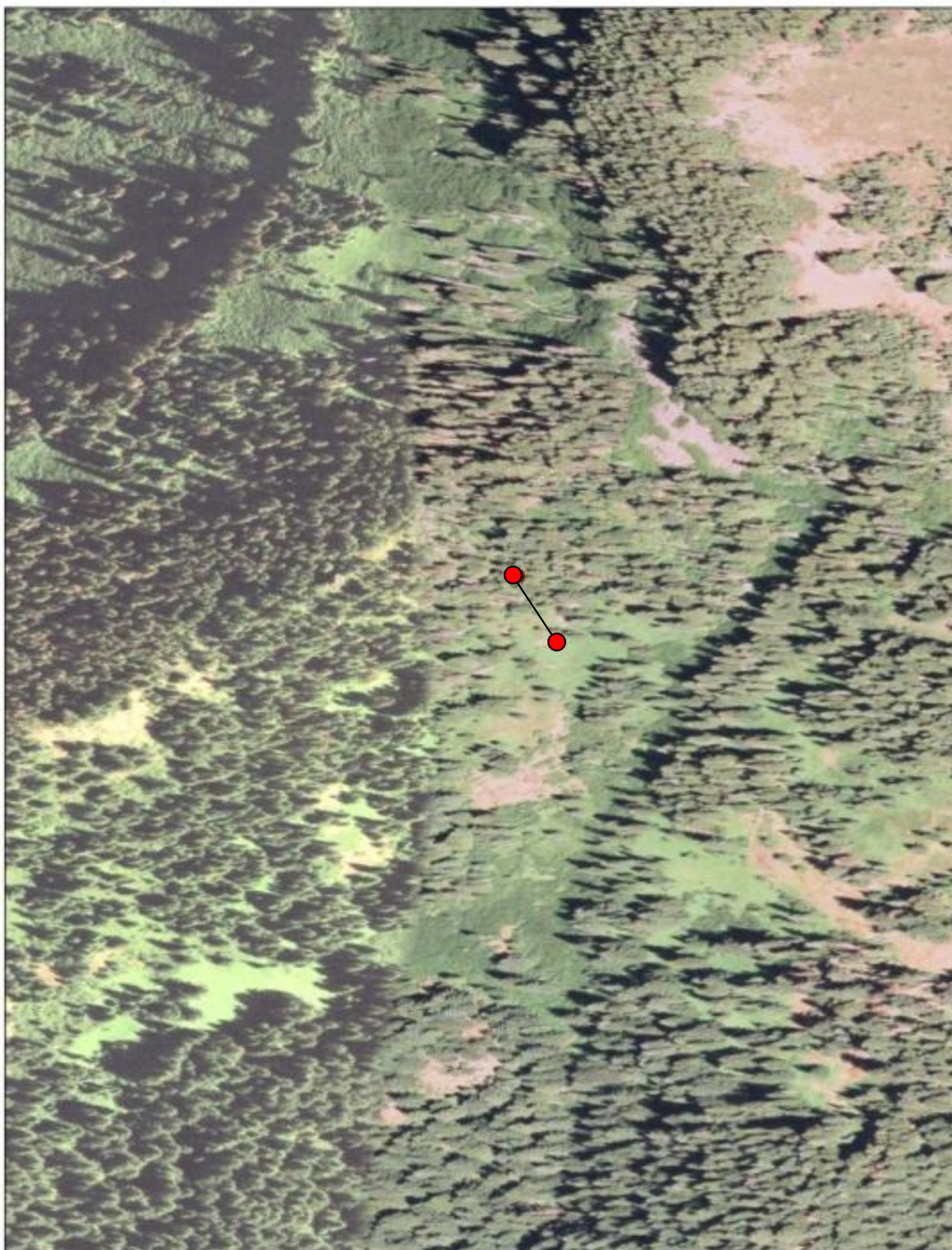


### **Aerial and ground-based photographs of TSBR forest-meadow ecotone transects**

From Appendix C of Haugo, R. D., 2010. Causes and consequences of conifer invasion into Pacific Northwest grasslands, Ph.D. dissertation, University of Washington, Seattle.

Aerial and ground-based photographs of permanent forest-meadow ecotone transects in the Three Sisters Biosphere Reserve (TSBR), Oregon. Aerial photos (scale: 1:3500) were taken in 2006. Photographs are oriented N (top) to S (bottom). Transect end points are noted by red circles (see FSDB data entity TP06412 for UTM's). Most ground-based photos are from 1983 (study initiation), but these are supplemented by photos from 1993 and 2009. This document includes 20 of the original 21 transects (omits Cow Swamp, Transect 9).



Appendix C.1. Aerial photograph of the Yankee Mountain transect (landscape context: montane mesic slope) in 2006. The transect (68 m long) begins near a ridge top and extends downslope (upper left to lower right) through an ecotone with *Abies grandis* and *Pseudotsuga menziesii*.



Appendix C.2. Yankee Mountain transect (landscape context: montane mesic slope) in 1983. Looking upslope toward the ecotone (a) and downslope through the ecotone (b). Visible tree species include *Abies grandis* and *Pseudotsuga menziesii*.



Appendix C.3. Aerial photograph of the Ollalie Meadow transect (landscape context: montane mesic slope) in 2006. The transect passes (120 m long; left to right) on level terrain from *Abies grandis* forest into dense ecotone with *Pinus contorta*, *Pseudotsuga menziesii*, and *Abies grandis*.



Appendix C.4. Ollalie Meadow transect (landscape context: montane mesic slope) in 1983. Looking along the ecotone to the forest. Visible tree species include *Pinus contorta* and *Pseudotsuga menziesii* (background) and *Abies grandis* (foreground); ground vegetation includes *Haplopappus greenii*, *Bromus carinatus*, and *Carex pensylvanica*.



Appendix C.5. Aerial photograph of the Walker 1 transect (landscape context: montane mesic slope) in 2006. The transect (65 m long) begins near a ridge top and extends downslope (upper left to lower right) through an ecotone with *Abies grandis* into *Rubus parviflorus*-*Pteridium aquilinum* meadow.



Appendix C.6. Walker 1 transect (landscape context: montane mesic slope). (a) Looking downslope along transect within the ecotone in 1993 (note tape running next to young *Abies grandis*). (b) Looking upslope toward the ecotone in 2009. Visible tree species include *Abies grandis* and *Pseudotsuga menziesii*. *Acer circinatum* is at the forest-meadow boundary; *Rubus parviflorus* and *Pteridium aquilinum* dominate the ground vegetation..



Appendix C.7. Aerial photograph of the Walker 2 transect (landscape context: montane mesic slope) in 2006. The transect (151 m long) begins near a ridge top and extends downslope (upper left to lower right) through a patchy ecotone with *Abies grandis* and *Pseudotsuga menziesii*.





Appendix C.8. Walker 2 transect (landscape context: montane mesic slope). Looking upslope to the ecotone and forest in 1983 (a) and 2009 (b). Visible tree species include *Abies grandis* and *Pseudotsuga menziesii*.



Appendix C.9. Aerial photograph of the Quaking Aspen 1 transect (landscape context: montane hydric basin) in 2006. The transect (87 m long) begins in mixed forest of *Tsuga mertensiana*, *Abies amabilis*, *A. lasiocarpa*, and *Picea engelmannii* and extends across a sharp ecotone into hydric meadow.



Appendix C.10. Quaking Aspen 1 (landscape context: montane hydric basin). Looking across the meadow to the ecotone and forest in (a) 1983 and (b) 2009. Visible tree species include *Abies lasiocarpa*, *Tsuga mertensiana*, and *Picea engelmannii*.



Appendix C.11. Aerial photograph of the Quaking Aspen 2 transect (landscape context: montane hydric basin) in 2006. The transect (70 m long) begins in mixed forest of *Tsuga mertensiana*, *Abies amabilis*, *A. lasiocarpa*, and *Picea engelmannii* and extends across a sharp ecotone into hydric meadow.



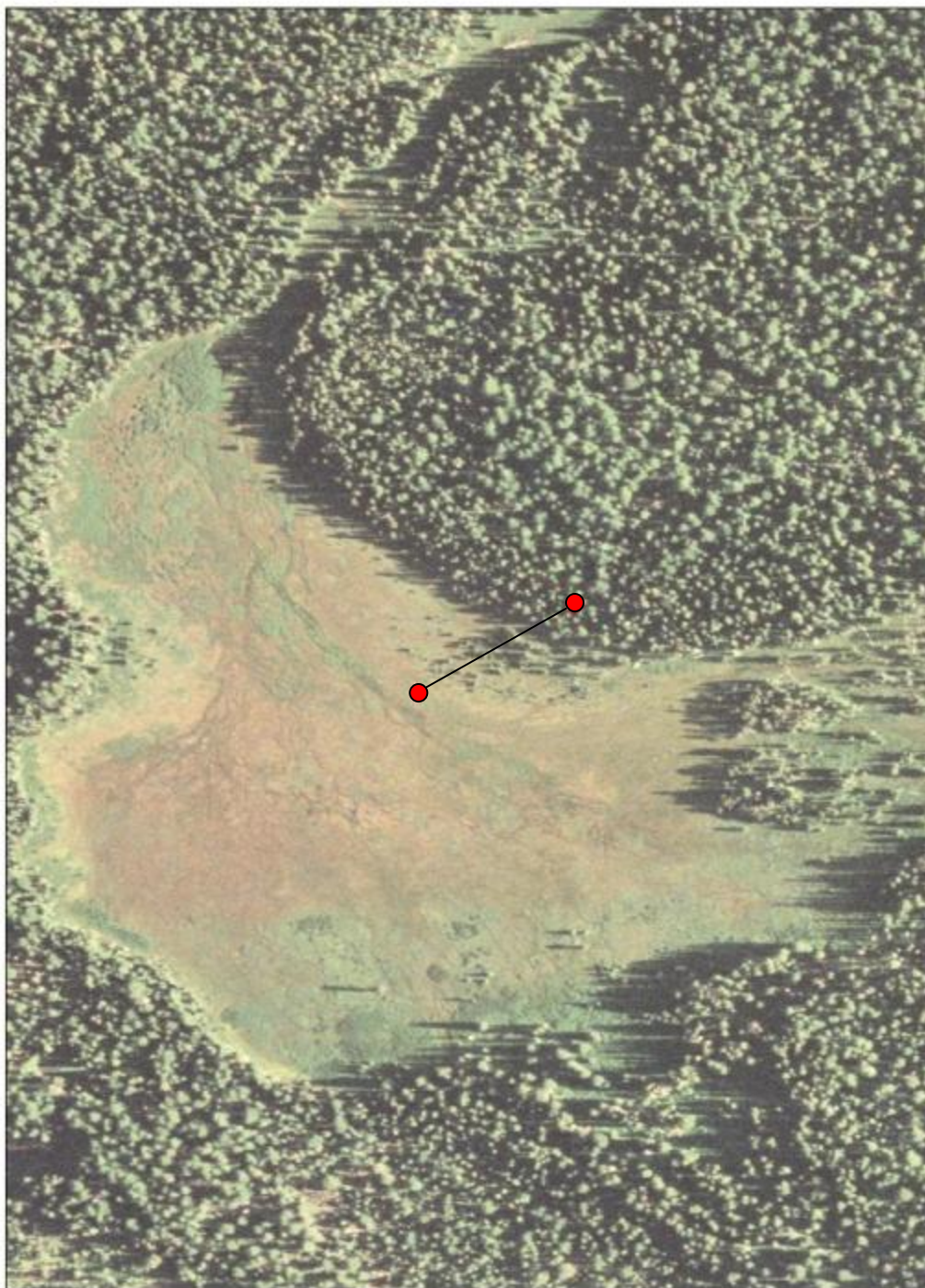
Appendix C.12. Quaking Aspen 2 (landscape context: montane hydric basin). Looking across the meadow to the ecotone and forest in (a) 1983 and (b) 2009. Visible tree species include *Abies lasiocarpa*, *Tsuga mertensiana*, and *Picea engelmannii*.



Appendix C.13. Aerial photograph of the Corral Flat transect (landscape context: montane hydric basin) in 2006. The transect (58 m long) begins in diverse forest of *Tsuga mertensiana*, *Picea engelmannii*, *Pseudotsuga menziesii*, *Abies lasiocarpa*, and *A. procera*, and extends (left to right) into hydric meadow invaded by *Picea engelmannii* and *Pinus contorta*.



Appendix C.14. Corral Flat transect (landscape context: montane hydric basin) in 1983. Looking from the transect end point in the meadow to the forest. Visible tree species include *Picea engelmannii* and *Pinus contorta* (ecotone and forest). Ground vegetation includes a diversity of graminoids and hydric-meadow forbs.

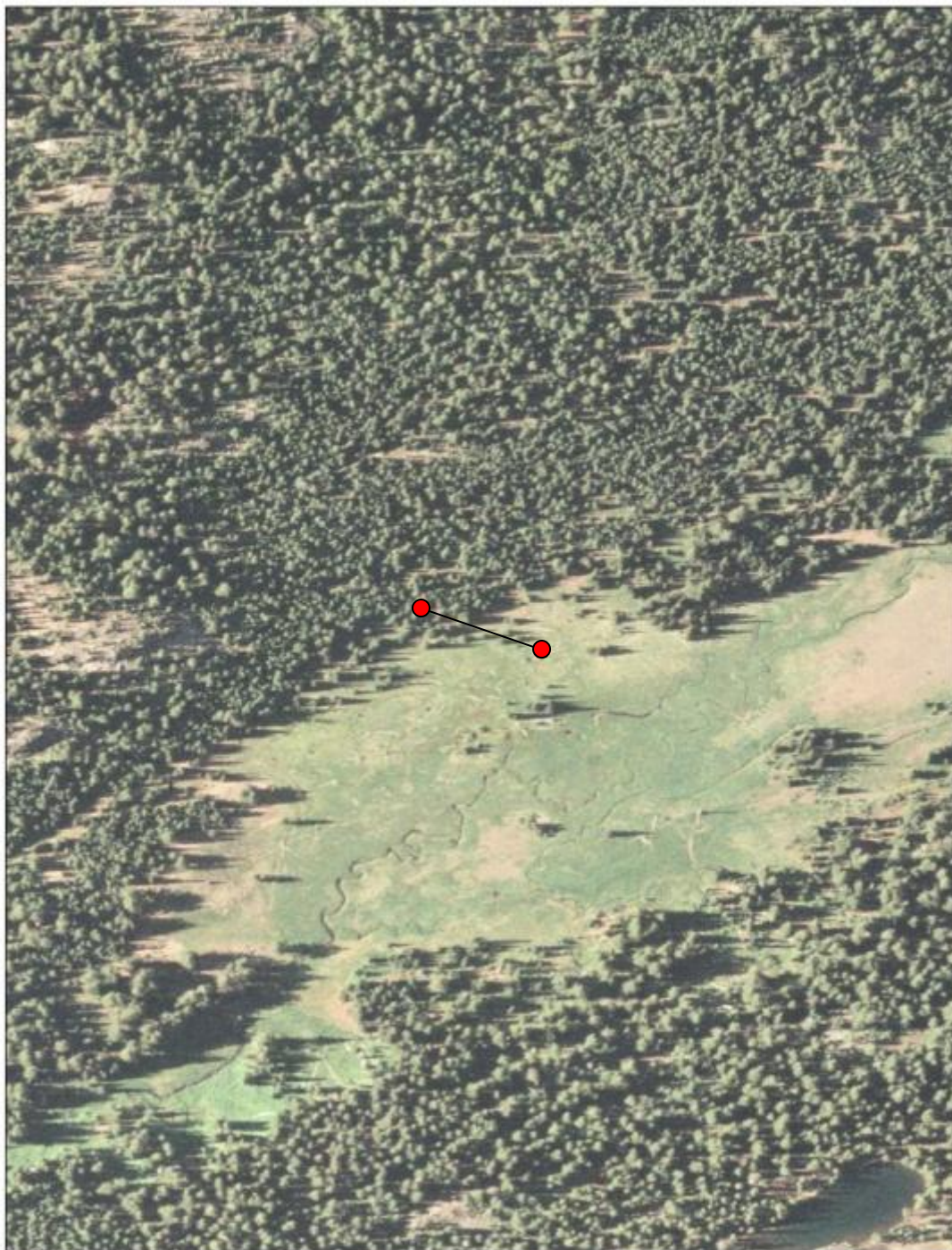


Appendix C.15. Aerial photograph of the Cow Swamp transect (landscape context: montane hydric basin) in 2006. The transect (110 m long) begins in mixed forest of *Picea engelmannii*, *Abies amabilis*, and *Pinus contorta* and extends across ecotone with *Pinus contorta* into hydric meadow.





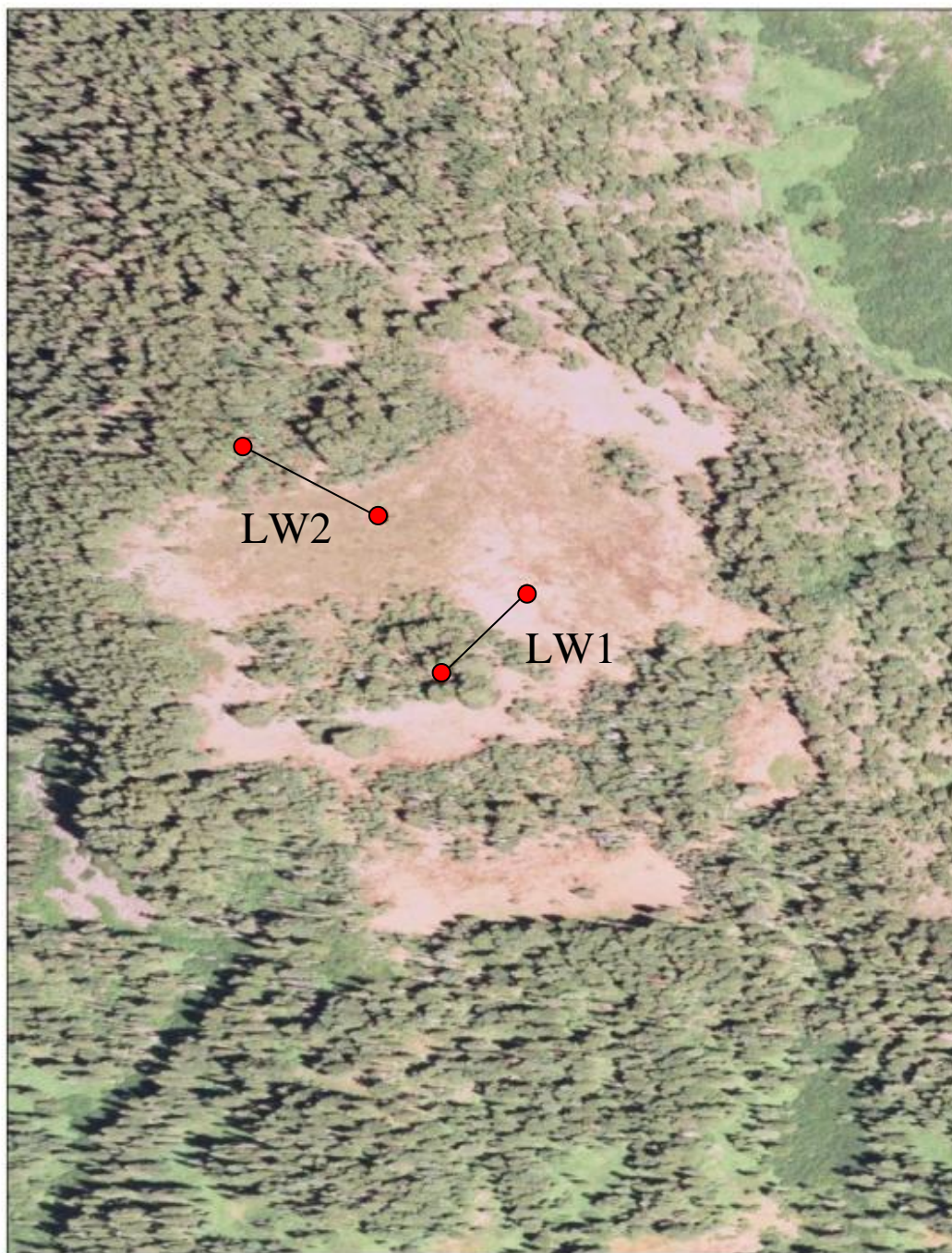
Appendix C.16. Cow Swamp transect (landscape context: montane hydric basin) in 1983. Looking across the meadow to the ecotone and forest (note transect tape running through image). Visible tree species include *Picea engelmannii* (forest) and *Pinus contorta* (ecotone); ground vegetation is dominated by *Deschampsia caespitosa* and other hydric-meadow graminoids and forbs.



Appendix C.17. Aerial photograph of the Separation Creek transect (landscape context: montane hydric basin) in 2006. The transect (75 m long) begins in forest of *Tsuga mertensiana* and *Abies lasiocarpa* and extends across patchy ecotone into hydric meadow.



Appendix C.18. Separation Creek transect (landscape context: montane hydric basin). Looking across the meadow to the ecotone in (a) 1983 (note transect tape running across image) and (b) 2009. Visible tree species include *Abies lasiocarpa* and *Tsuga mertensiana*. Ground vegetation is dominated by *Deschampsia caespitosa*.



Appendix C.19. Aerial photograph of the Lower Mountain 1 (LW1; 76 m long) and Lower Mountain 2 (LW2; 93 m long) transects (landscape context: subalpine early snowmelt) in 2006. Transects begin in forests of *Tsuga mertensiana* and *Abies lasiocarpa* and extend across dense ecotones into meadows dominated by *Festuca viridula* (tan color at LW2) or *Arenaria capillaris* (lighter color at LW1).



Appendix C.20. Lowder Mountain 1 transect (landscape context: subalpine early snowmelt). Looking from the meadow to the ecotone and forest in (a) 1983 and (b) 2009. Note the sparse meadow vegetation in both transects. Visible tree species include *Tsuga mertensiana* in the forest (background) and *Tsuga mertensiana* and *Abies lasiocarpa* in the ecotone..



Appendix C.21. Lowder Mountain 2 transect (landscape context: subalpine early snowmelt). Looking from the meadow to the ecotone and forest in (a) 1983 and (b) 2009. *Tsuga mertensiana* dominates the forest (background) and ecotone. The principal meadow species is *Festuca viridula*.



Appendix C.22. Aerial photograph of the Rebel Rock transect (landscape context: subalpine early snowmelt) in 2006. The transect (82 m long) extends (right to left) from a ridge top through a patchy ecotone dominated by *Tsuga mertensiana*, *Abies grandis*, and *A. lasiocarpa*.



Appendix C.23. Rebel transect (landscape context: subalpine early snowmelt). Looking across the ecotone in (a) 1993 and (b) 2009. Visible tree species (both up and downslope) include *Tsuga mertensiana*, *Abies grandis*, and *Abies lasiocarpa*; visible meadow species include *Festuca viridula* and *Lupinus latifolius* (in flower in 2009).





Appendix C.24. Aerial photograph of the James Creek transect (landscape context: subalpine early snowmelt) in 2006. The transect (98 m long) extends (upper right to lower left) from open forest of *Tsuga mertensiana* downslope across a patchy ecotone with *Tsuga mertensiana* and *Abies lasiocarpa*.



Appendix C.25. James Creek (landscape context: subalpine early snowmelt) in 1983 looking across the ecotone. Visible tree species include *Tsuga mertensiana* and *Abies lasiocarpa*. The principal meadow species is *Festuca viridula*.



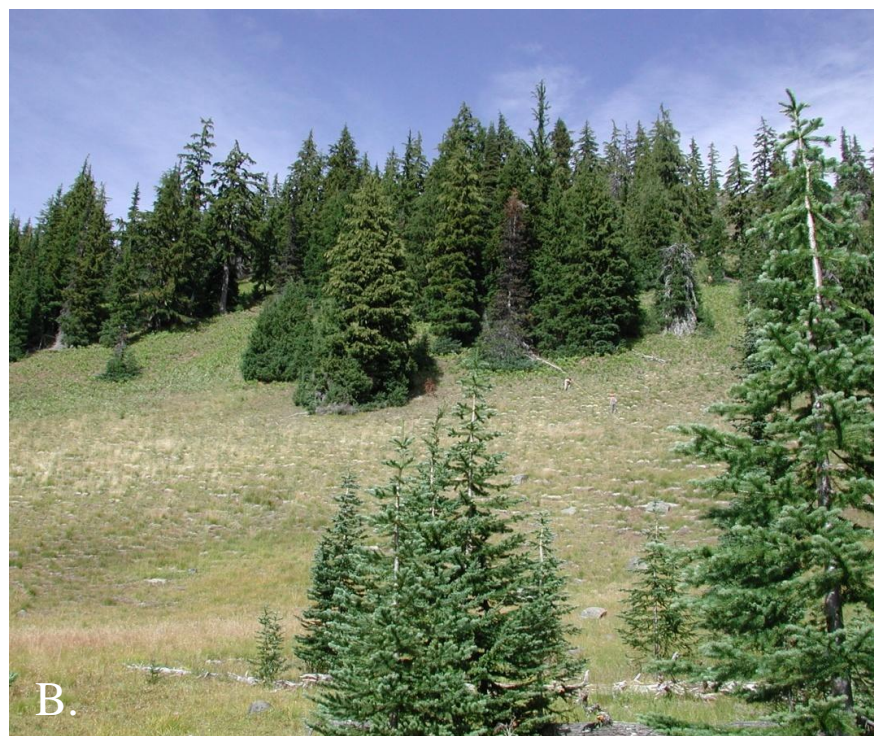
Appendix C.26. Aerial photograph of the Wickiup Plains transect (landscape context: subalpine early snowmelt) in 2006. The transect (79 m) begins in *Tsuga mertensiana* forest and extends across ecotone into dry, graminoid-dominated meadow and pumice flat.



Appendix C.27. Wickiup Plains (landscape context: subalpine early snowmelt) in 1983 looking from the ecotone to meadow. Visible tree species in the ecotone is *Tsuga mertensiana*; graminoids including *Festuca viridula*, *Sitanion hystrix*, *Stipa occidentalis*, and *Juncus paryii*, dominate the ground vegetation.



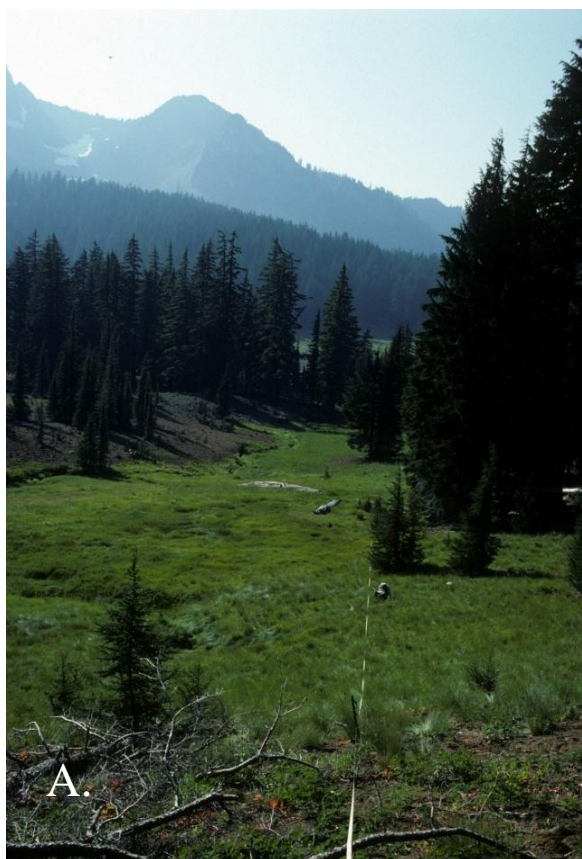
Appendix C.28. Aerial photograph of the Linton Meadow 1 transect (landscape context: subalpine early snowmelt) in 2006. The transect (60 m long) runs downslope (upper right to lower left) from forest of *Tsuga mertensiana* and *Abies lasiocarpa* into meadow dominated by *Festuca viridula*.



Appendix C.29. Linton Meadow 1 transect (landscape context: subalpine early snowmelt). Looking upslope to the meadow, ecotone, and forest in (a) 1983 and (b) 2009. Visible tree species are *Tsuga mertensiana* and *Abies lasiocarpa*. Meadow is dominated by *Festuca viridula*. Transect passes beneath recently dead *A. lasiocarpa* (2009 photograph).



Appendix C.30. Aerial photograph of the Linton Meadow 2 transect (landscape context: subalpine early snowmelt) in 2006. The transect (60 m long) extends downslope (right to left) from open *Tsuga mertensiana* forest across a sharp ecotone into meadow dominated by *Festuca viridula* and *Carex spectabilis*.



Appendix C.31. Linton Meadow 2 transect (landscape context: subalpine early snowmelt). (a) Looking downslope from the ecotone to the meadow in 1983. (b) Looking across the ecotone in 2009. Visible tree species is *Tsuga mertensiana* (forest and ecotone); ground vegetation is dominated by *Festuca viridula* and *Carex spectabliis* (lower on the slope).







Appendix C.32. Aerial photograph of the Obsidian Flat transect (landscape context: subalpine early snowmelt) in 2006. The transect (60 m long) extends (right to left) from open *Tsuga mertensiana* forest downslope into meadow dominated by *Festuca viridula*.



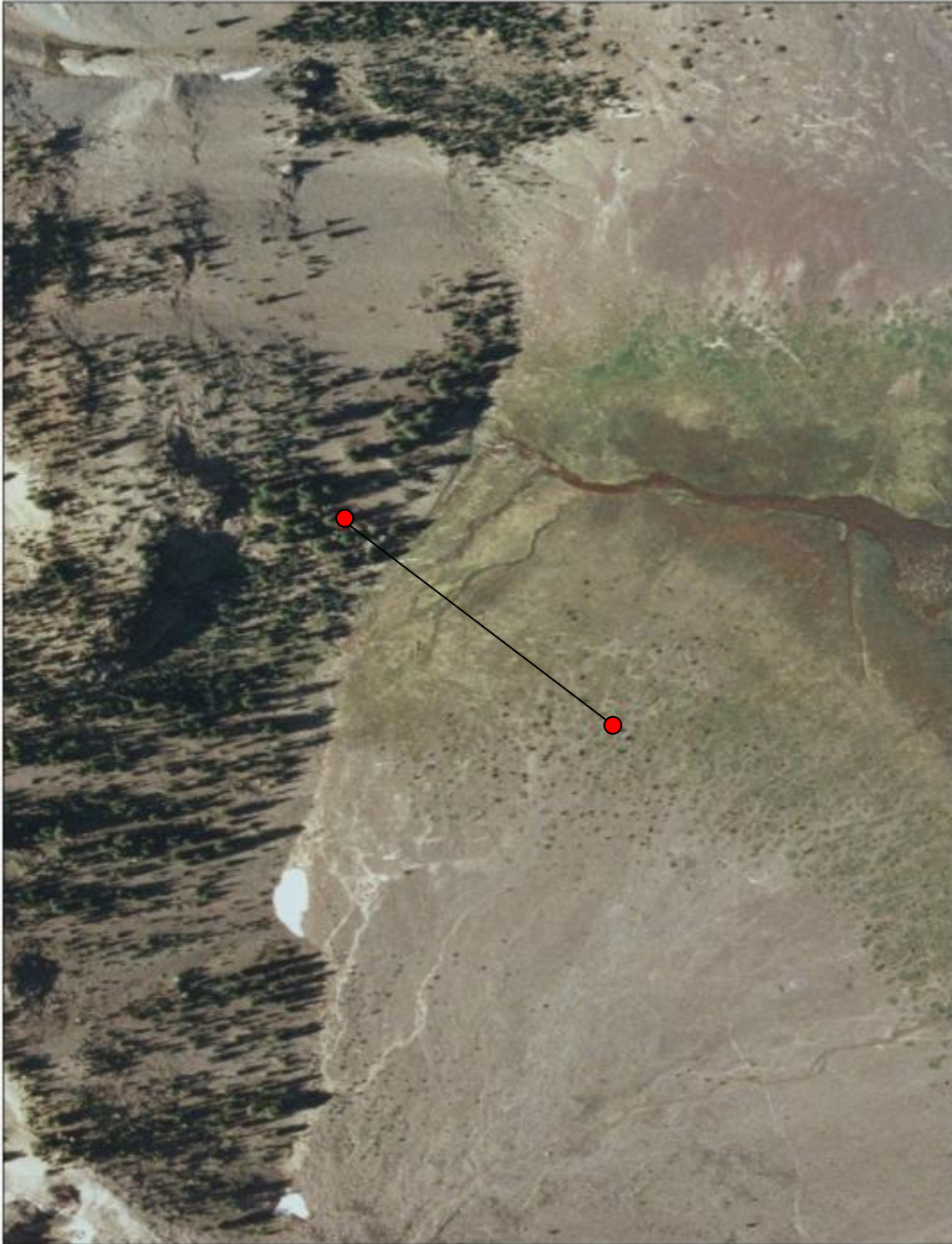
Appendix C.33. Obsidian Flat transect (landscape context: subalpine early snowmelt) in 2009. Looking from the meadow to ecotone and forest (note transect tape running across image). Visible tree species include *Tsuga mertensiana* (ecotone and forest); dead *T. mertensiana* and *Pinus albicaulis* are visible in the forest (center and right, respectively). Ground vegetation is dominated by *Festuca viridula*.



Appendix C.34. Aerial photograph of the Obsidian Creek transect (landscape context: subalpine early snowmelt) in 2006. The transect (90 m long) runs from hilltop forest of *Tsuga mertensiana* and *Abies lasiocarpa* downslope onto a graminoid-dominated flat.



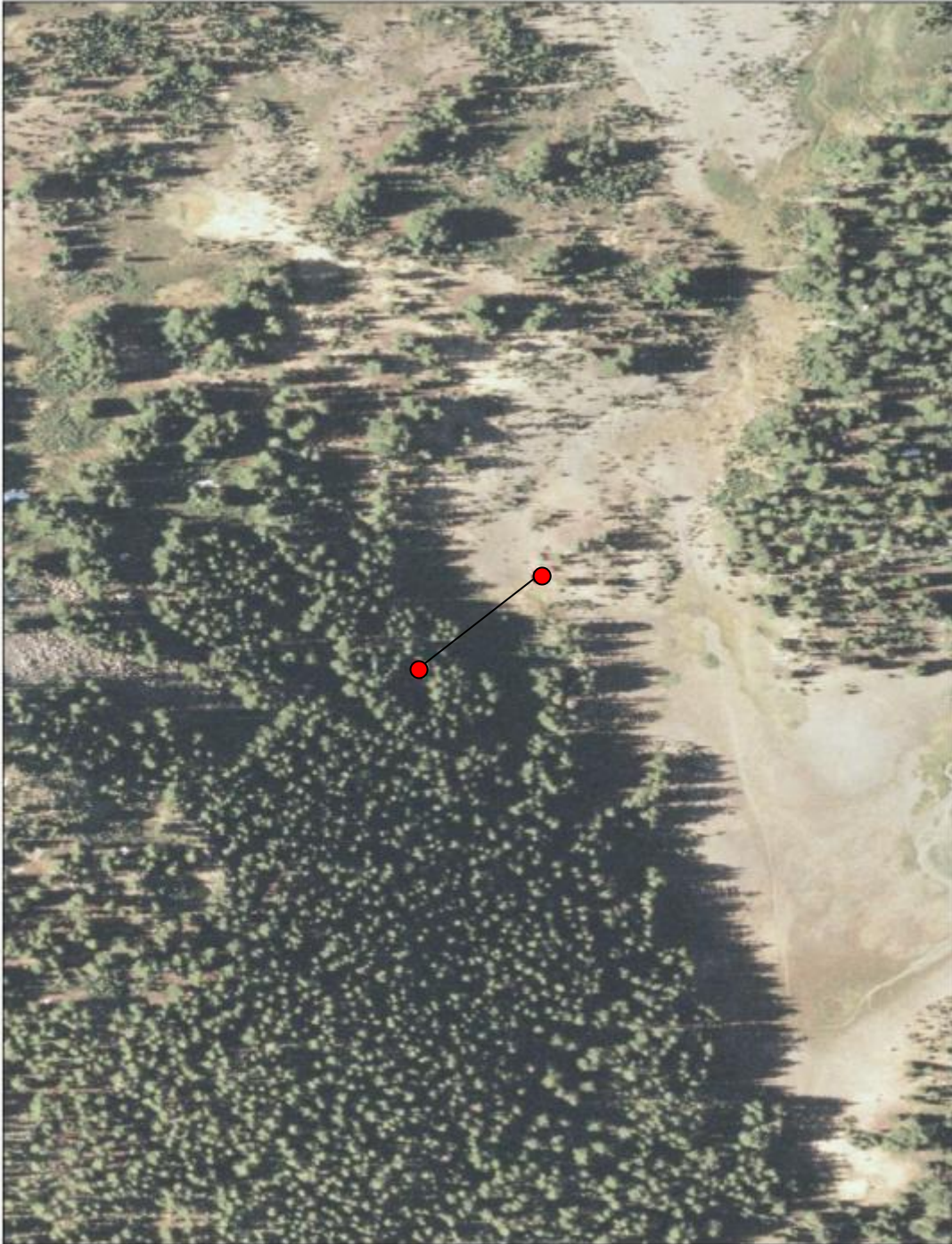
Appendix C.35. Obsidian Creek transect (landscape context: subalpine early snowmelt) in 2009. Looking across the ecotone. Visible tree species include *Tsuga mertensiana* and *Abies lasiocarpa*. Ground vegetation is dominated by *Festuca viridula* and *Carex spectabilis* (lower on the flat).



Appendix C.36. Aerial photograph of the Green Lake transect (landscape context: subalpine late snowmelt) in 2006. The transect (220 m long) runs from open *Pinus albicaulis* forest on the slope onto a broad meadow flat.



Appendix C.37. Green Lake transect (landscape context: subalpine late snowmelt) in 1983. Looking down the transect across the meadow; small *Pinus contorta* are scattered in the background.



Appendix C.38. Aerial photograph of the Racetrack transect (landscape context: subalpine late snowmelt) in 2006. The transect (100 m long) runs downslope (left to right) from *Tsuga mertensiana* forest into a heath-dominated and sedge-dominated late snowmelt basin.



A.



B.

Appendix C.39. Image of Racetrack (landscape context: subalpine late snowmelt). (a) Looking through dense establishment of *Tsuga mertensiana* in the ecotone in 1993. (b) Looking upslope at ecotone and forest from the meadow in 2009. Visible tree species is *Tsuga mertensiana* (forest and ecotone). Bare pumice soils are visible in the foreground. A dense carpet of *Carex nigricans* extends to the base of the slope giving way to a heath-dominated (*Phyllodoce empetriiformis*) community within which invasion is most dense.