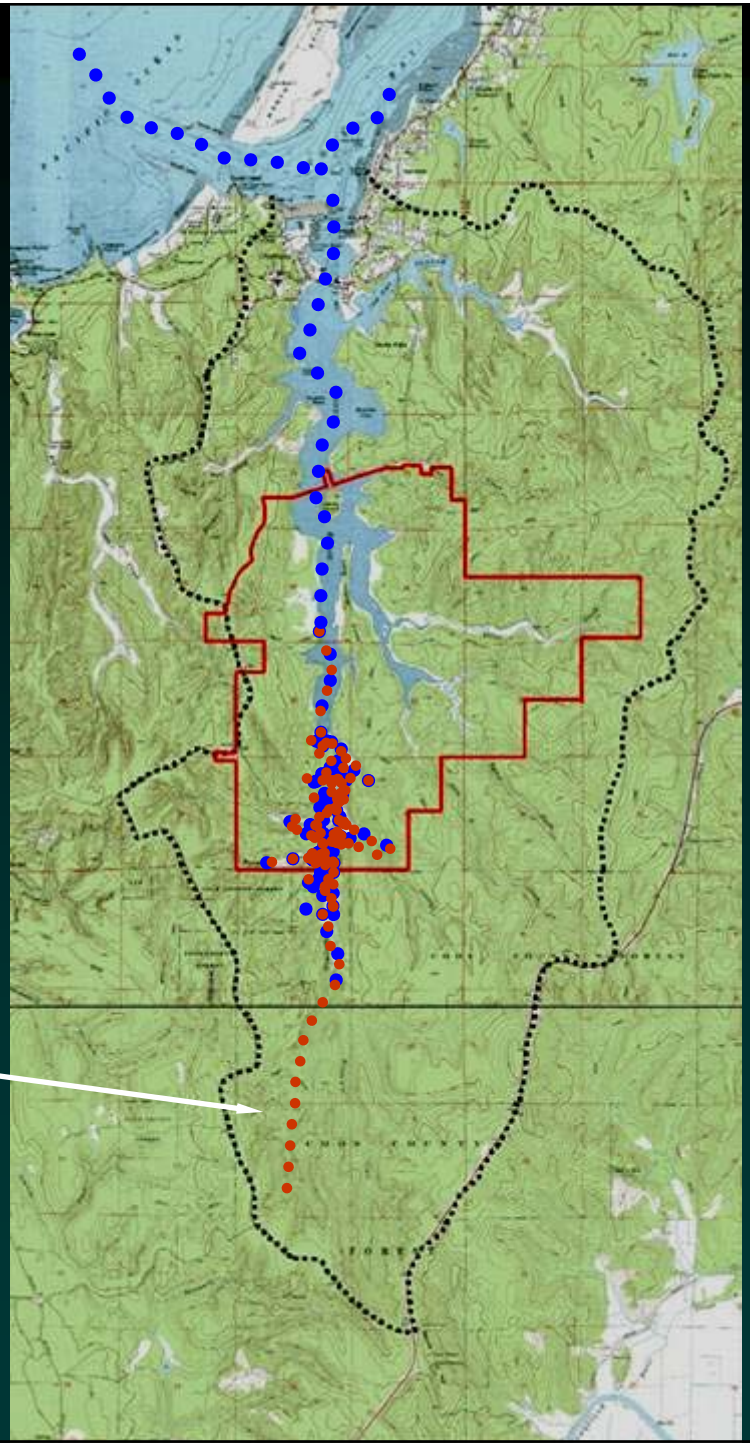
ESTUARINE WETLAND RESTORATION

Lessons Learned so far from the
Winchester Tidelands Restoration Project

South Slough NERR
Coos Bay, OR

South Slough Watershed

Juvenile Coho salmon life history



Coho spawning

Age 0 Fry
4-8 months estuarine residence

Age 1 Smolts
3-4 weeks estuarine residence

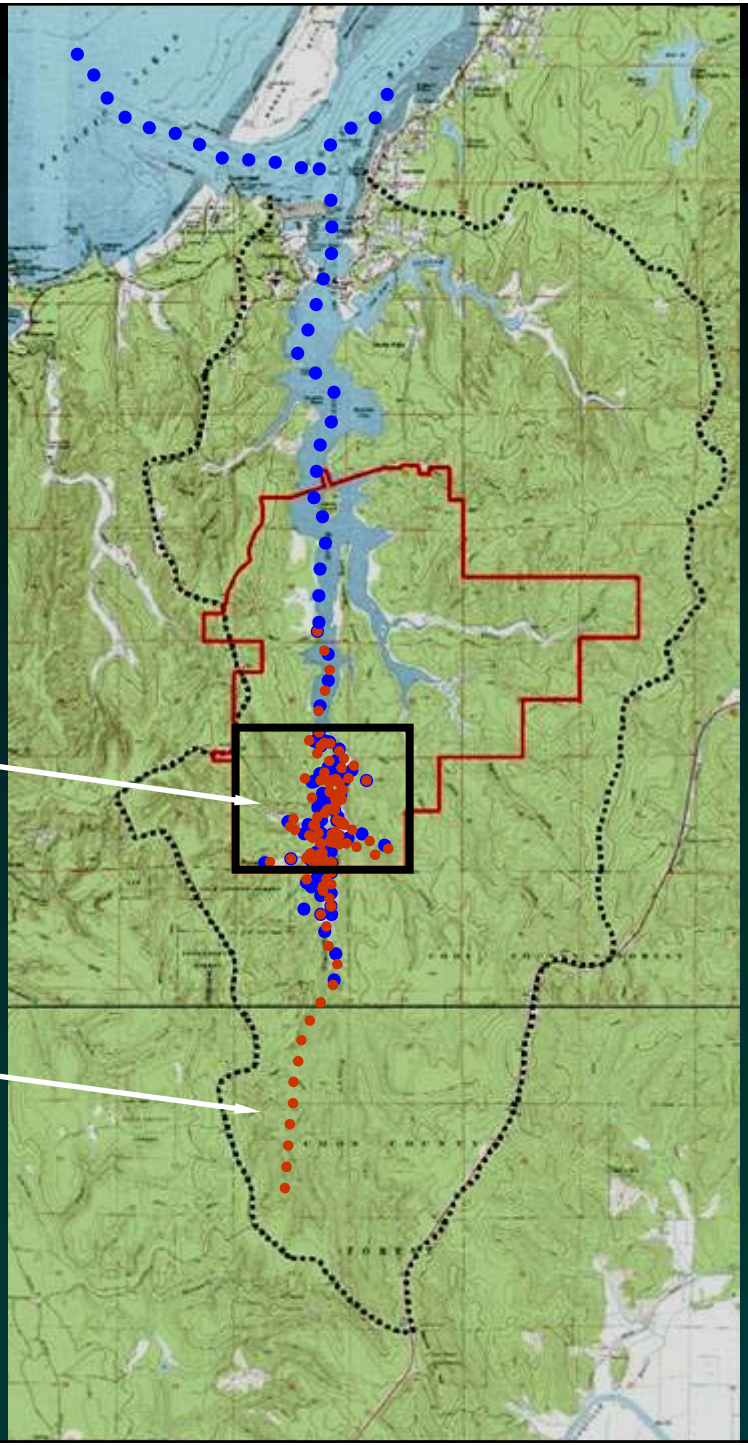
After Miller and Sadro 2003 mark-recapture/acoustic tagging

South Slough Watershed

Juvenile Coho salmon life history

Winchester Tidelands Restoration Project Area

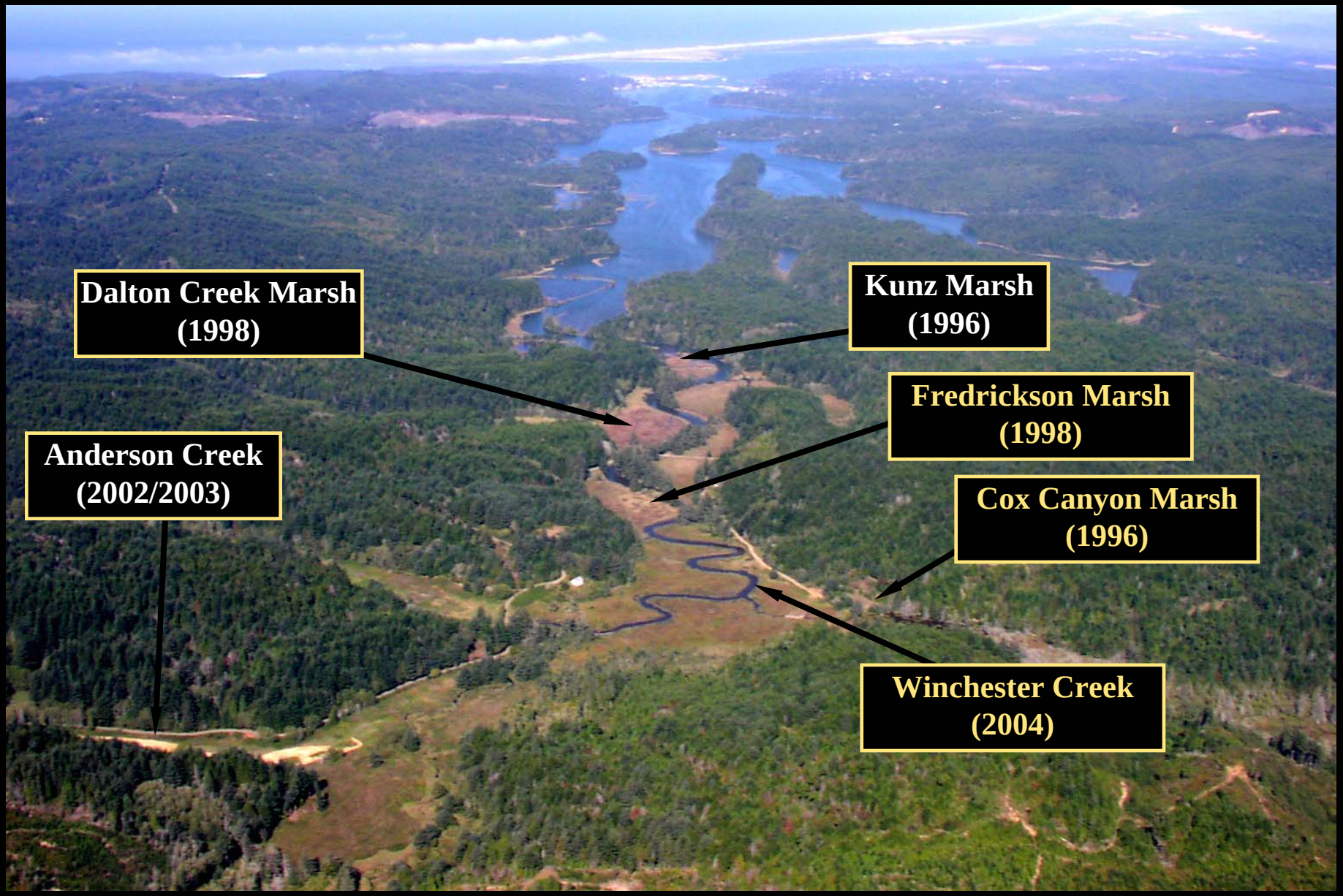
Coho spawning

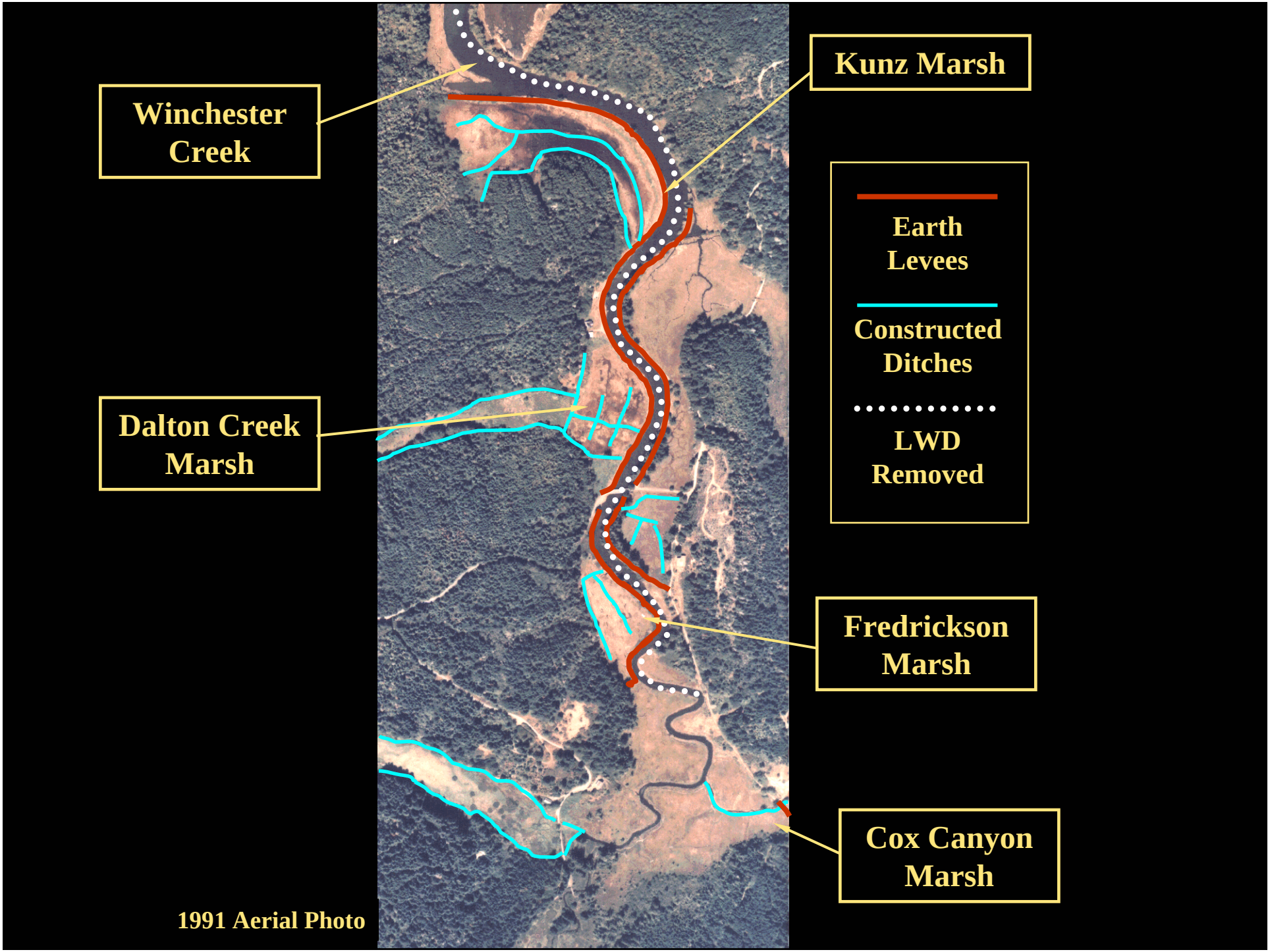


Age 0 Fry
4-8 months estuarine residence

Age 1 Smolts
3-4 weeks estuarine residence

Source: Miller and Sadro 2003 mark-recapture/acoustic tagging


Dalton Creek Marsh
(1998)
Kunz Marsh
(1996)
Fredrickson Marsh
(1998)
Anderson Creek
(2002/2003)
Cox Canyon Marsh
(1996)
Winchester Creek
(2004)


Winchester Creek
Kunz Marsh
Earth Levees
Constructed Ditches
LWD Removed
Dalton Creek Marsh
Fredrickson Marsh
Cox Canyon Marsh
1991 Aerial Photo

Winchester Tidelands Restoration Project Approach

- Estuarine Wetland Restoration Advisory group
- Informal Information Gaps Assessment
- Demonstration projects
- Advisory Group/Coastal Decision Maker and Restoration Practitioner Workshops
- Publications/Outreach Documents

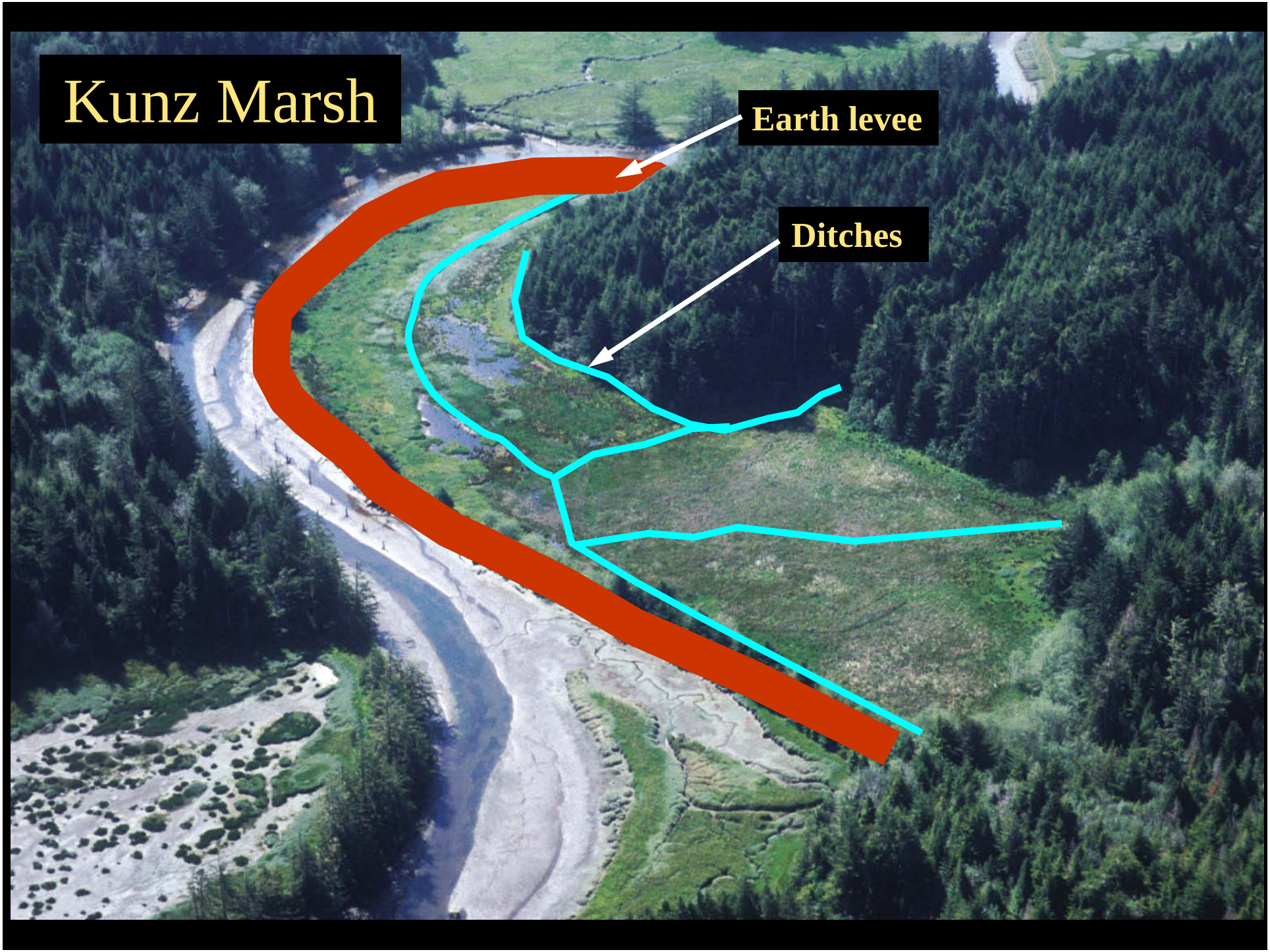
Demonstration Project Approach

- Use Reserve as outdoor lab to test innovative restoration techniques
- Restore to pre-contact conditions- as represented by Reserve reference sites
- Use “self-design” methods (manipulate key site attributes- allow natural processes to do the work)
- Demonstrate restoration methods within reach of restoration practitioners (e.g., watershed assns.)

Projects

1991 Aerial Photo

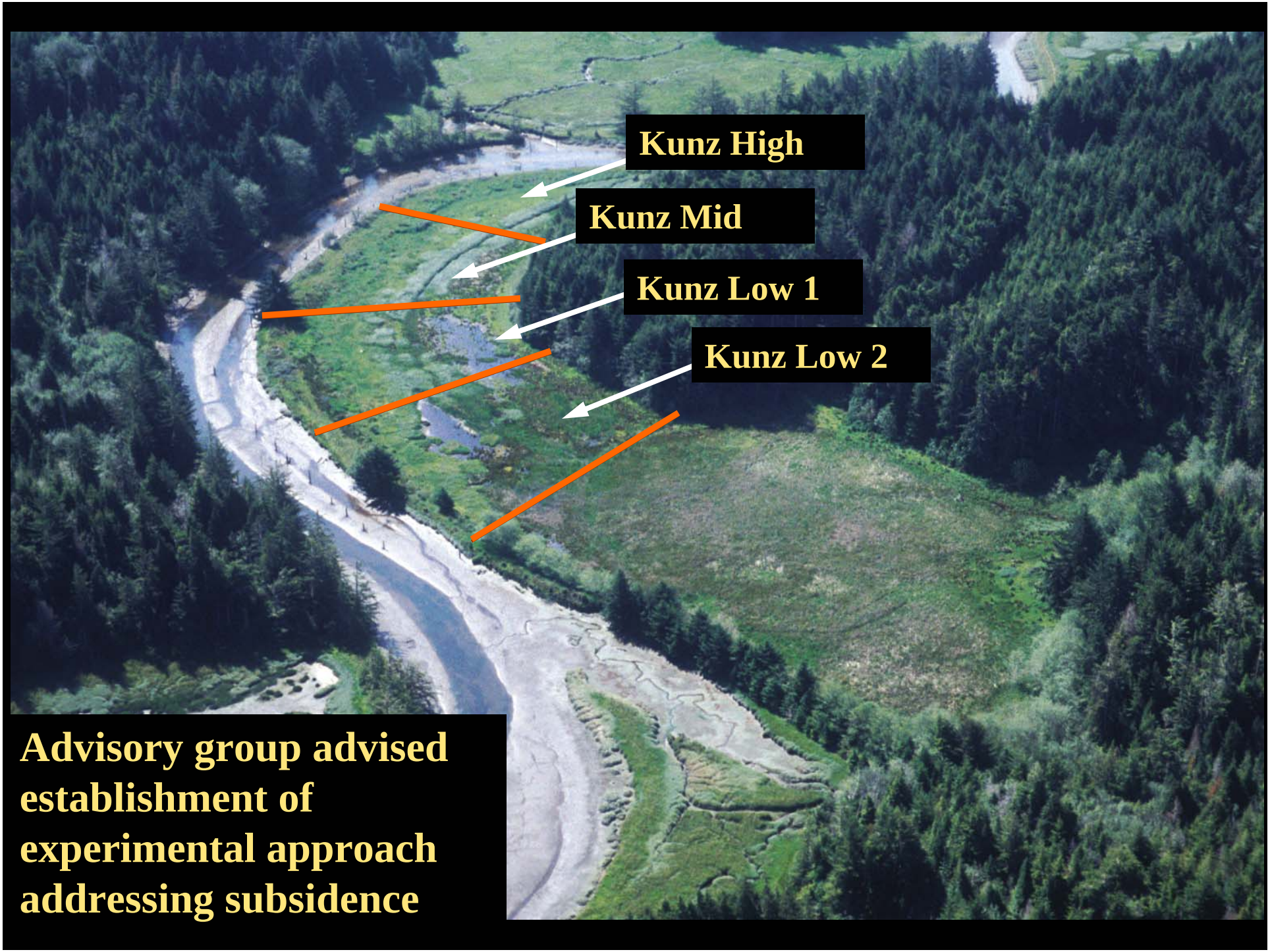

Kunz Marsh


Kunz Marsh
Earth levee
Ditches

Kunz Marsh

Major Issues:

- Little or no salmonid access to marsh plain/edge
- Tidal channel network reduced to linear ditches
- Little or no connection with rest of estuary (nutrient exchange)
- Subsided marsh surface (0.80 m)

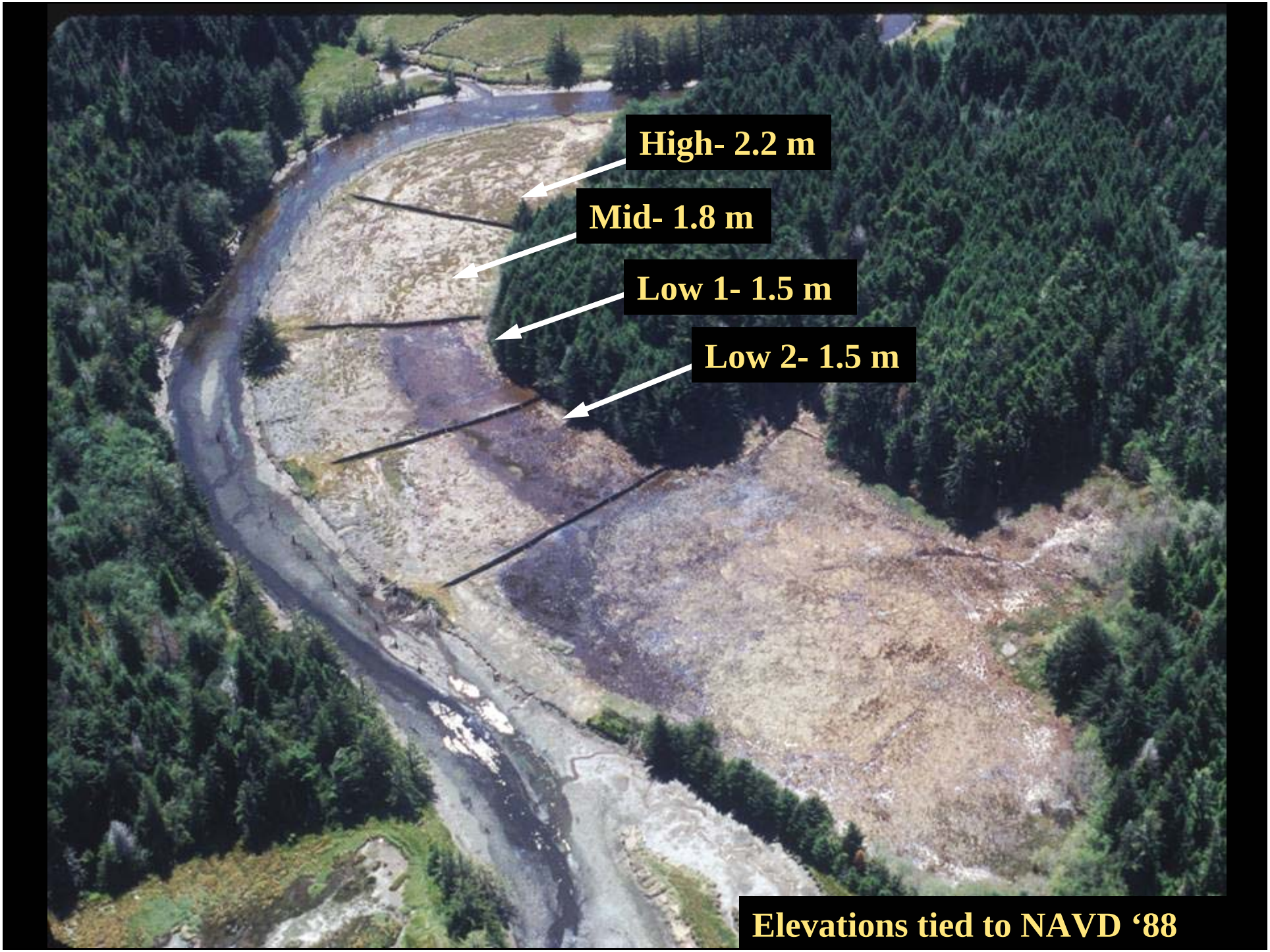


Advisory group advised establishment of experimental approach addressing subsidence

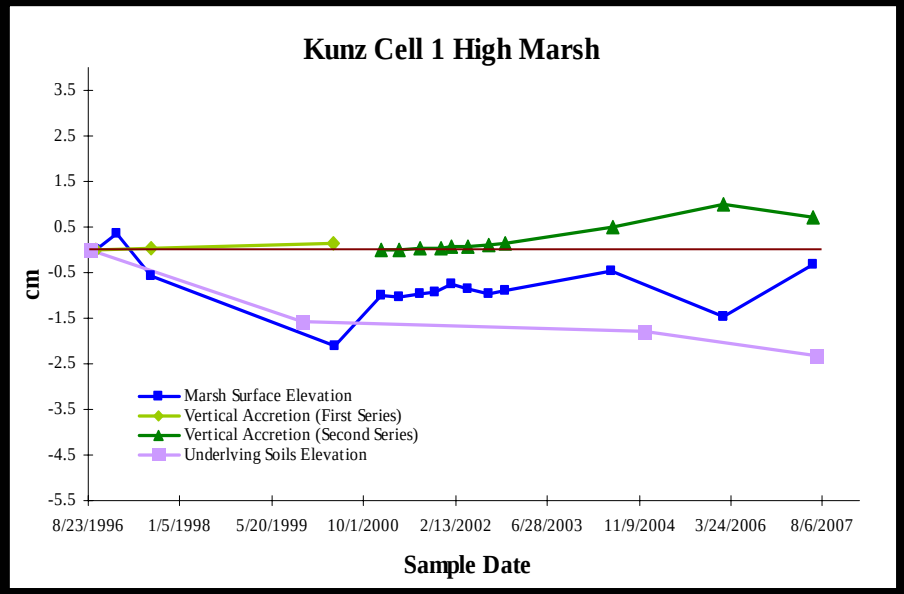
Dike remnant to prevent premature flooding

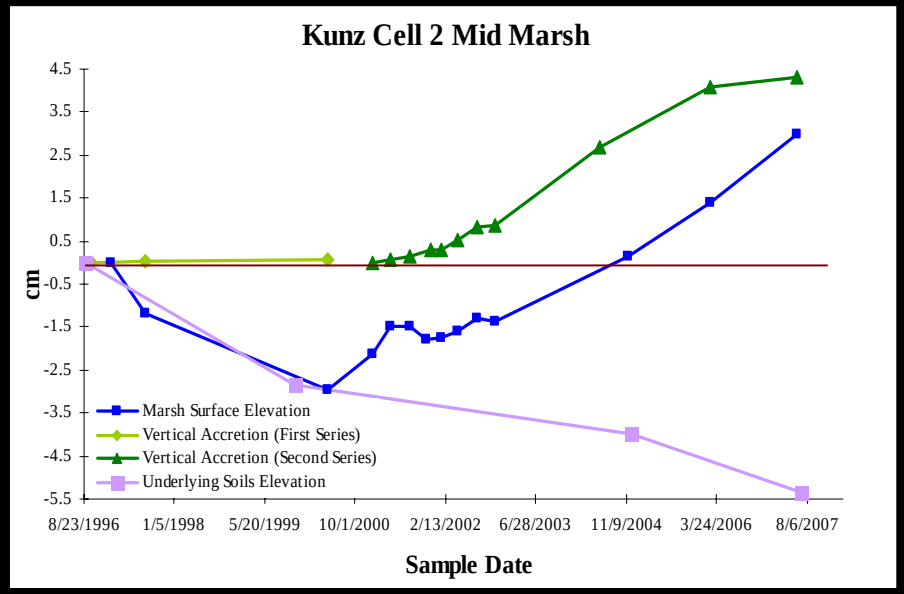
Dike material moved to create cells

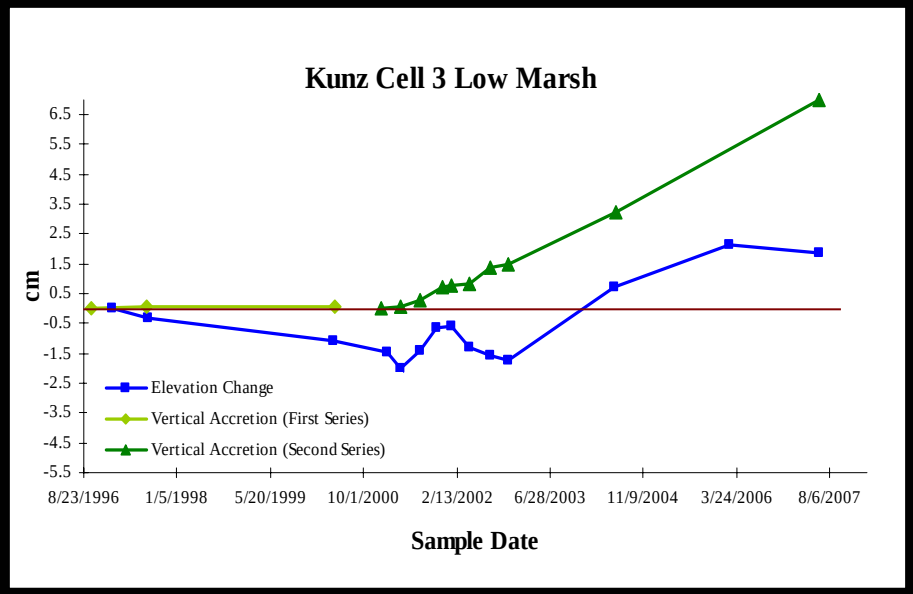
Dike remnant removed when cells fully graded

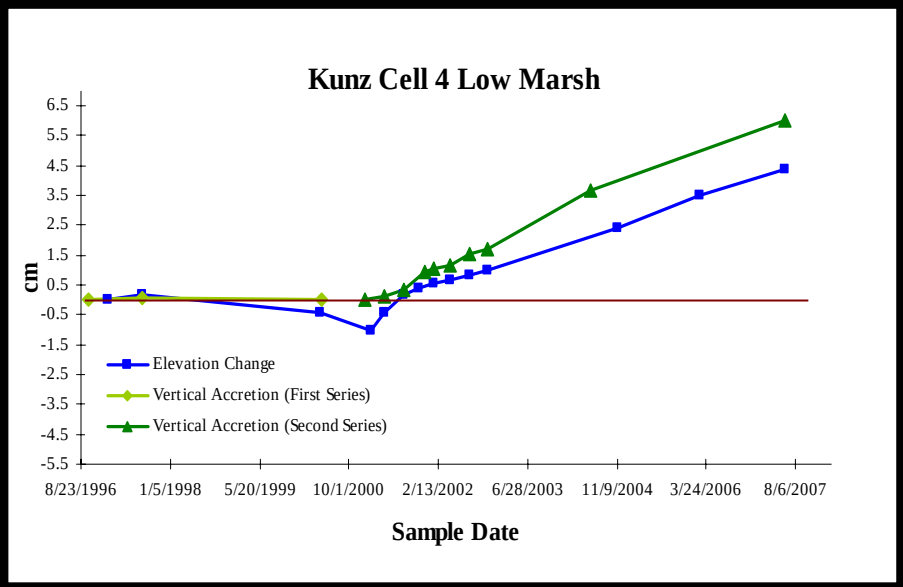

High- 2.2 m
Mid- 1.8 m
Low 1- 1.5 m
Low 2- 1.5 m
Elevations tied to NAVD ‘88

Sediment Dynamics



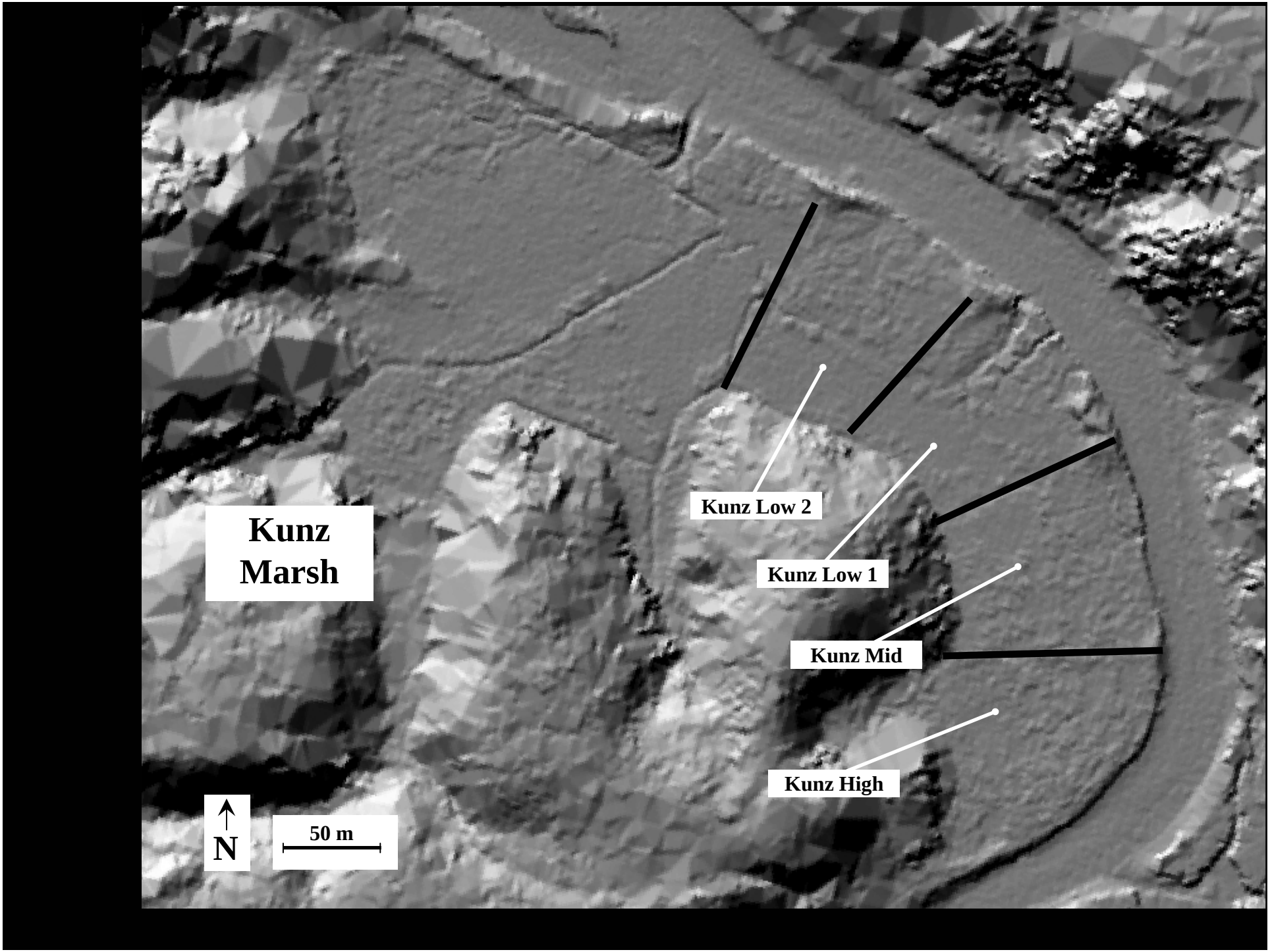


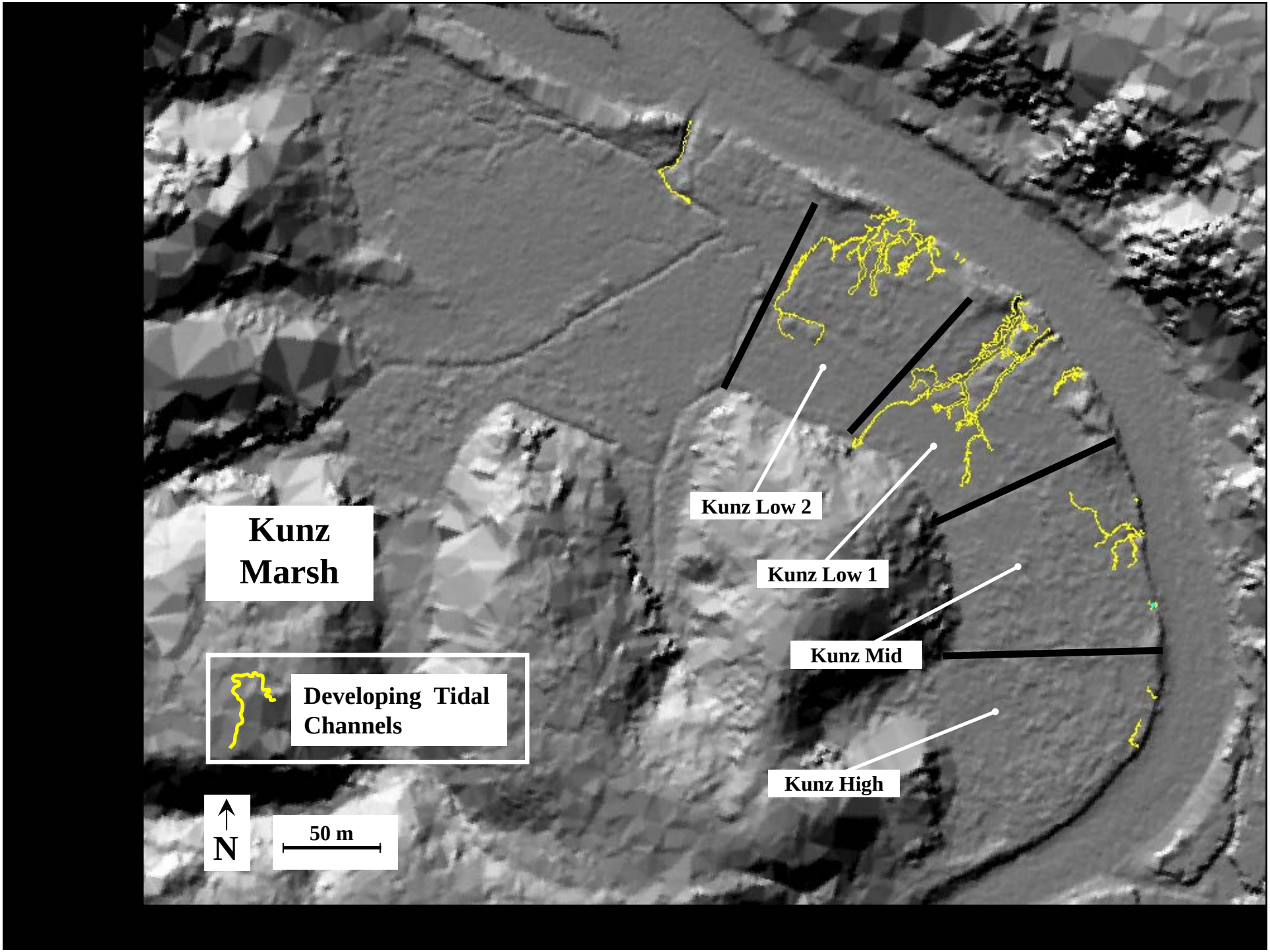




(Assisted by D. Varoujean and various volunteers 1996-2007)

Tidal Channels


Kunz
Marsh
Kunz Low 2
Kunz Low 1
Kunz Mid
Kunz High
N
50 m


Kunz Marsh
Developing Tidal Channels
N
50 m
Kunz Low 2
Kunz Low 1
Kunz Mid
Kunz High

Tidal Channels- developing “passively”

More channels developing at lower elevations:

- 7 channels detected in 1999 – 2 in High cell
- 23 channels detected in 2005- 0 in High cell
- 47 channels detected in 2007- 2 in High cell

Tidal Channels Morphometrics

Kunz Tidal Channels Winter 2007

Site	Channel Order	Number of Channels	Average Length (m)	Total Length (m)	Total Area (Hec.)	Drainage Density	Length Ratio	Average Sinuosity	Bifurcation Ratio
Kunz High	1st	2	21.53	21.53	0.546	0.004	NA	1.20	NA
Kunz Mid	1st	3	5.58	126.32	0.598	0.021	0.21	1.59	1.00
	2nd	3	26.68				0.90		3.00
	3rd	1	29.56						
Kunz Low 1	1st	5	7.80	354.55	0.548	0.065	0.28	1.16	1.25
	2nd	4	28.19				2.41		0.50
	3rd	8	11.69				0.11		8.00
	4th	1	109.25						
Kunz Low 2	1st	9	4.74	274.31	0.626	0.044	0.50	1.42	1.00
	2nd	9	9.54				0.13		4.50
	3rd	2	72.92						

Tidal Channels Morphometrics

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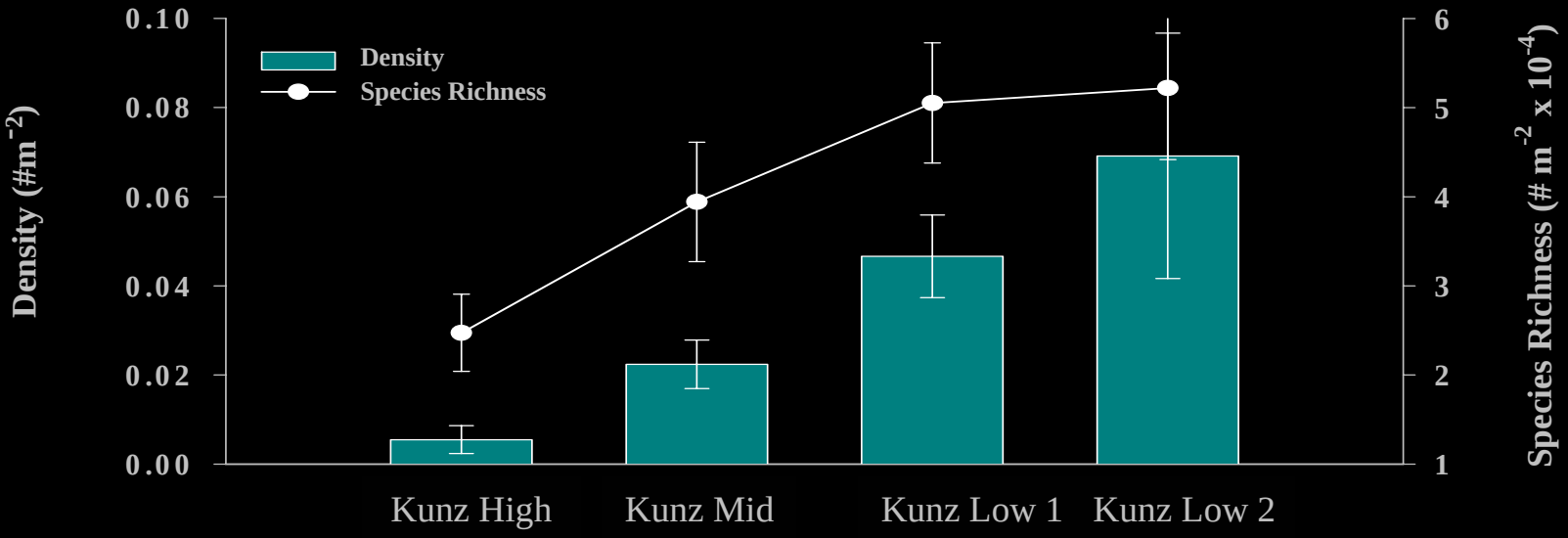
	3rd	2	72.92						

Targets?

Channel Order	Length Ratio	Average Sinuosity	Drainage Density (m/m2)	Bifurcation Ratio
1st	0.10 - 0.30	1.1 - 2.0	0.033 - 0.066	3.50
2nd	0.40 - 0.70			
3rd	0.50 - 0.70			

Fish Use

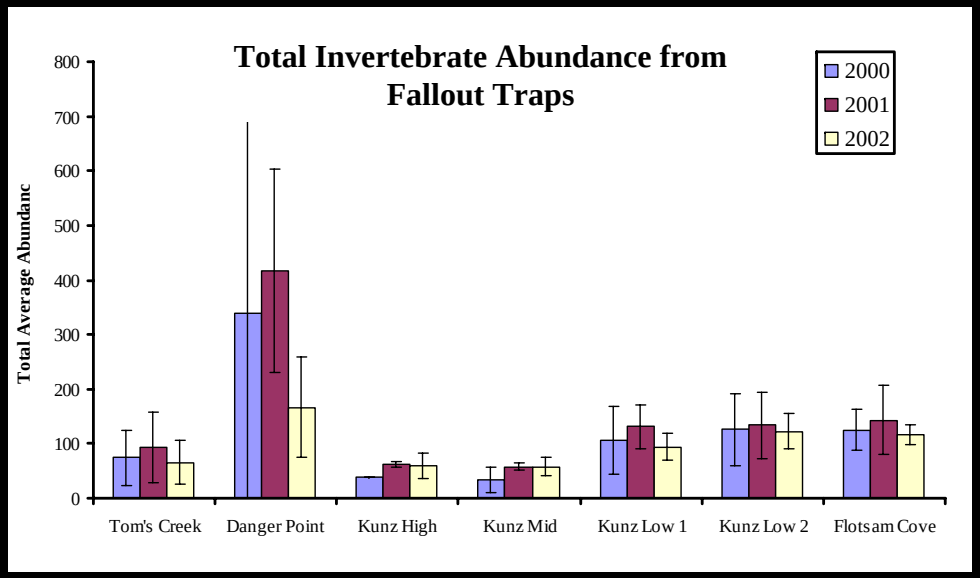
Mean Total Density and Species Richness- 11/98-3/99



Greater numbers of fish and higher diversity of fish species used the lower cells as compared with the upper cells

(S. Sadro, B. Miller and various volunteers 1998-99)

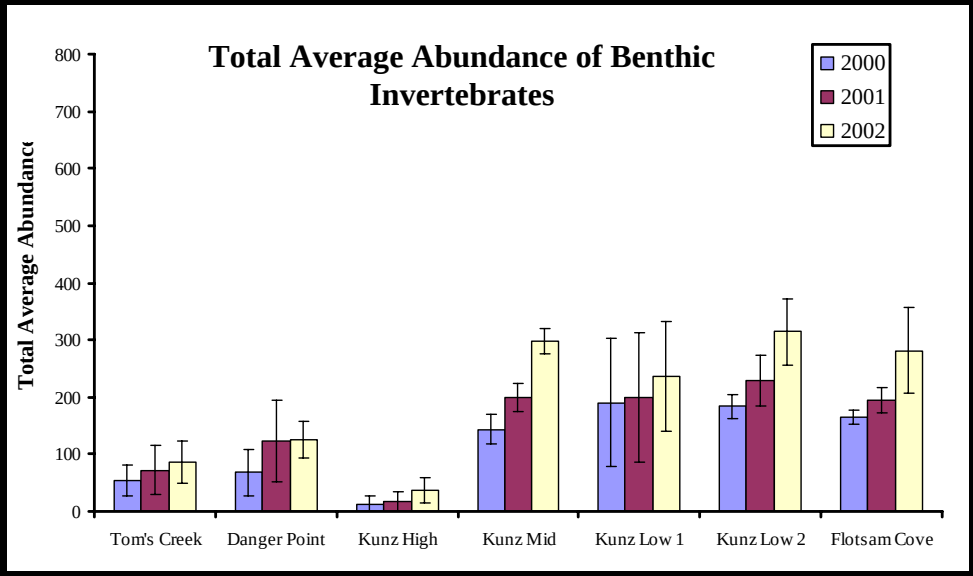
Invertebrate Community Development 2000-2002



Abundance of fallout insects was greater in lower cells by 2002 and greater in lower reference site except Danger Point

For all three years, abundance of benthic invertebrates was greater in all cells and low reference site compared with the Kunz high marsh and high reference marshes

(D. Varoujean [field], and A. Gray [analysis] 2000-05)



Vegetation Recruitment

Kunz Mid Marsh Cell- 1996

Kunz Mid Marsh Cell- 1999

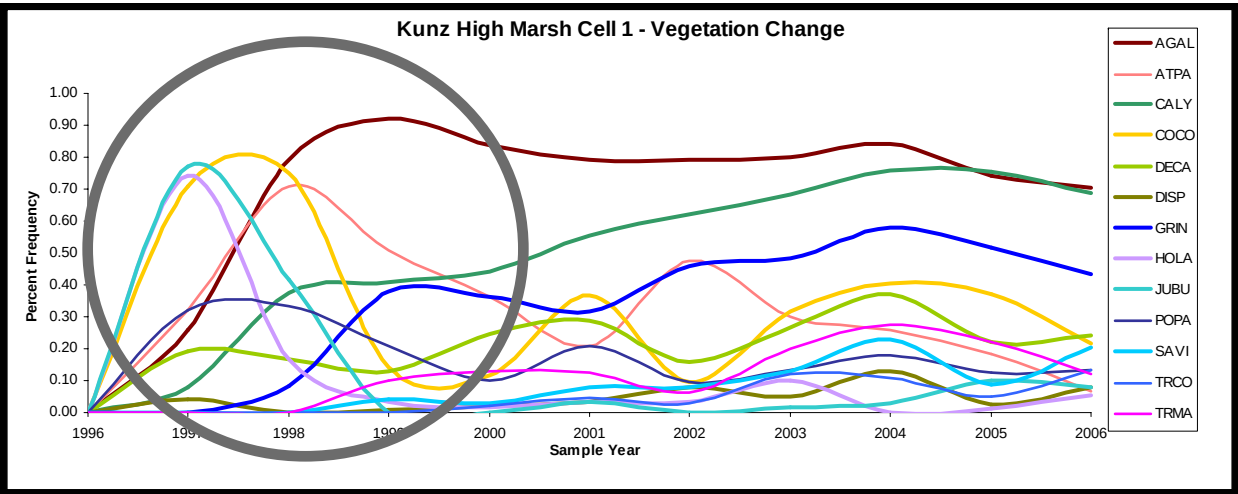
Kunz Mid Marsh Cell- 2002

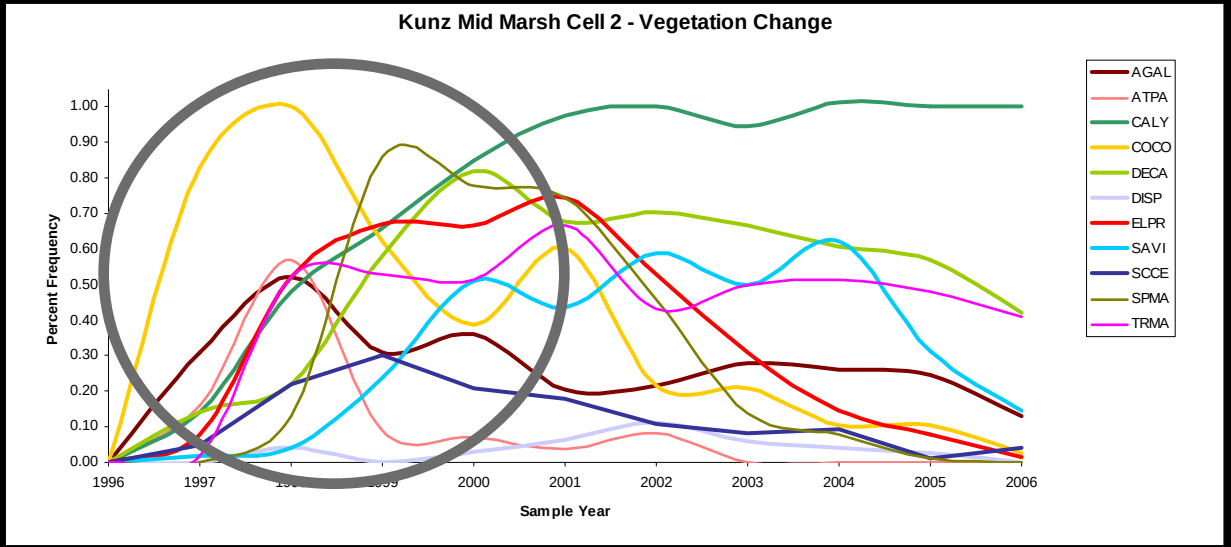
Ten years of Kunz Marsh Vegetation Recruitment

High and Mid Marsh <u>Early Years:</u>

Higher cells dominated by competitively subordinate fugitive and remnant pasture species

(Assisted by D. Philips, K. Sparks, A. Gray and various volunteers 1996-2007)





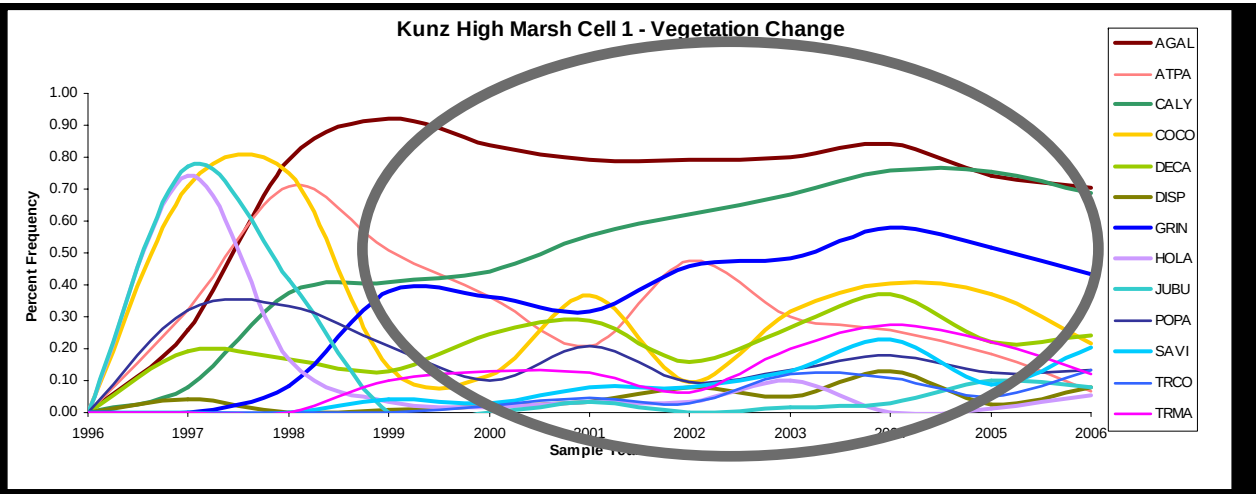
Dominant species:
Cotula coronopifera (brass buttons)
Juncus bufonious (toad rush)
Holcus lanatus (velvet grass)

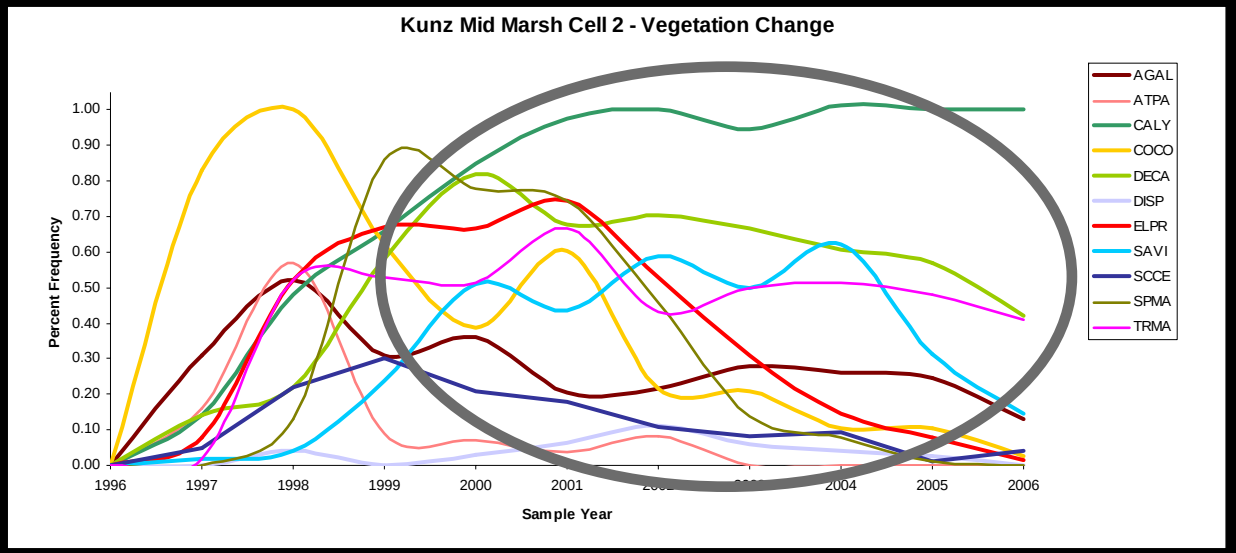
Ten years of Kunz Marsh Vegetation Recruitment

High and Mid Marsh Later Years:

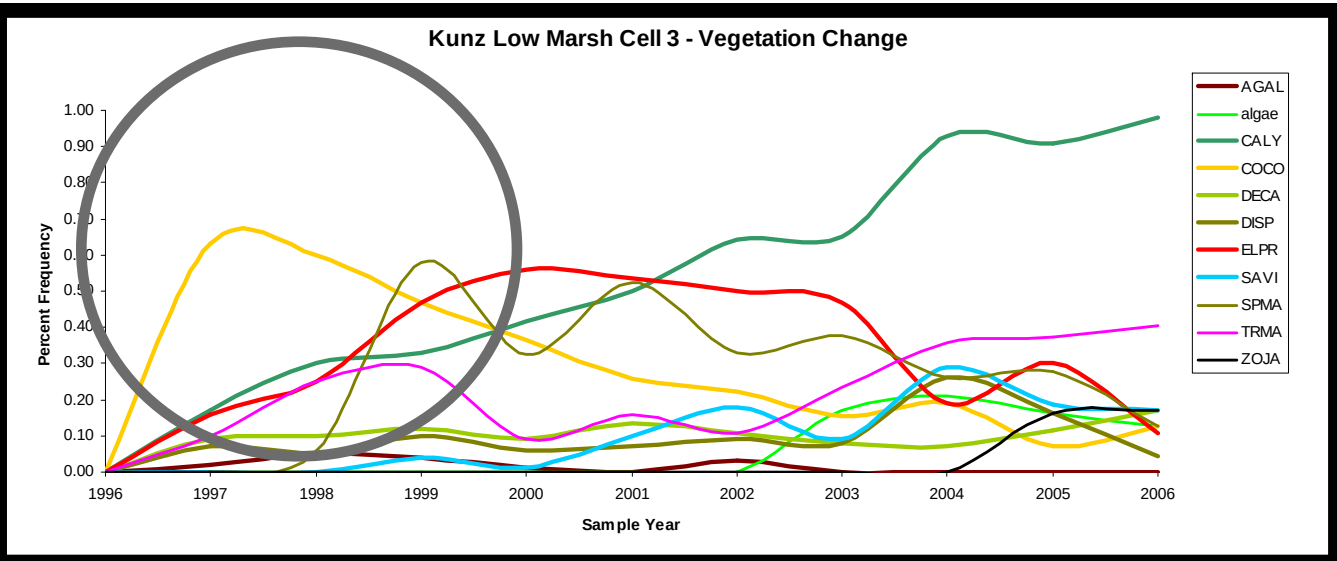
Fugitive and remnant pasture species give way to permanent colonizers- dominated by Carex lyngbyei and Agrostis spp.

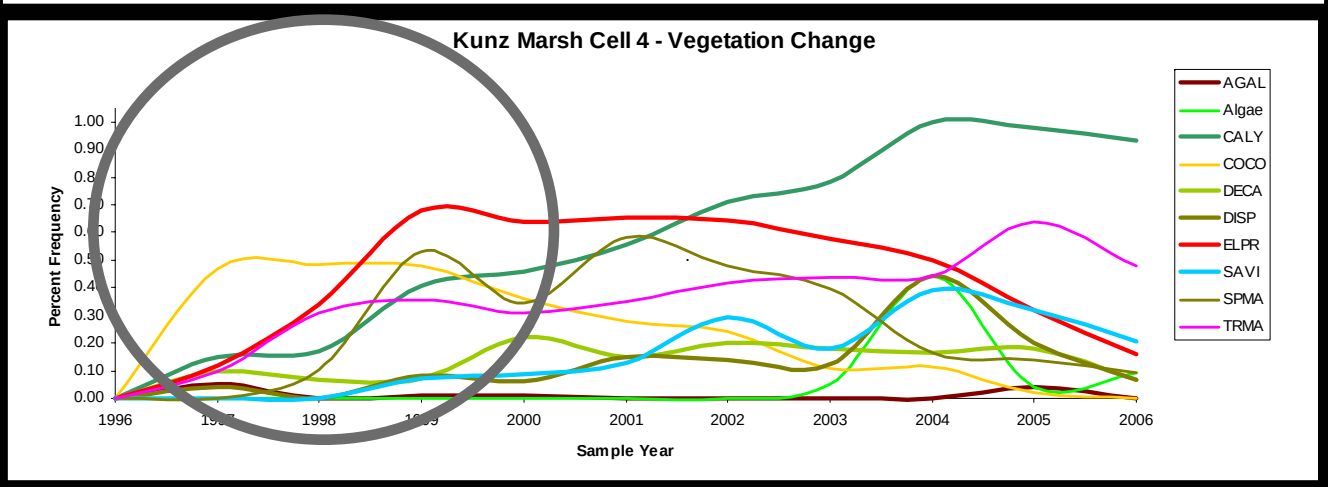
(Assisted by D. Philips, K. Sparks, A. Gray and various volunteers 1996-2007)





Dominant species:
Carex lyngbyei (Lyngby's sedge)
Agrostis spp. (bentgrass) (high marsh only)
Grindellia integrifola (gumweed) (high marsh only)
Deschampsia caespitosa (tufted hairgrass) (mid marsh)





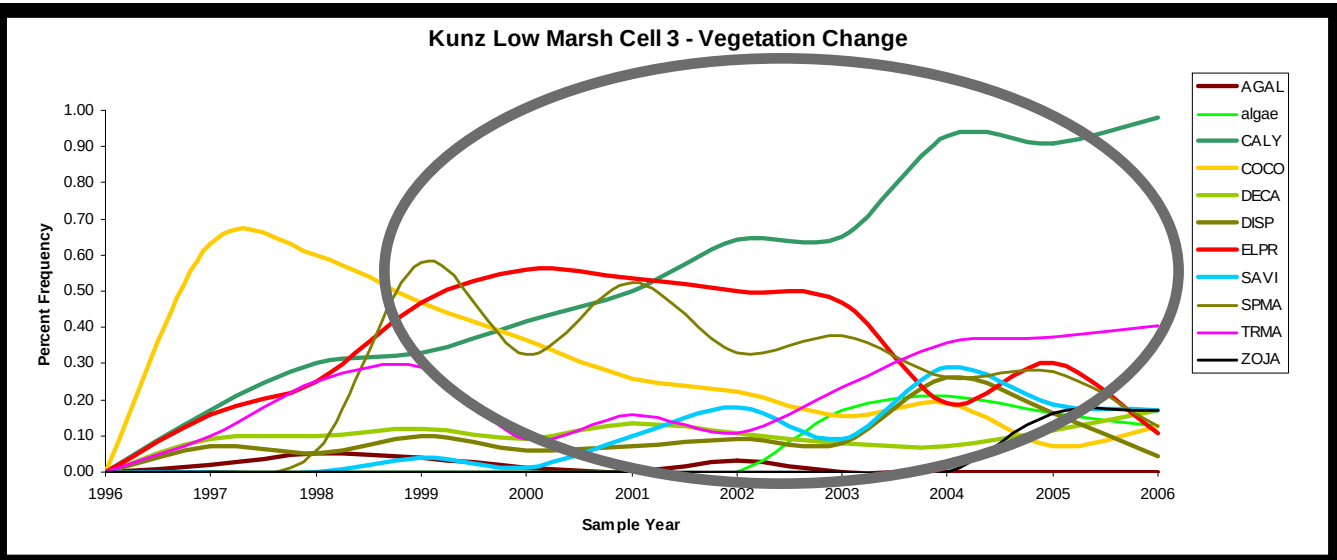
Ten years of Kunz Marsh Vegetation Recruitment

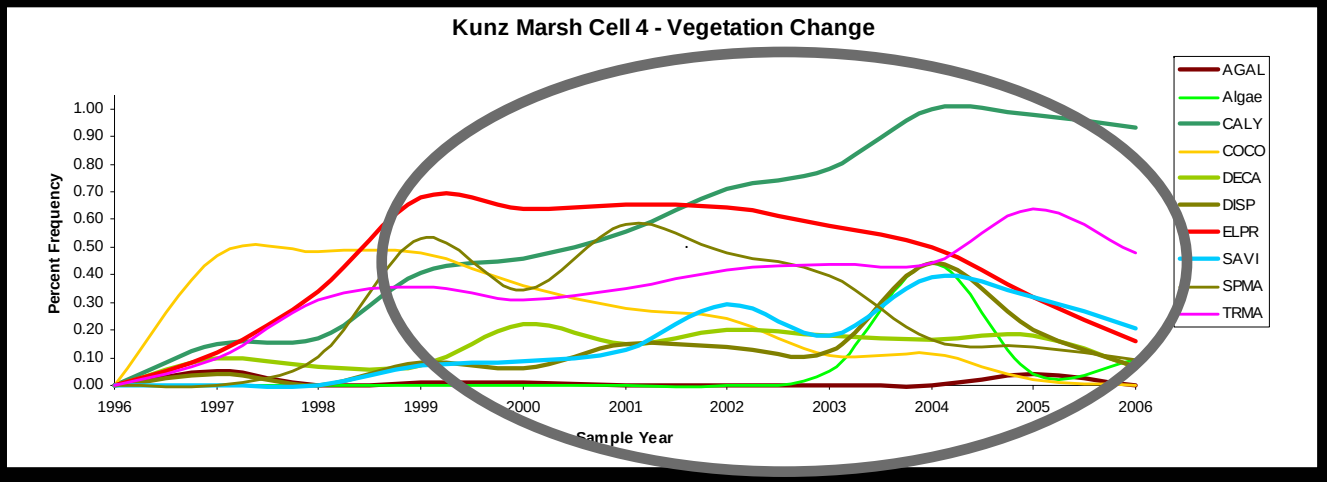
Low Marsh Early Years:

Lower cells dominated by few fugitive species- slow community development

Dominant species:
Cotula coronopifera (brass buttons)
Eleocharis parvula (dwarf spike rush)
Spergularia marina (salt sandspurry)

(Assisted by D. Philips, K. Sparks, A. Gray and various volunteers 1996-2007)





Ten years of Kunz Marsh Vegetation Recruitment

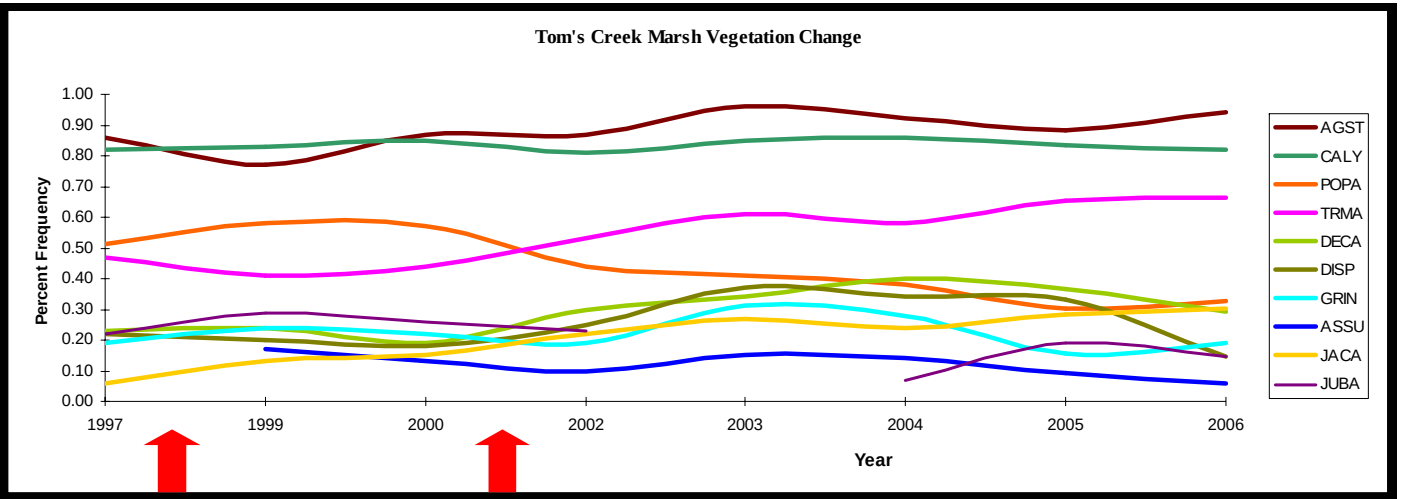
Low Marsh Later Years:

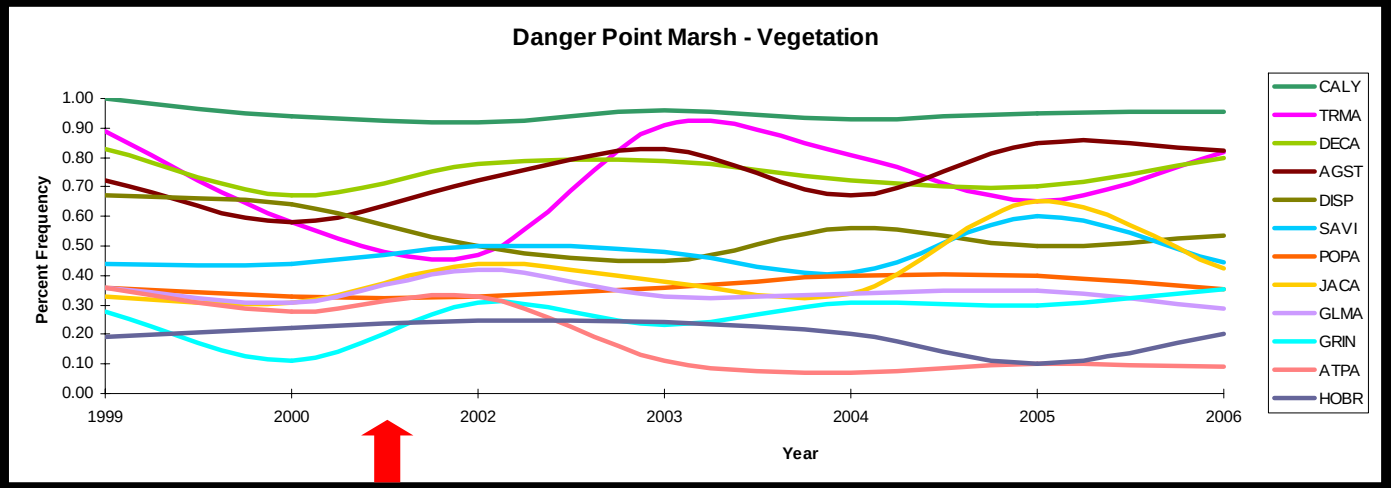
Fugitive species out-competed by permanent colonizers- Lyngby's sedge in particular

Dominant species:
Carex lyngbyei (Lyngby's sedge)
Triglochin maritimum (arrowgrass)

(Assisted by D. Philips, K. Sparks, A. Gray and various volunteers 1996-2007)

1997-2006 Reference mature high marshes show a relatively stable mix of permanent colonizers





Dominant species:

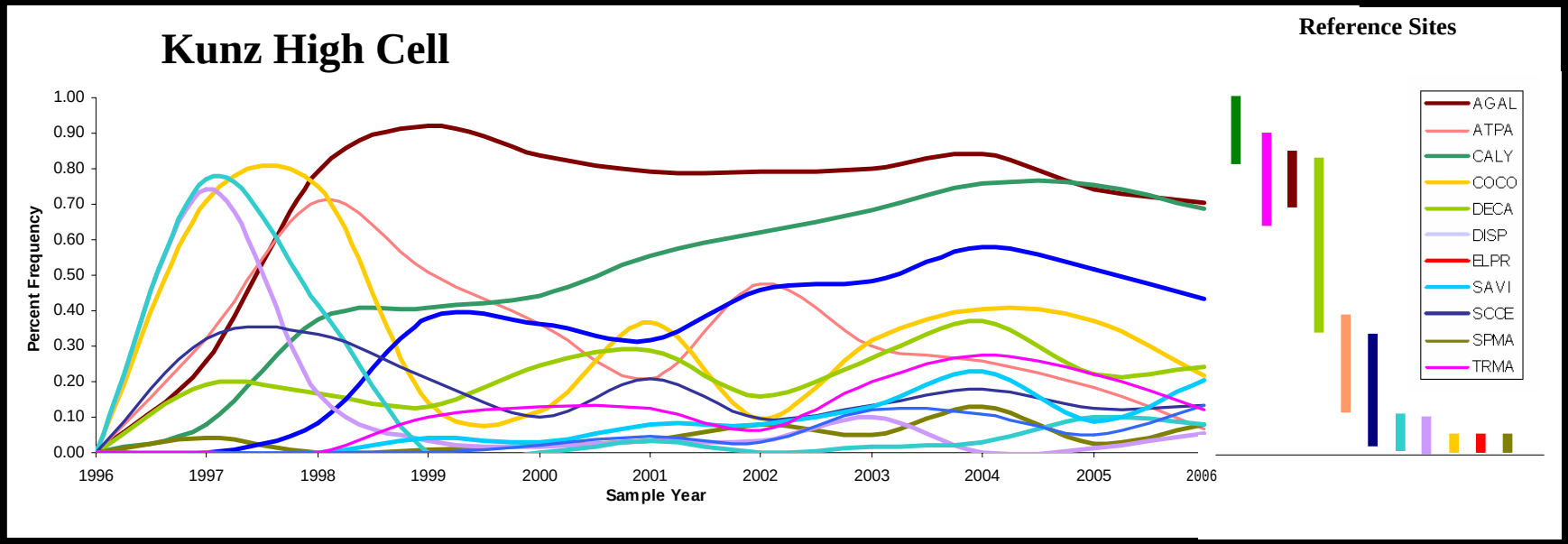
Agrostis spp. (bentgrass) *Carex lyngbyei* (Lyngby's sedge)

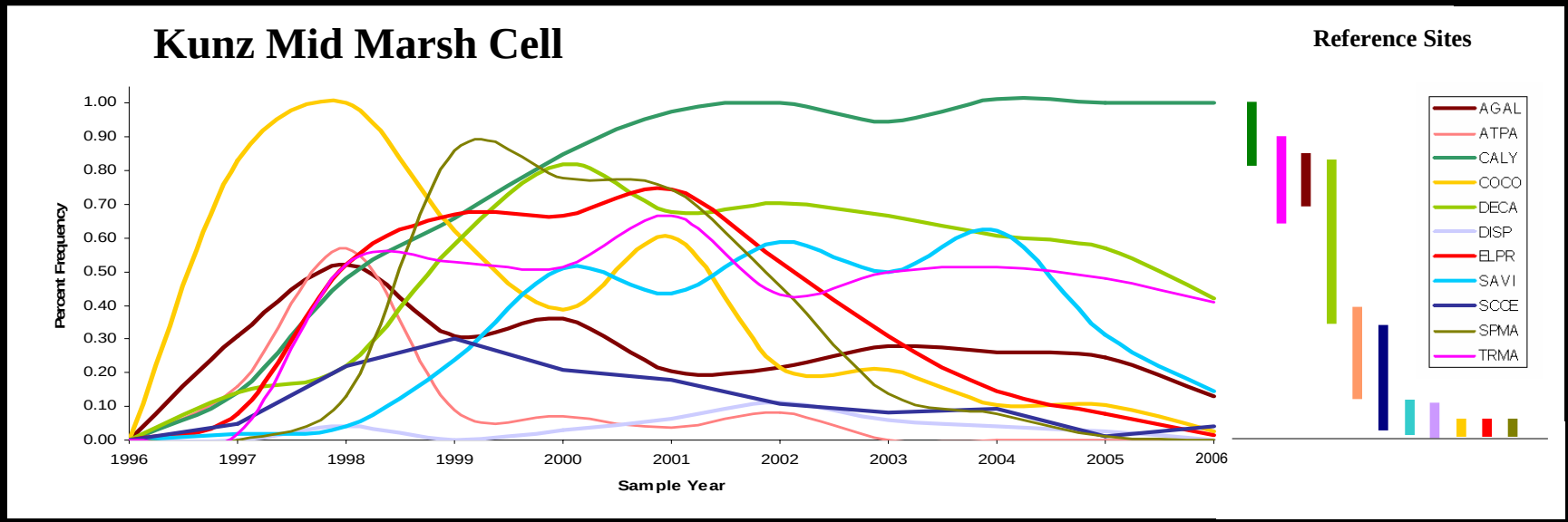
Deschampsia ceaspitosa (*T. hairgrass*) *Triglochin maritimum* (arrowgrass)

Years with no data

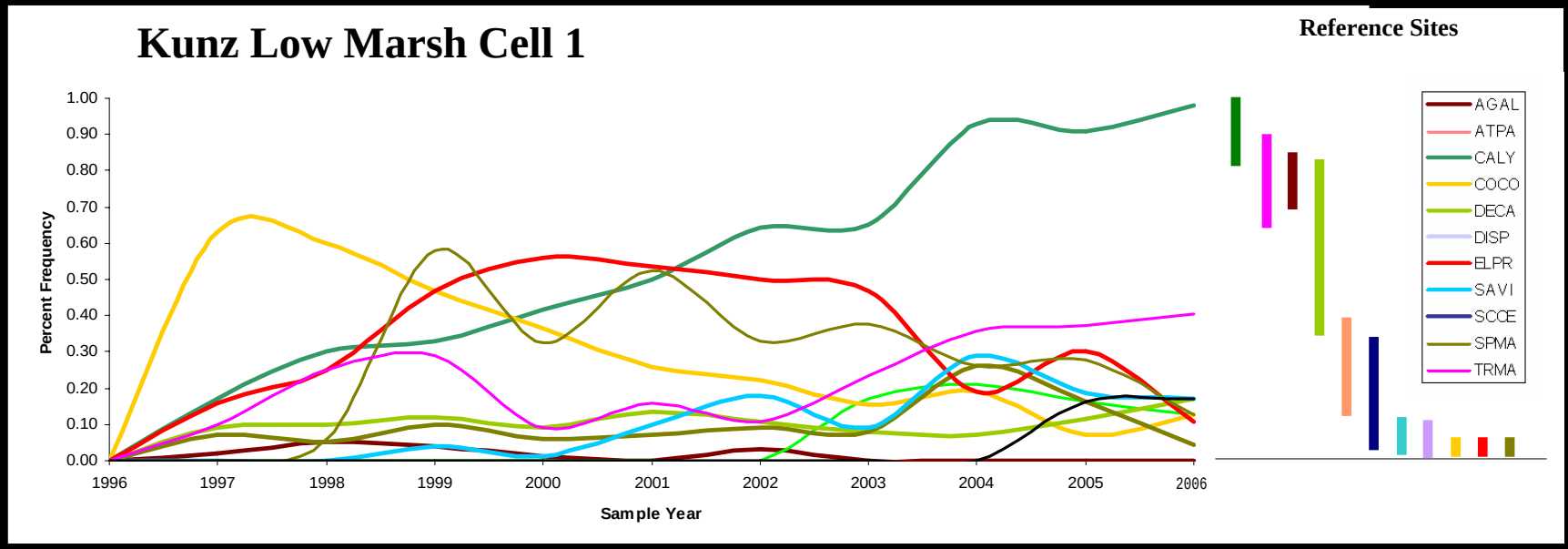
(Assisted by D. Philips, K. Sparks, A. Gray and various volunteers 1996-2007)

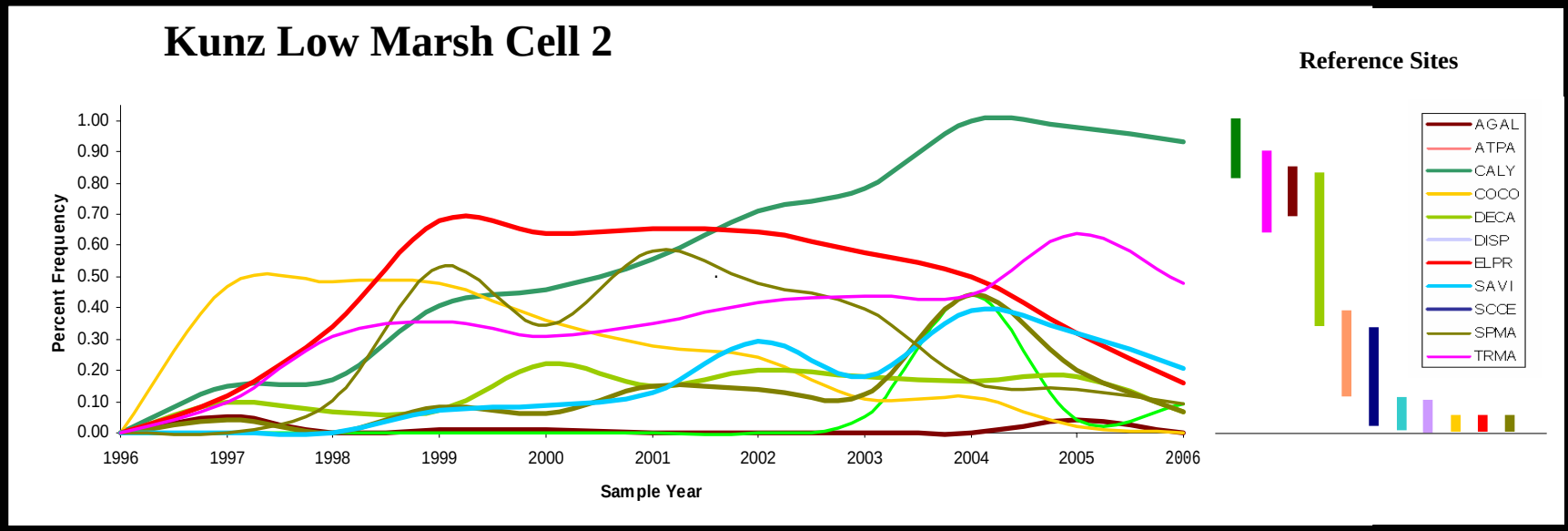
Comparison with Mature Marsh "Targets"



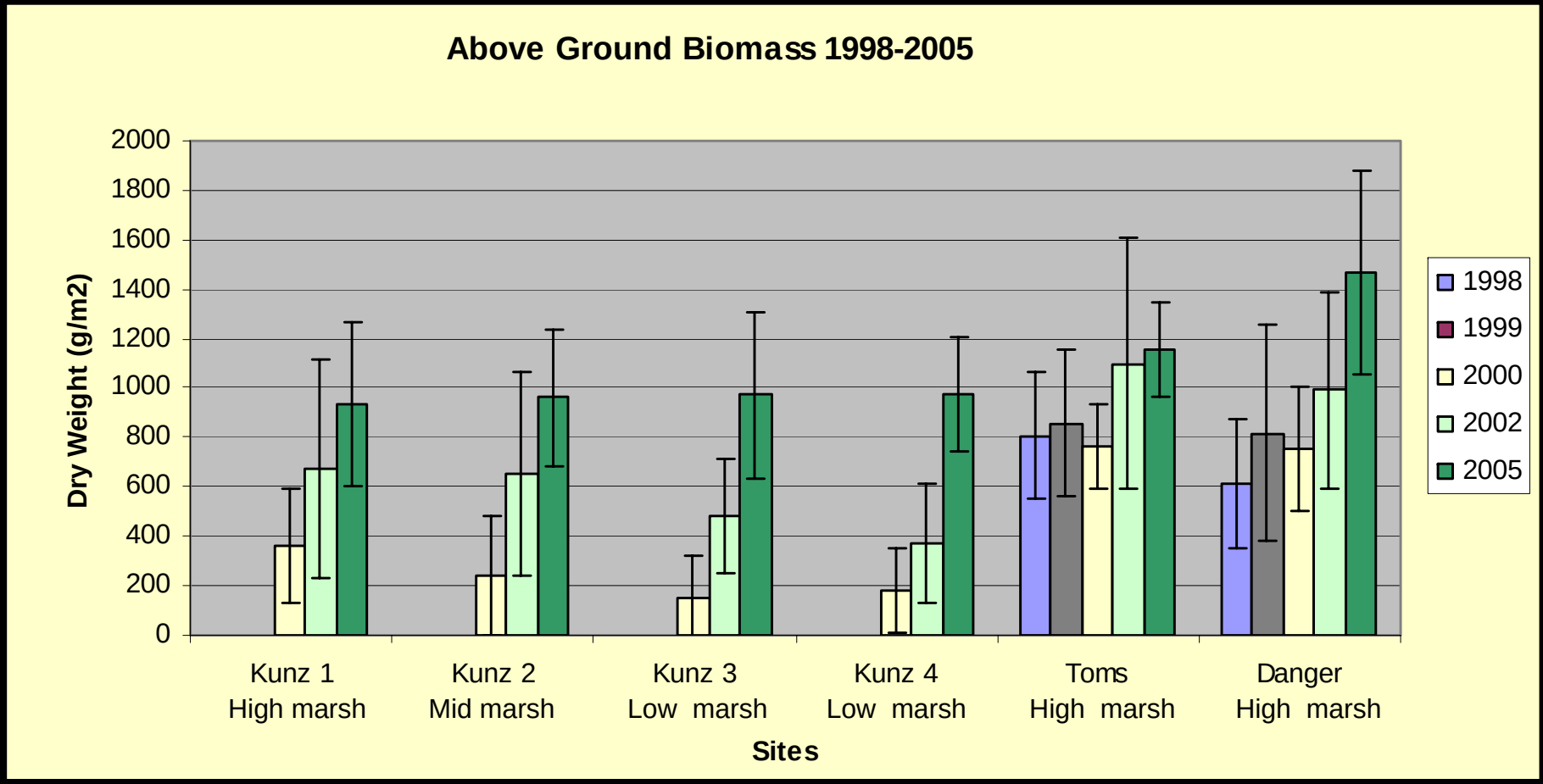


Comparison with Mature Marsh "Targets"





1998-2005 Above-Ground Biomass



(Assisted by S. Sadro, K. Sparks, various volunteers and OR Youth Conservation Corps crews 1998-2005)

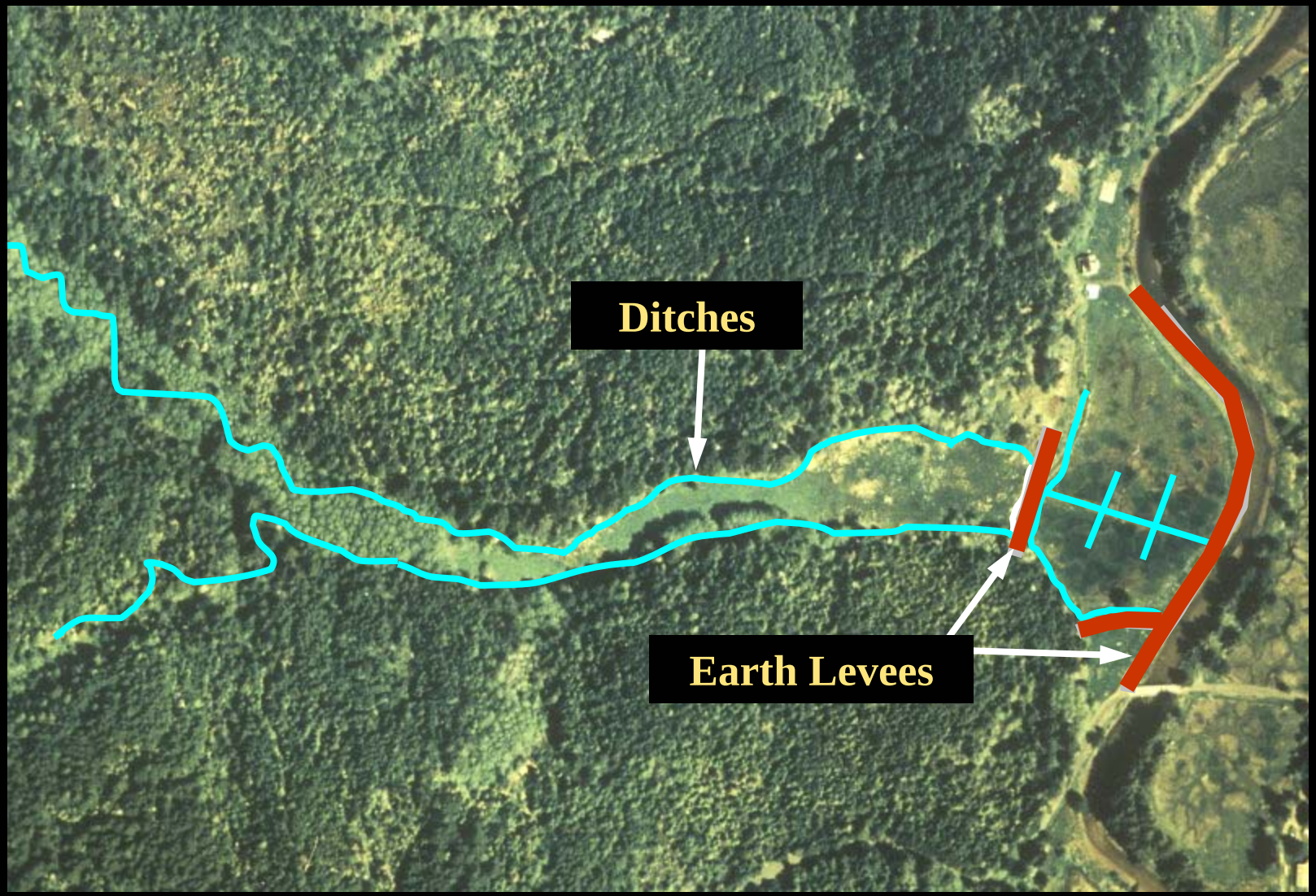
Dalton Creek Restoration Project

1991 Aerial Photo

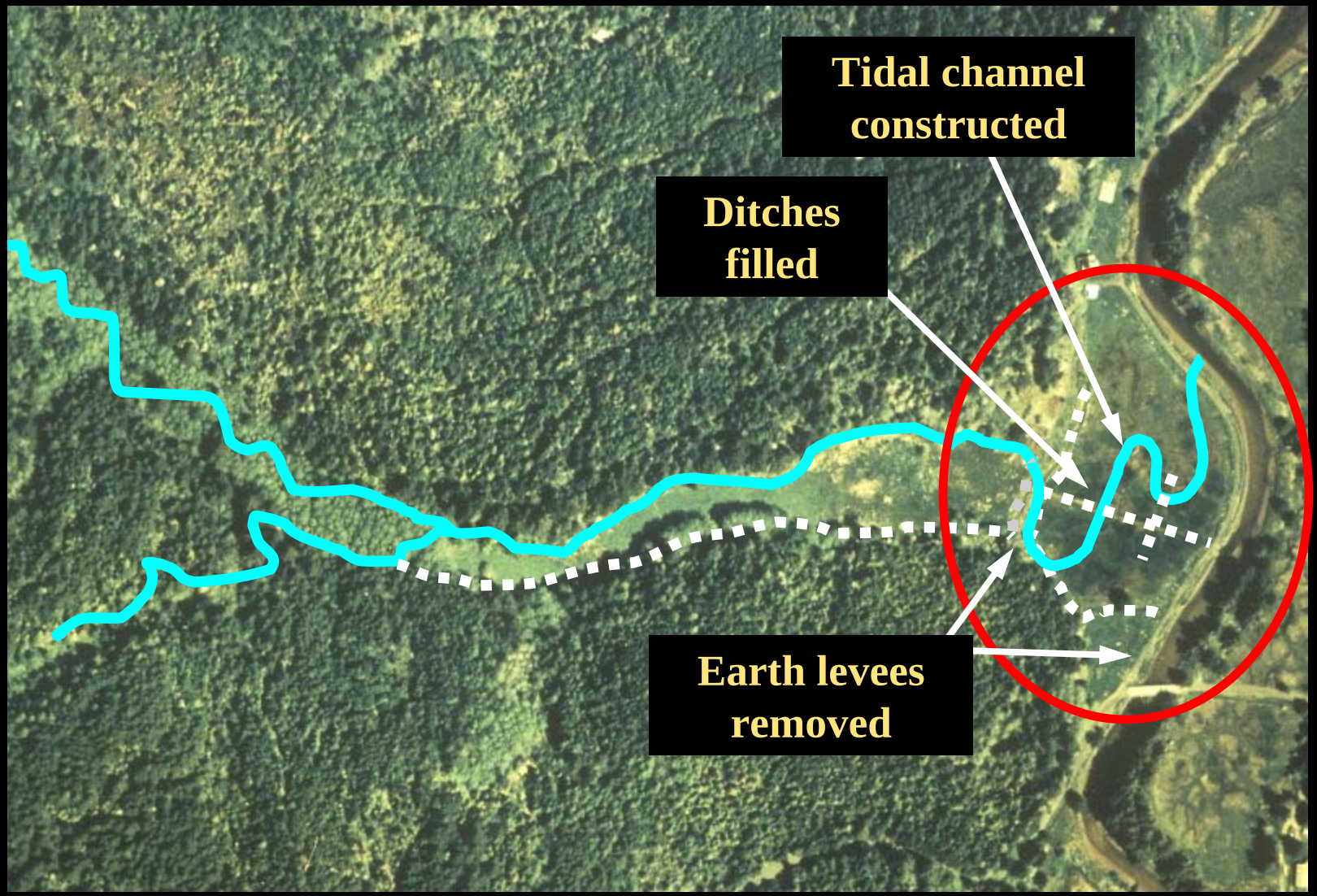
Dalton Creek Marsh

Major Issues:

- Ditches, salmonid access, lack of estuarine connection
- Logistical: No access to marsh surface for excavating equipment except tracked vehicles between muted tides



Dalton Creek Lower Watershed and Floodplain- 1991



Dalton Creek Lower Watershed and Floodplain- 1991

1991

1999

2005

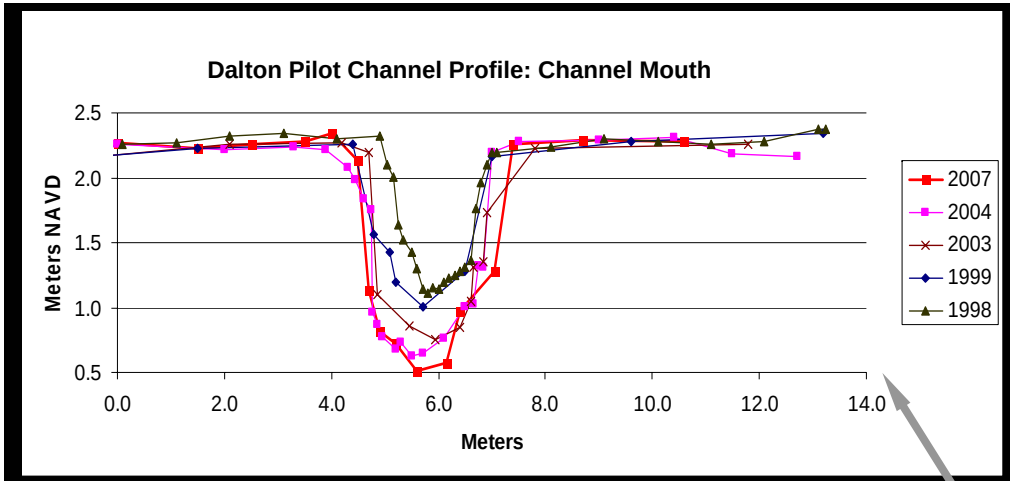
Ditch length: 125 m
Pilot channel length: 400 m

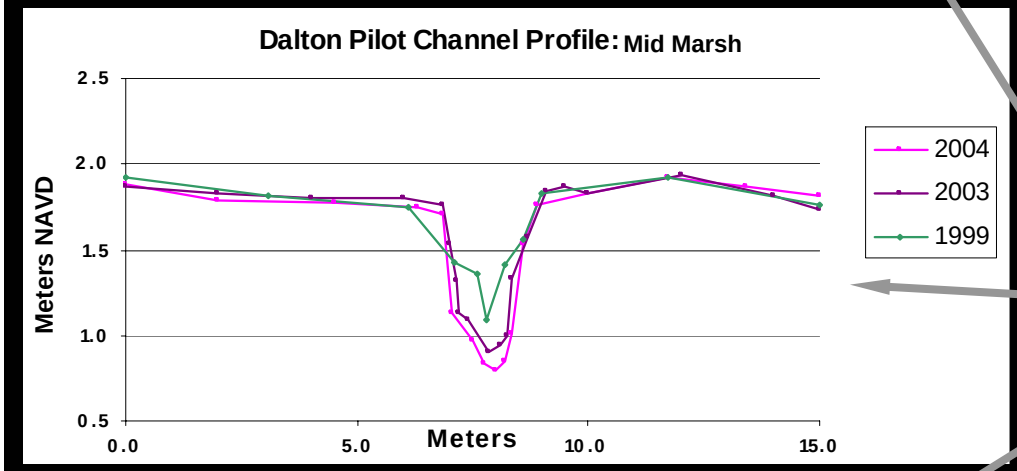
Use of explosives for tidal channel construction

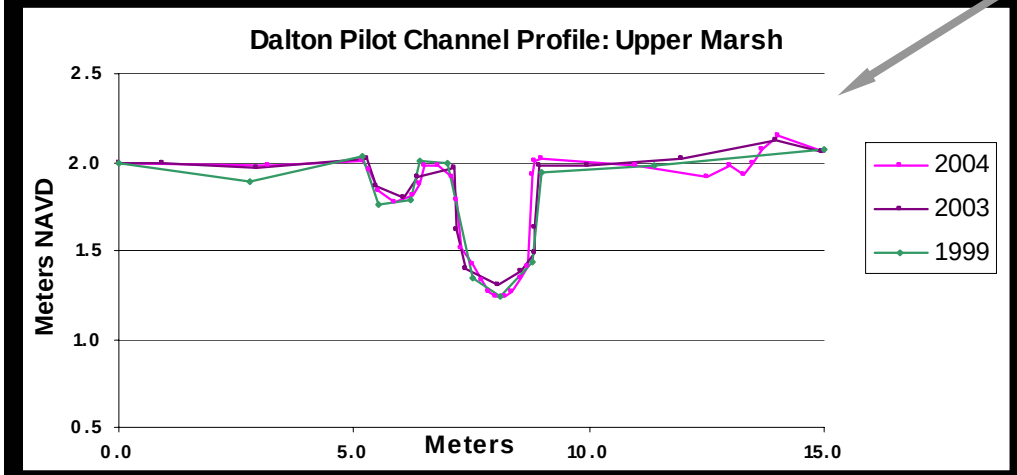
1998

1999

2002





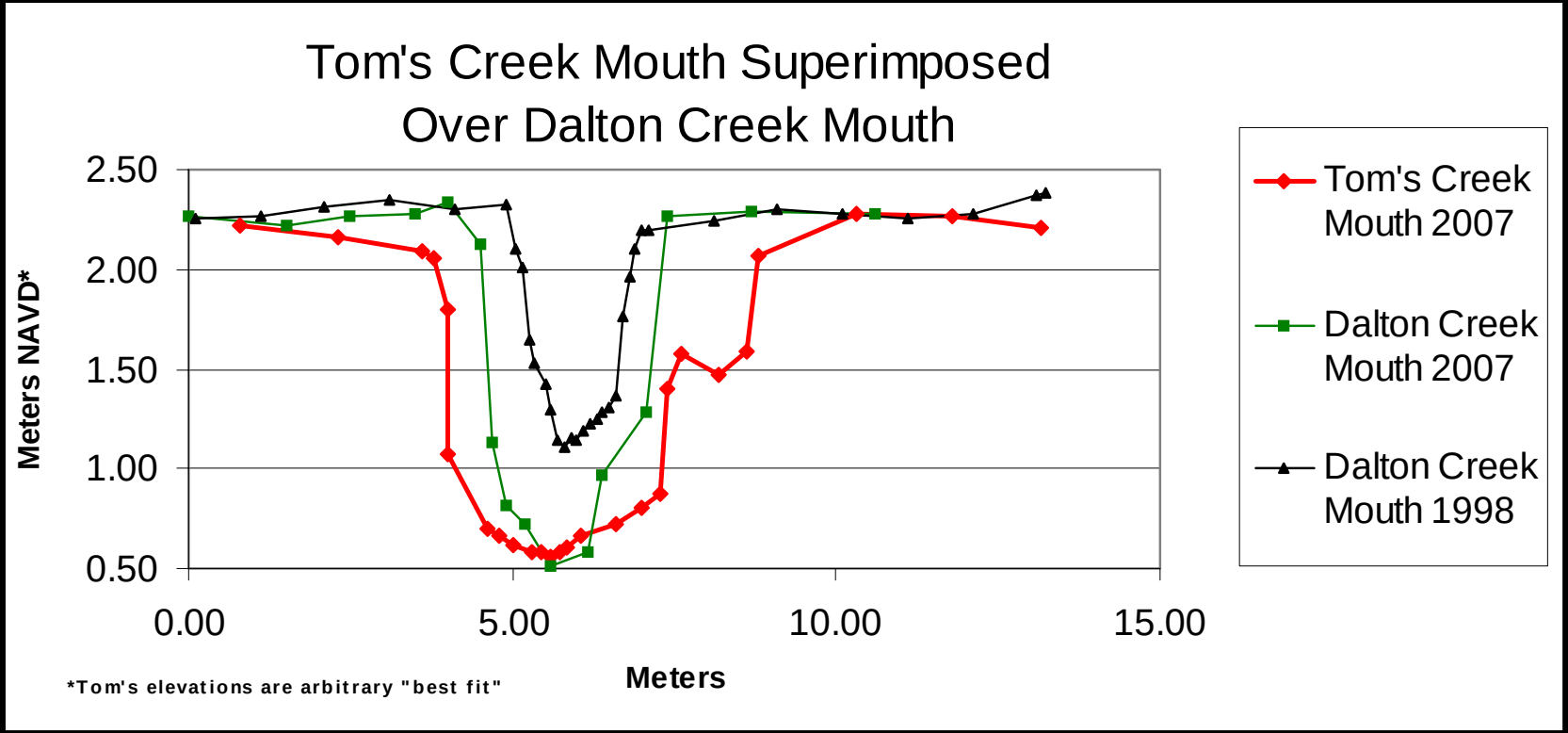


Change over six to nine years channel cross sectional area

X-section area (m^2)	1999	2004	2007
Mouth	2.0	3.2	3.8
Mid-marsh	0.5	0.9	
Upper marsh	0.7	0.7	

(Assisted by T. Barnes, D. Jones and various volunteers 1998-2007)

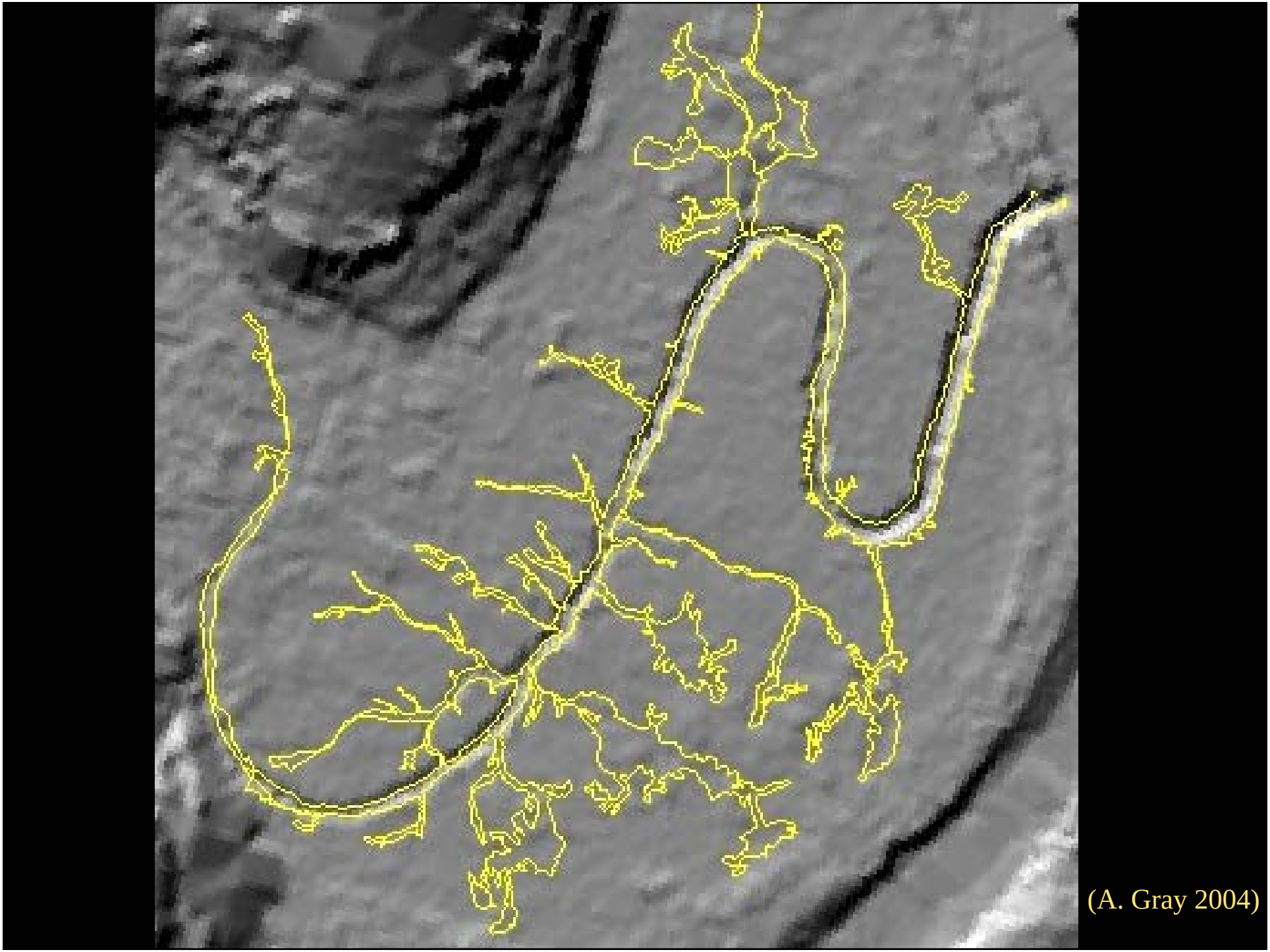
Comparison with Tom's Creek Reference Site



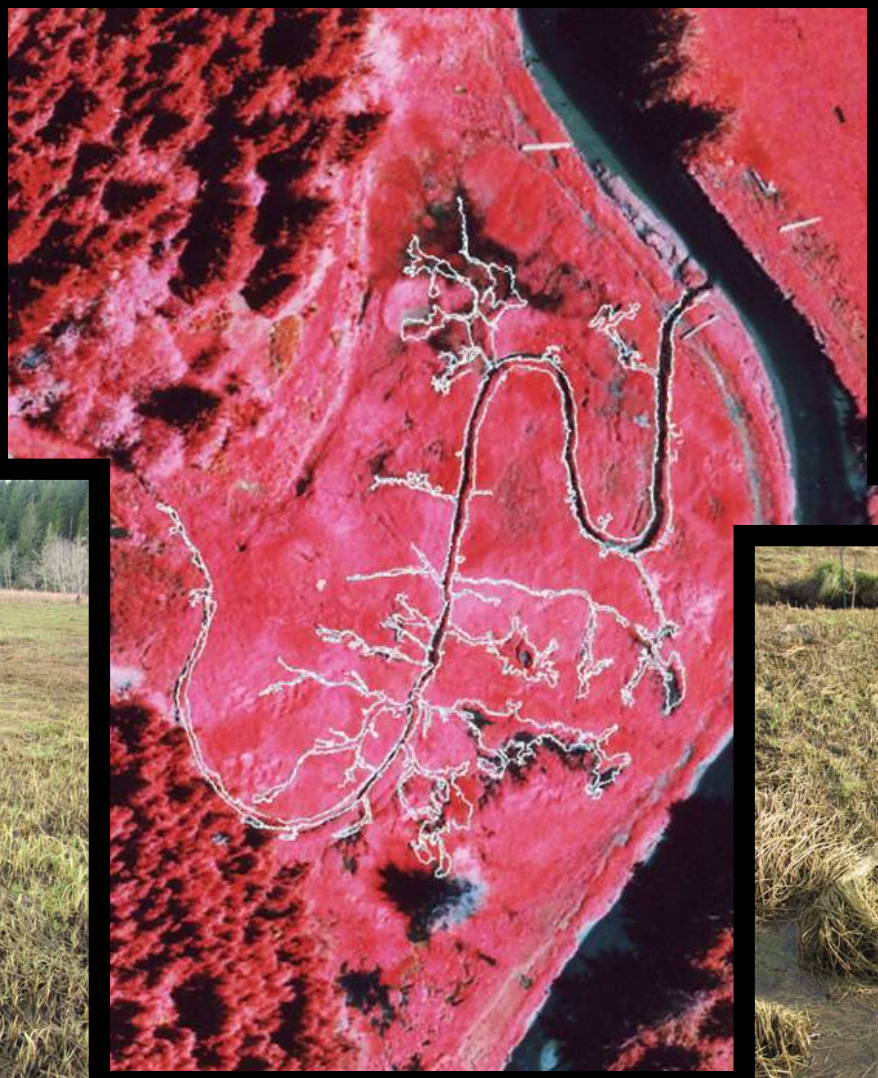
X-section area (m^2)	1998	2007
Dalton Mouth	1.5	3.8
Tom's Mouth		5.3

In 2007 Dalton Creek mouth is 71% of Tom's

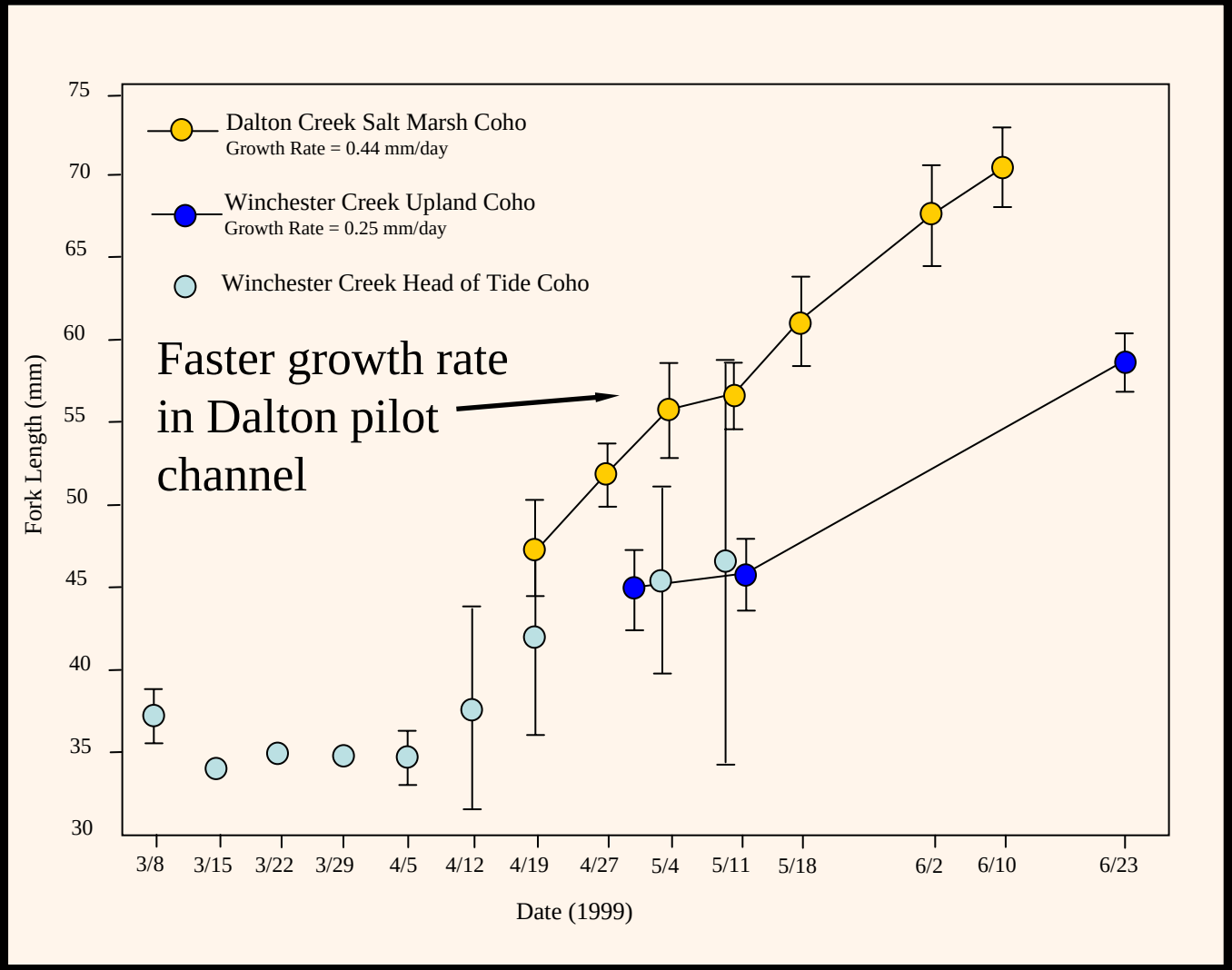
(Assisted by T. Barnes, D. Jones and various volunteers 1998-2007)


(A. Gray 2004)

Dalton Creek Marsh:
Evolution of lower order tidal channels



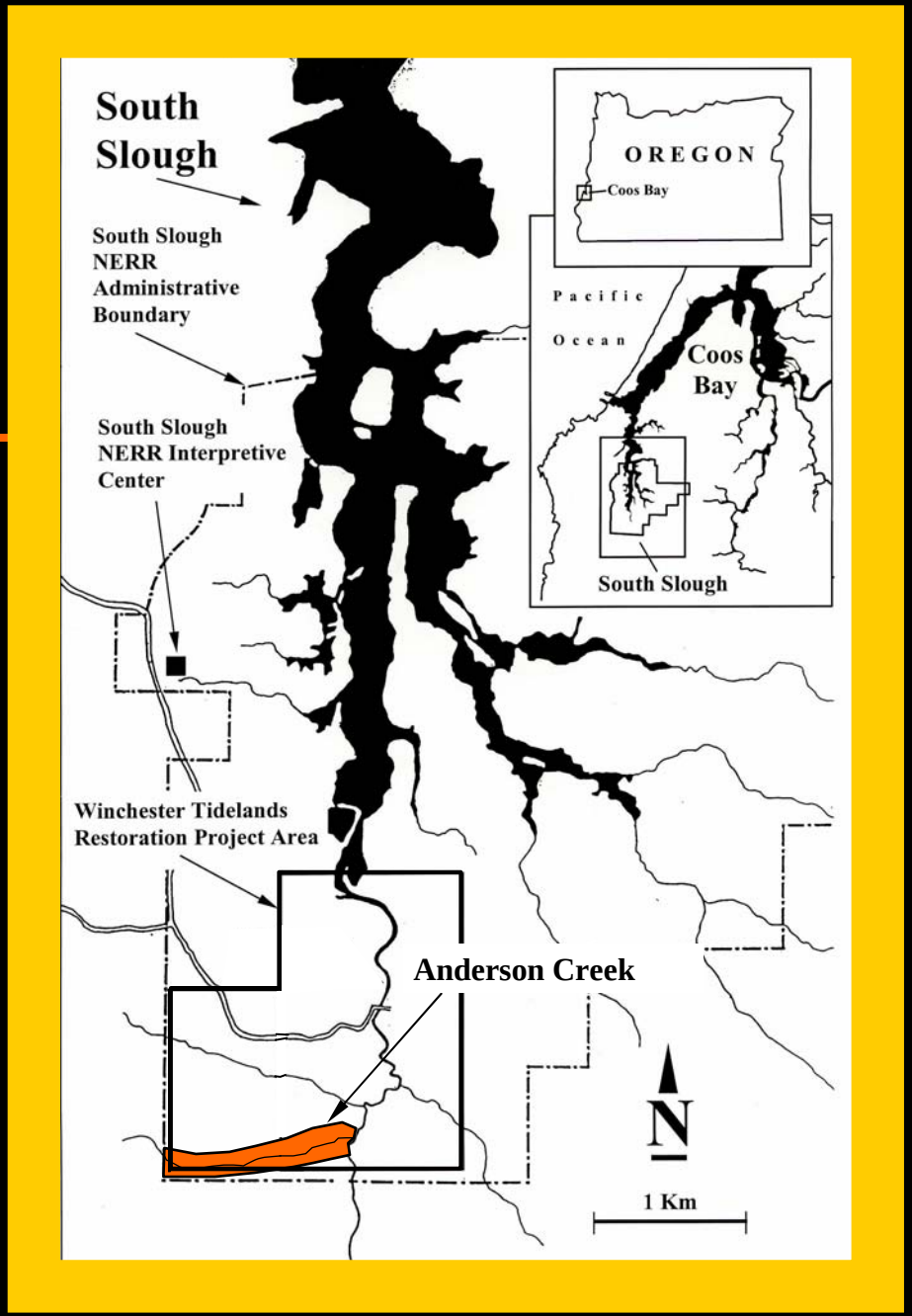
(A. Gray 2004)



Growth of 0+ coho salmon populations in Dalton Creek pilot channel and freshwater stream environments in 1999

(S. Sadro, B. Miller 1999)

Anderson Creek Restoration Project



Anderson Creek Marsh

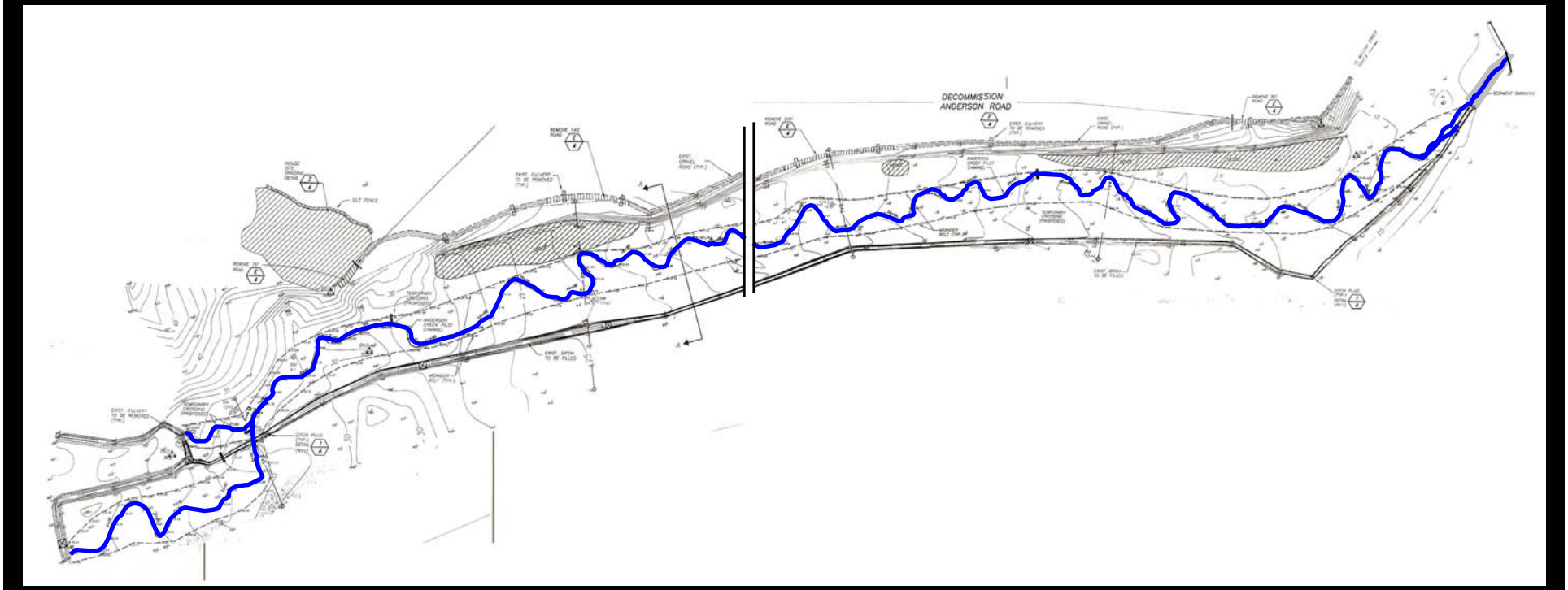
Major Issues:

- Non-tidal channel network reduced to a linear ditch
- Severe ditch downcutting- no hydrologic connection between stream and floodplain
- Salmonid habitat reduced in abundance and complexity
- Suspected turbidity caused by “banging” of ditch banks
- Invasive vegetation species

Anderson Creek Marsh 1991

N

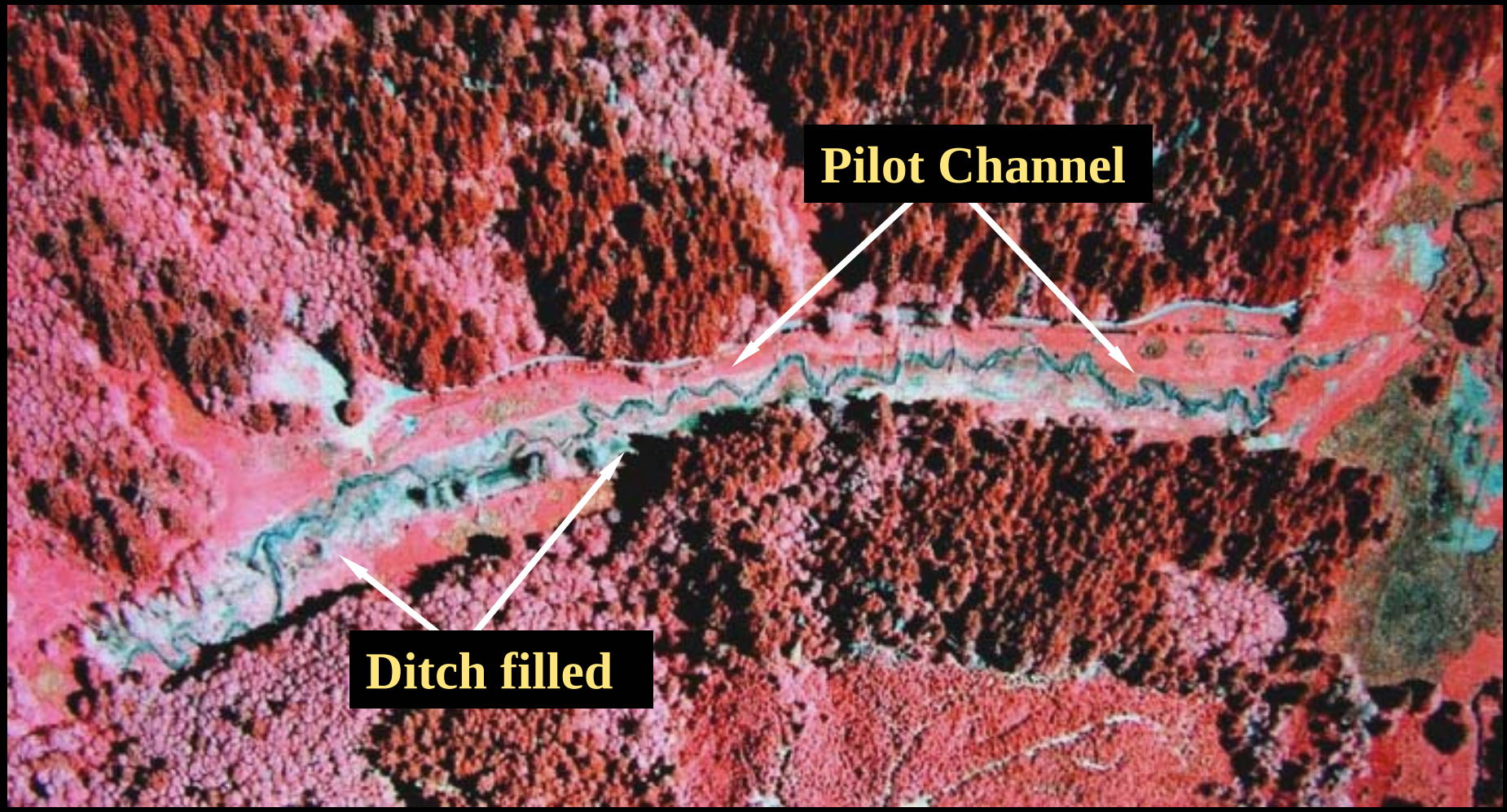
Ditch length: 850 m
Pilot channel length: 1,160 m



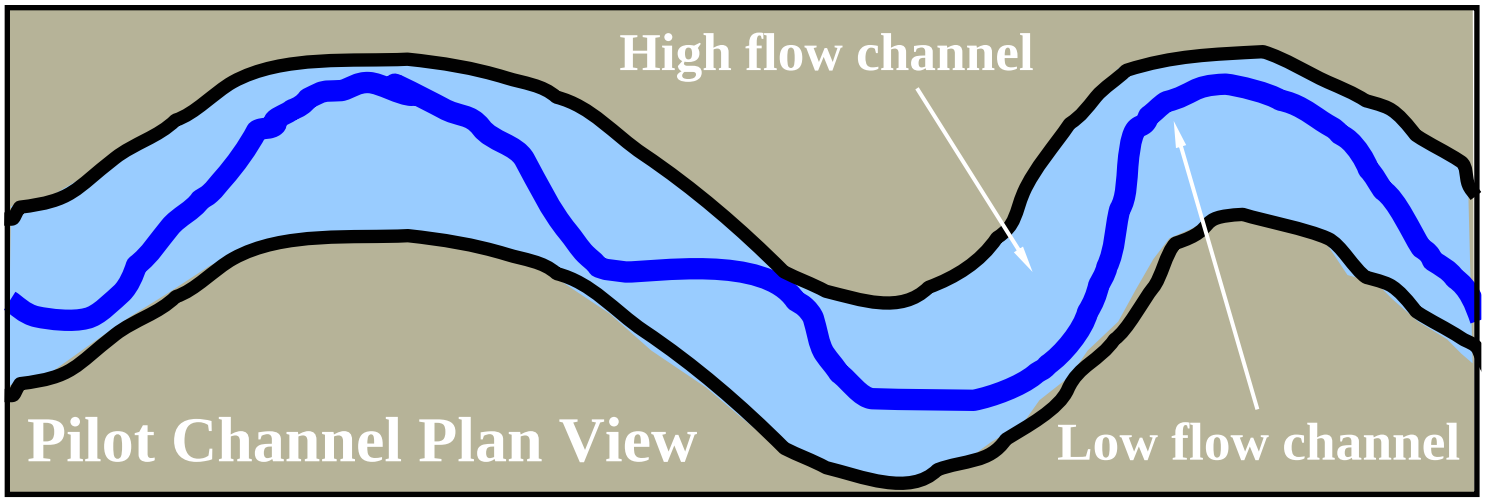
Anderson Creek Restoration
Project Design

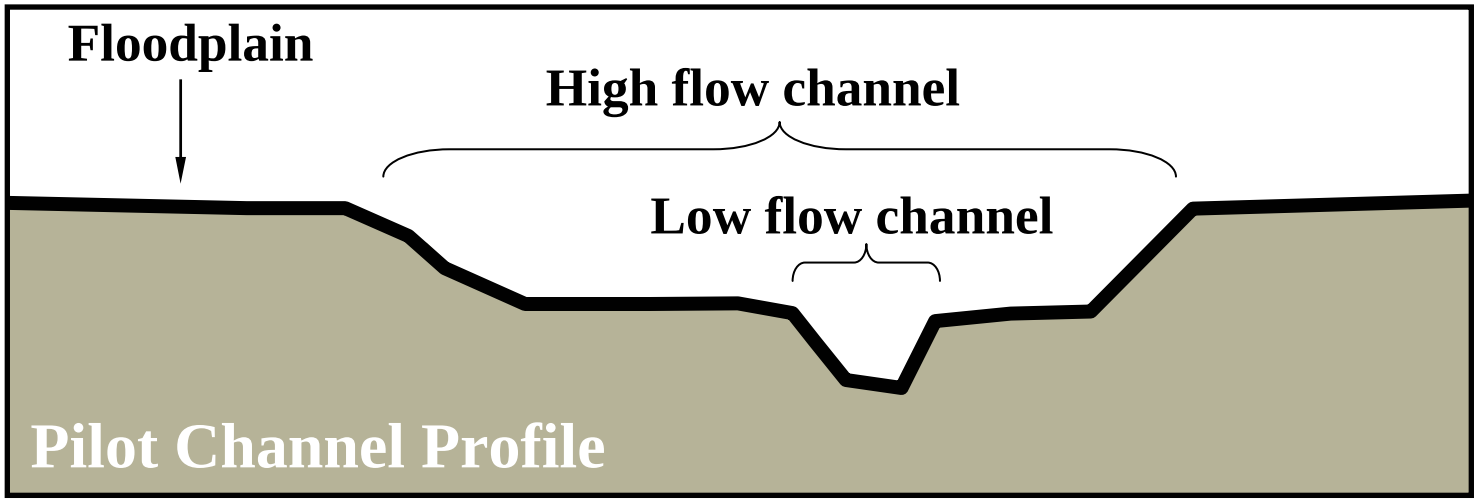
Anderson Creek
Pilot Channel

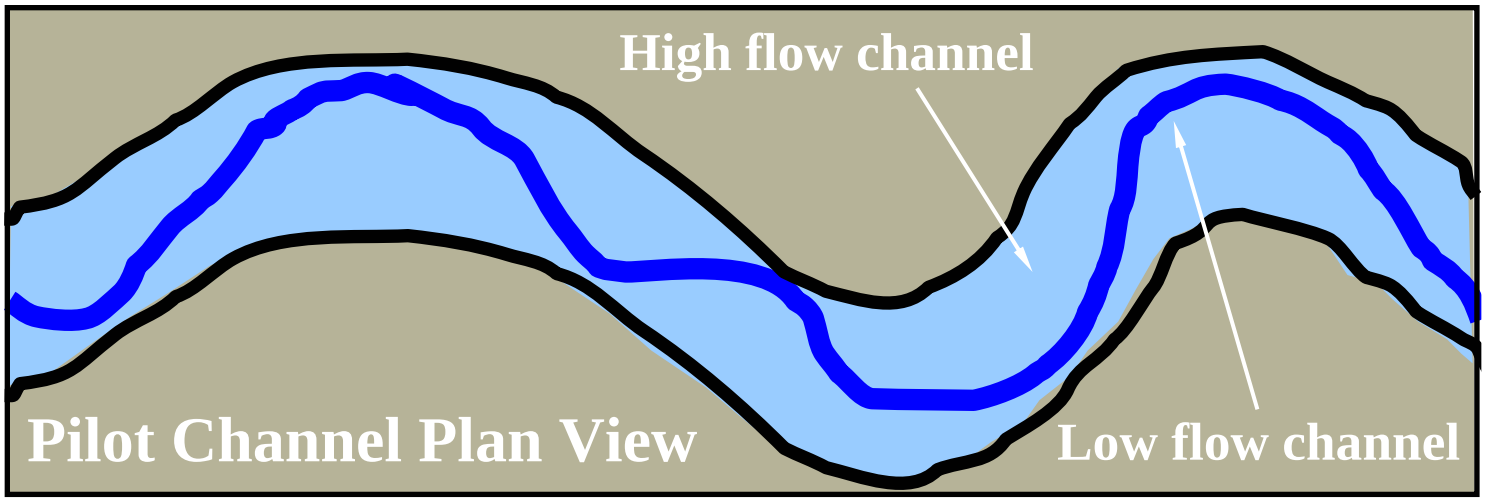
N



May 2003


High flow channel
Pilot Channel Plan View
Low flow channel


Floodplain
High flow channel
Low flow channel
Pilot Channel Profile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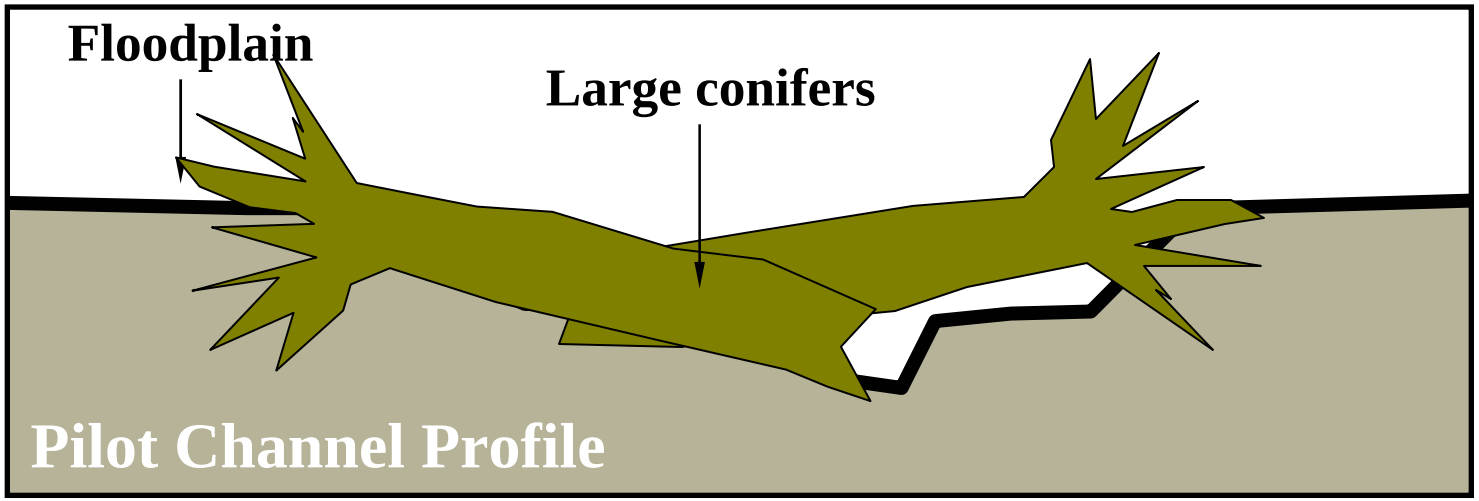

Floodplain
Large conifers
Pilot Channel Profile

Low flow channel under construction

High flow channel under construction

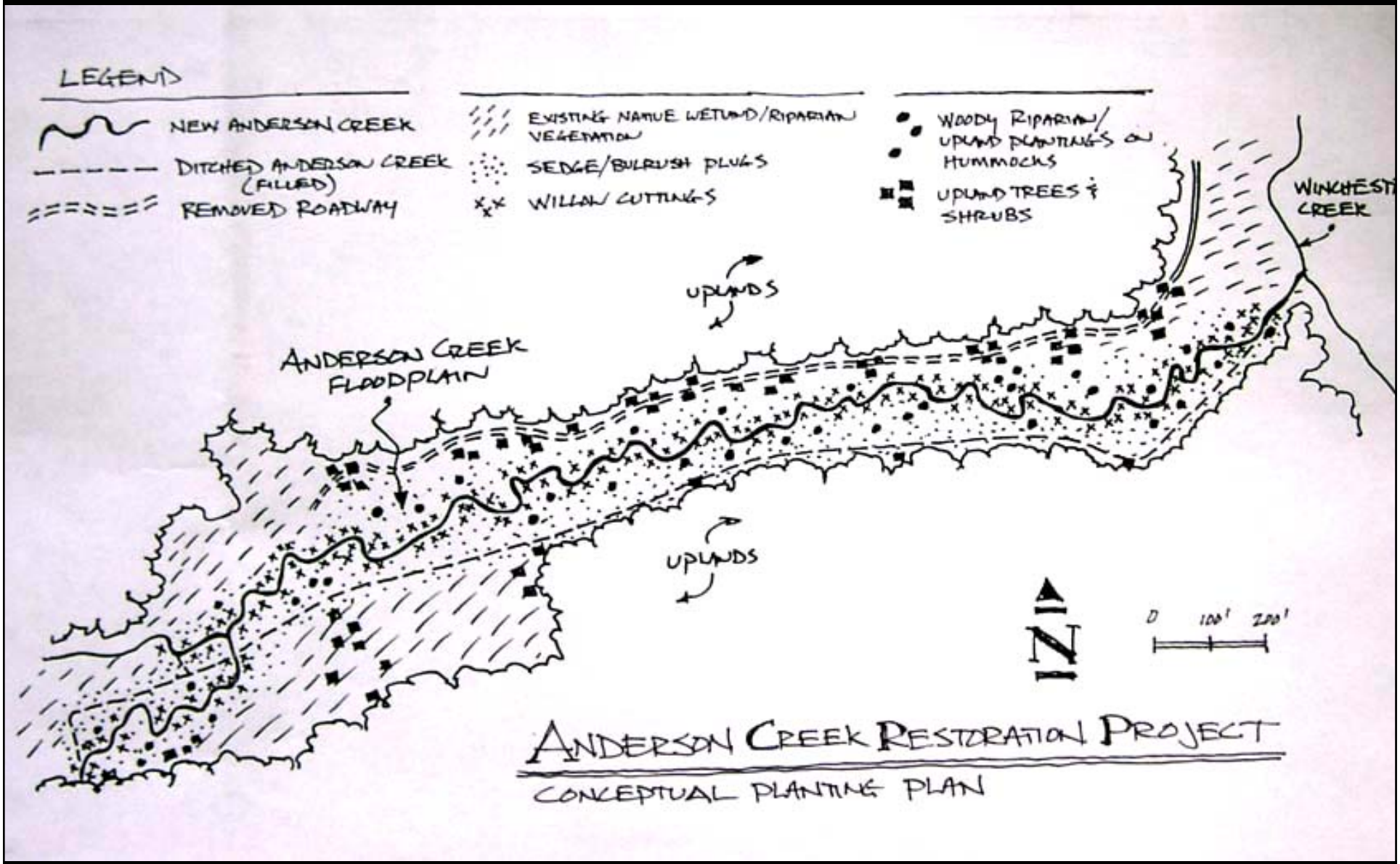
High flow channel “overwintering”

Anderson Creek Valley

October 2002

Final Phase of Restoration

Crew collected fish and amphibians from ditch and relocated them to habitat in adjacent floodplains


LEGEND
NEW ANDERSON CREEK
DITCHED ANDERSON CREEK (FILLED)
REMOVED ROADWAY
EXISTING NATIVE WETLAND/RIPARIAN VEGETATION
SEDGE/BULRUSH PLUGS
WILLOW CUTTINGS
WOODY RIPARIAN/ UPLAND PLANTINGS ON HUMMOCKS
UPLAND TREES & SHRUBS
WINCHEST
CREEK
UPLANDS
ANDERSON CREEK FLOODPLAIN
UPLANDS
N
0
100'
200'
ANDERSON CREEK RESTORATION PROJECT
CONCEPTUAL PLANTING PLAN

Slough Sedge (*Carex obnupta*) hay, baled at an adjacent site, used as mulch

Upland trees, willows and sedge planting in the Anderson Creek floodplain

February 2003

Carex obnupta **(slough sedge) plugs**

Willow stakes

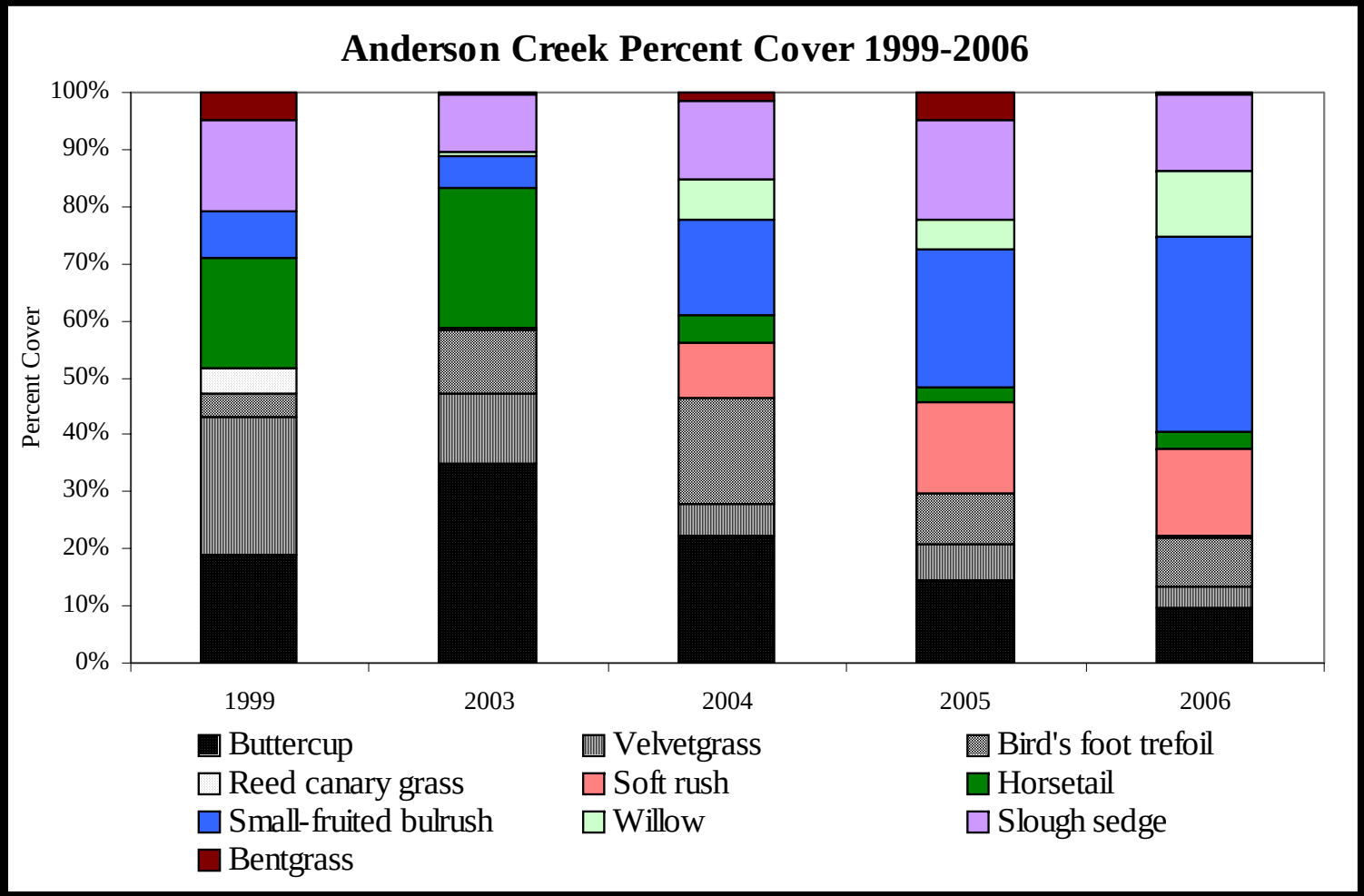
July 2006

Fall 2002

Summer
2003

Spring
2005

Project Construction: 2001 2002



Native vegetation (in color) increasing in percent cover over non-native species three years after planting and natural recruitment

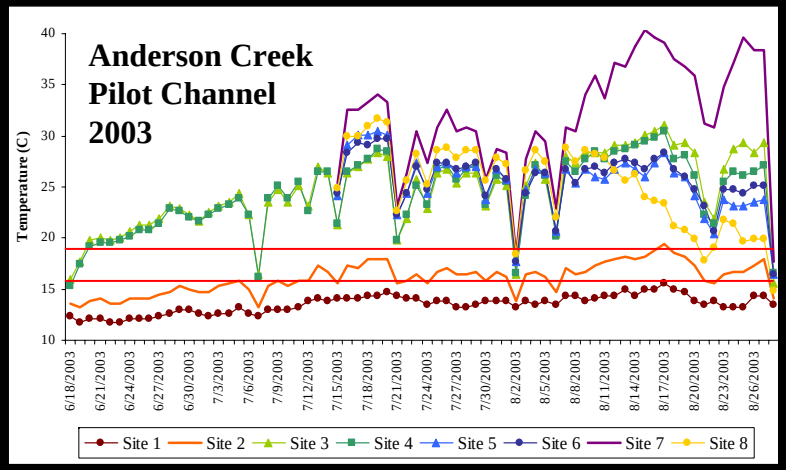
Dominant native species:
Carex obnupta (slough sedge); *Scirpus microcarpus* (small fruited bulrush); *Juncus effusus* (soft rush); Willow

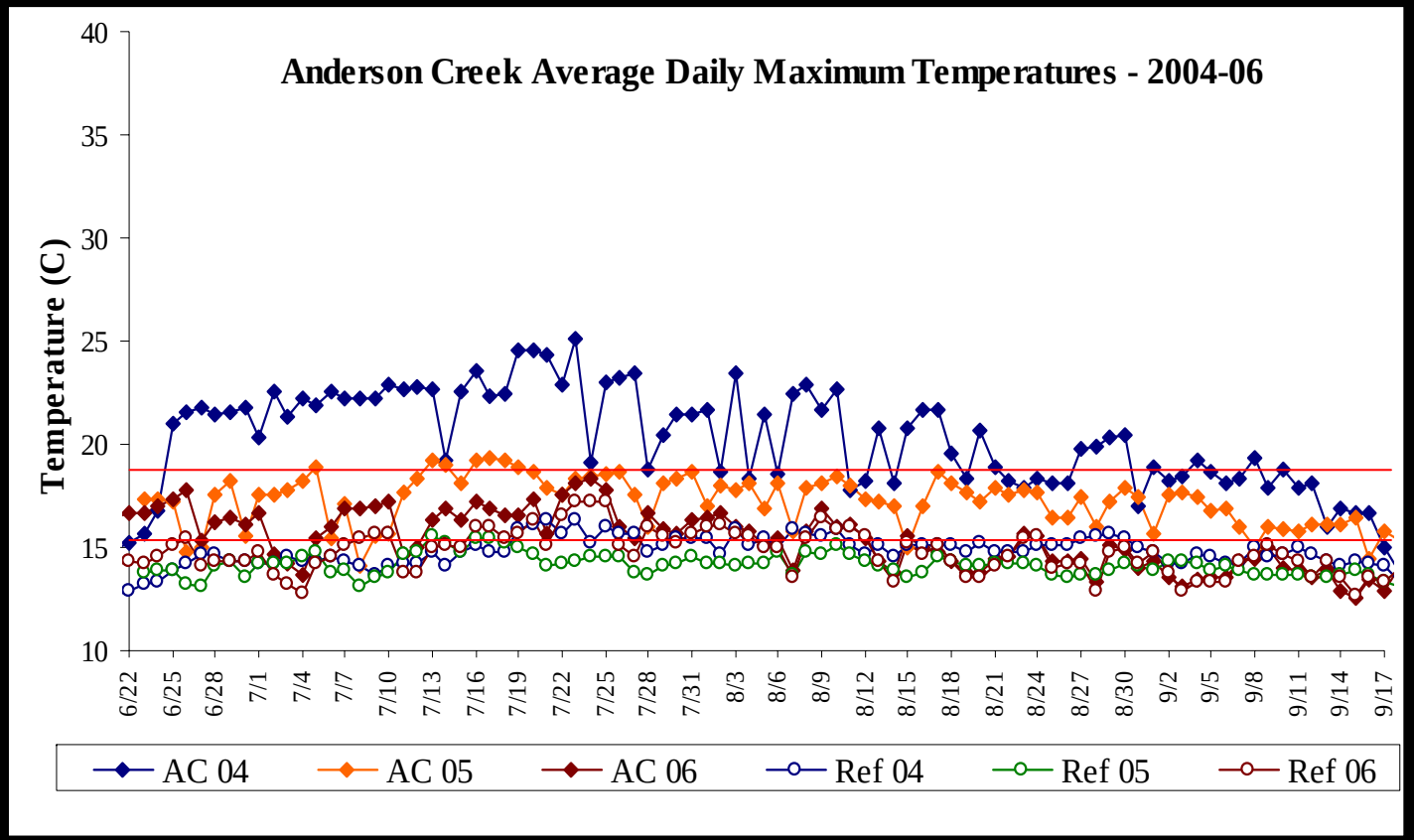
(L. Brophy and assisted by D. Varoujean, D. Philips, K. Sparks and volunteers 1999- 2006)

Anderson Creek Stream Temperature

Summer maximum stream temperature is dropping each year as plant community develops and shades channel

(Assisted by M. Koehler, A. Gray and volunteers 1999-2006)





Stream Habitat Surveys: 2000 & 2005

Anderson Ditch 6/22/00

Habitat Units	Total Number	Total Length	Average Width	Average Depth
Dammed Pools	2	8.60	2.20	0.43
Scour Pools	47	199.75	1.70	0.42
Glide	14	100.95	1.29	0.14
Riffle	42	418.50	1.13	0.10
Step/Falls	12	7.40	0.96	0.06

Anderson Pilot Channel 9/9/05

Habitat Units	Total Number	Total Length	Average Width	Average Depth
Dammed Pools	3	75.00	1.70	0.35
Scour Pools	9	53.00	1.20	0.39
Glide	0	0.00		
Riffle	22	773.00	0.80	0.15
Step/Falls	3	2.00	0.90	0.01

Tom's Creek Reference Site 7/21/05

Habitat Units	Total Number	Total Length	Average Width	Average Depth
Dammed Pools	6	58.00	7.60	0.61
Scour Pools	0	0.00		
Glide	20	450.00	1.40	0.58
Riffle	0	0.00		
Step/Falls	4	4.00	1.70	0.16

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Other Monitoring at Anderson

- Stream turbidity associated w/ construction
- Coliform bacteria associated w/ construction
- Groundwater elevation
- Channel morphology (60 x-sections and longitudinal profile)
- Fish use

Final Restoration Phase is under way!

First beaver dams/ponds:
Summer 2005
Winter 2006/07

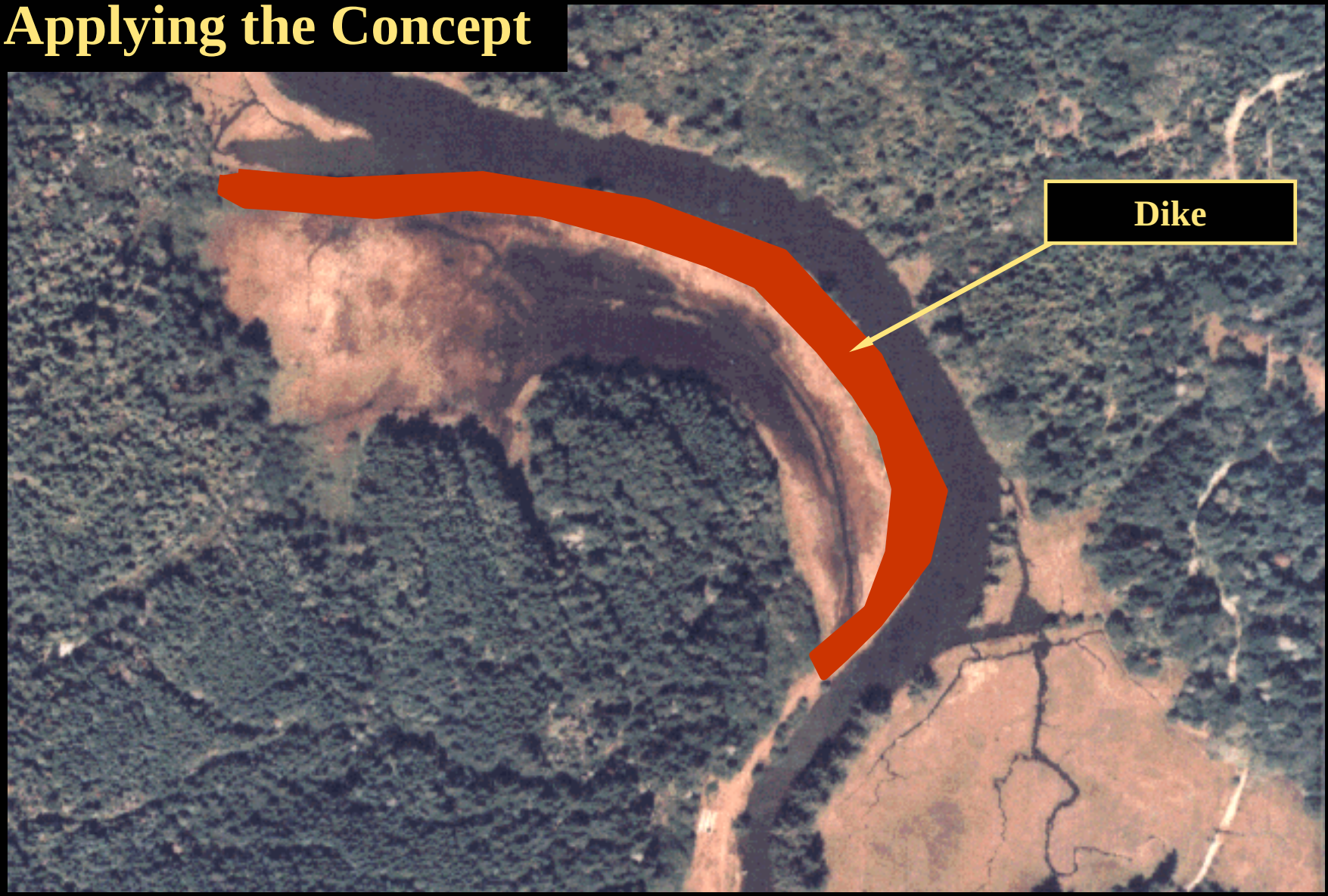
WTRP Lessons Learned

1. Few diked tidal wetland projects will have enough dike material to adjust the entire site for subsidence. Suggest trying the use of available dike material as a prograding bench next to upland edge?

Applying the Concept

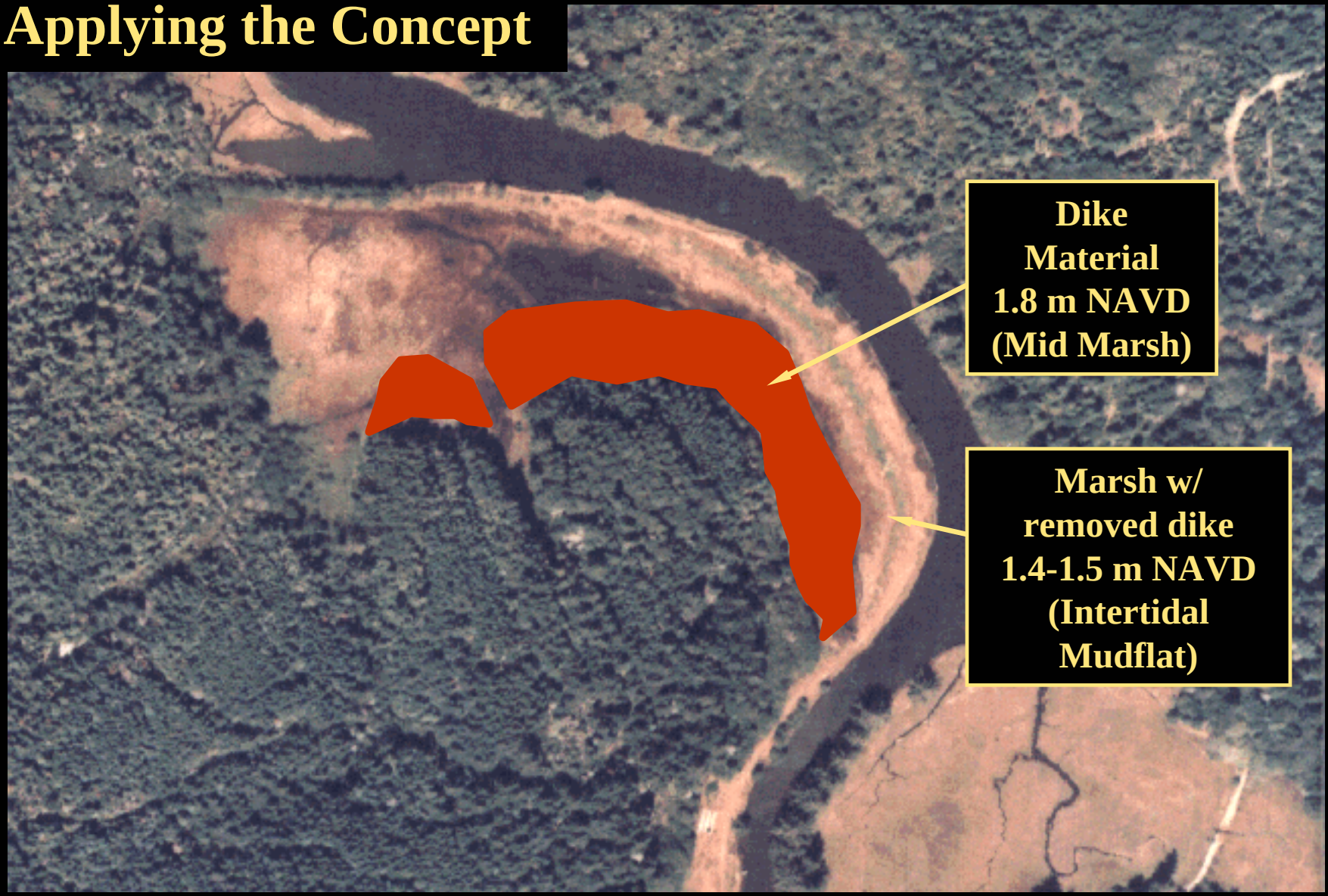
1991 Aerial Photo

Applying the Concept



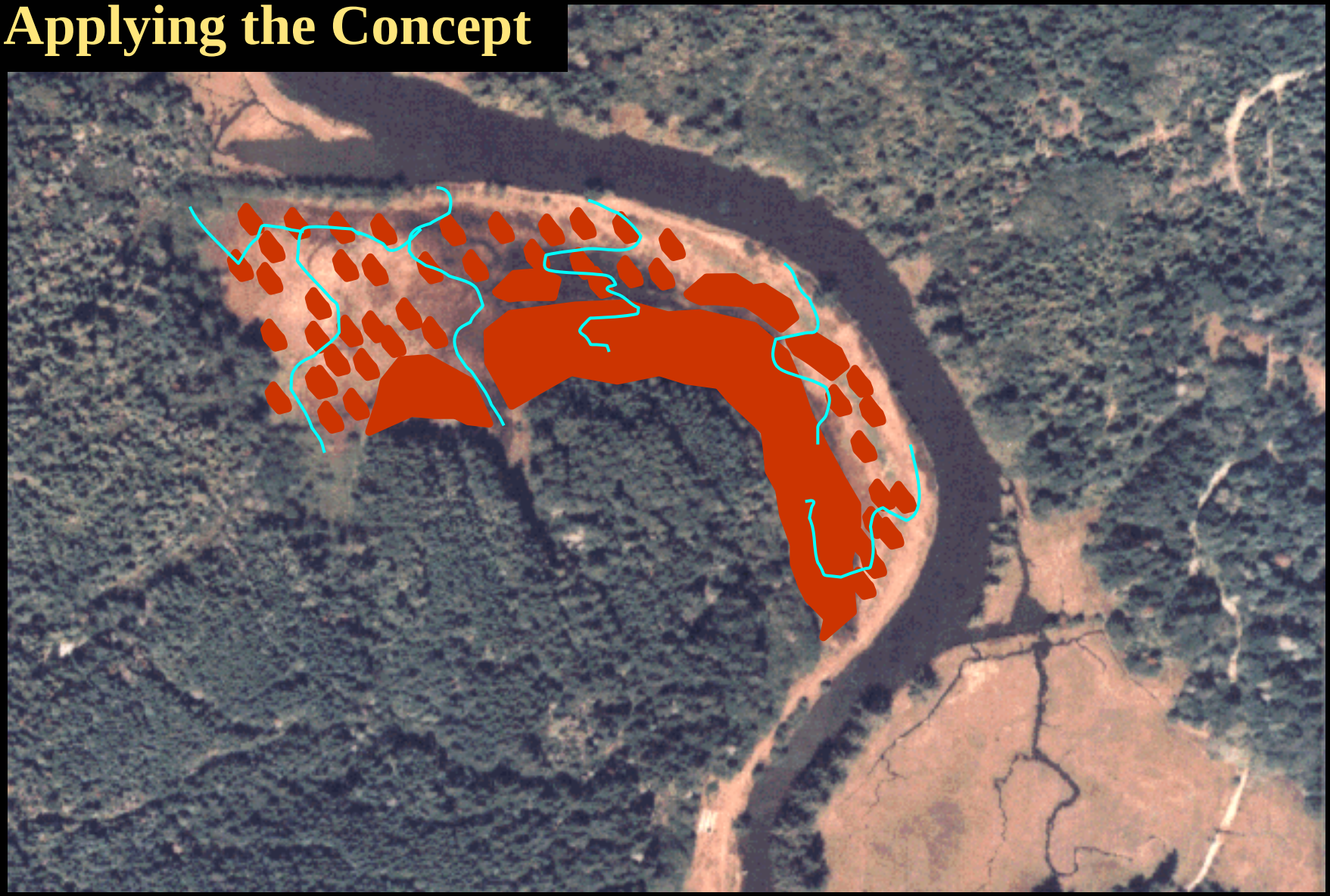
1991 Aerial Photo

Applying the Concept



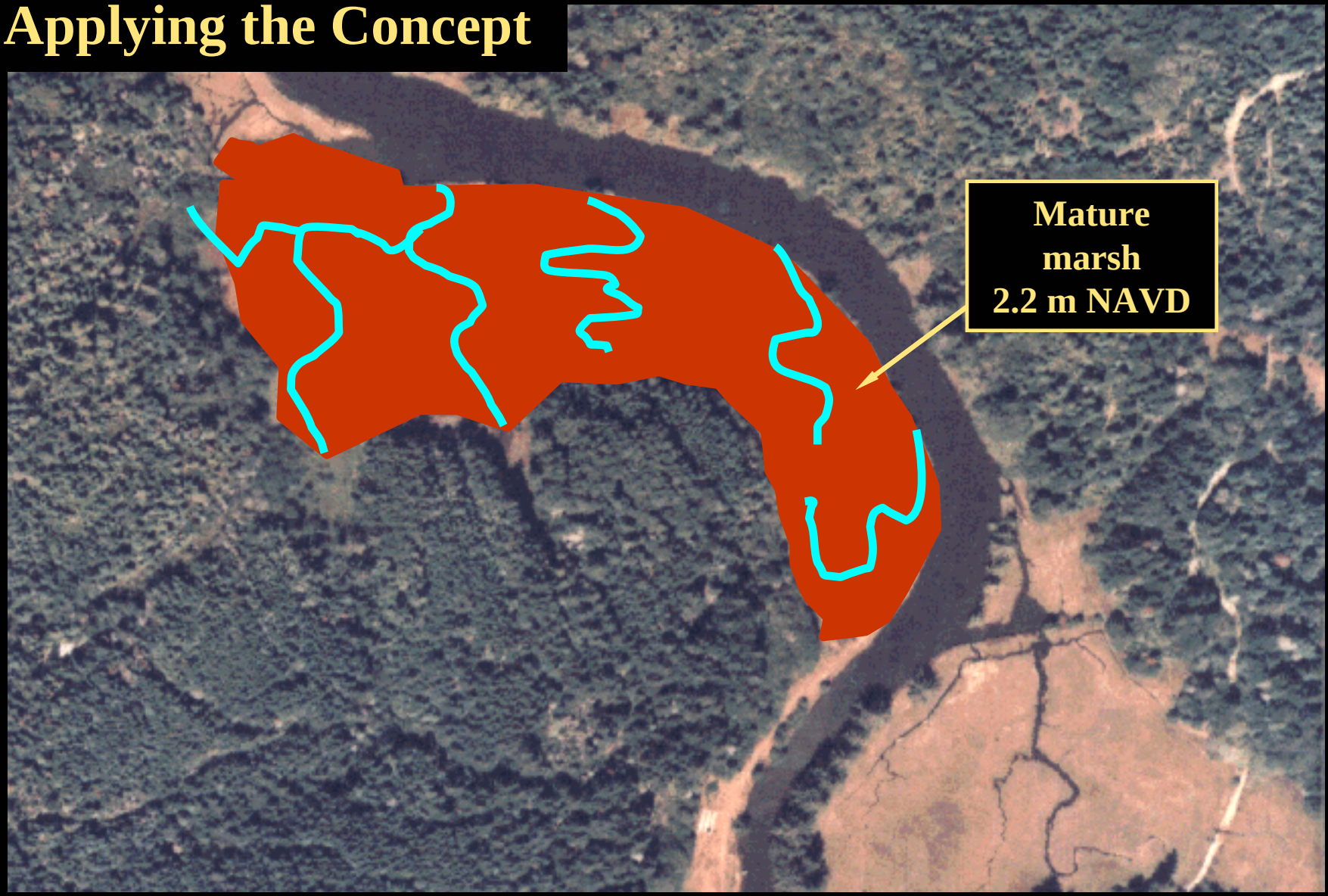
1991 Aerial Photo

Applying the Concept



1991 Aerial Photo

Applying the Concept



1991 Aerial Photo

WTRP Lessons Learned

2. Marsh elevations established at mid and low marsh elevations will facilitate “passive” bind tidal channel development. Suggest establishing high marsh with constructed pilot channel(s).

WTRP Lessons Learned

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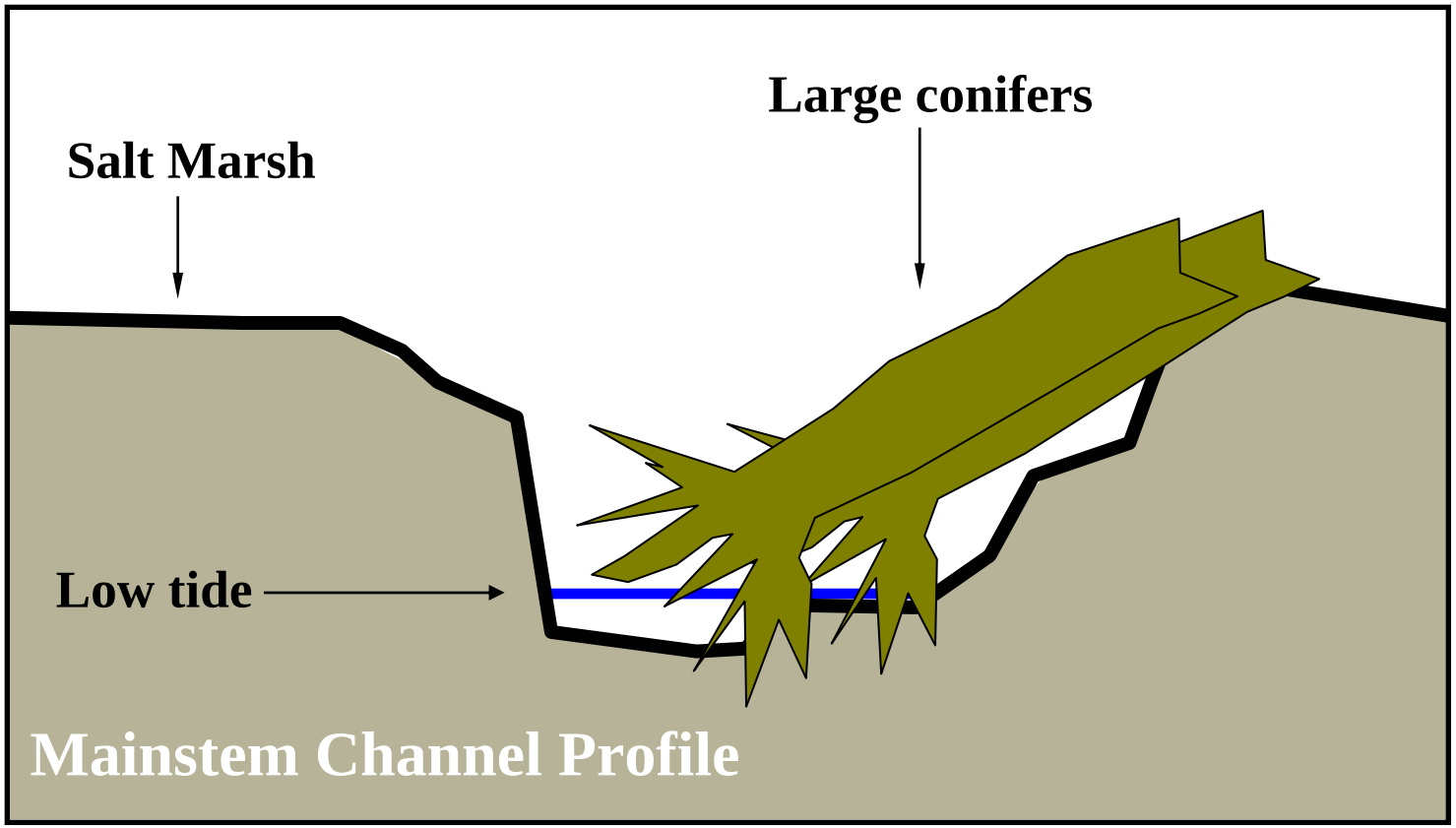
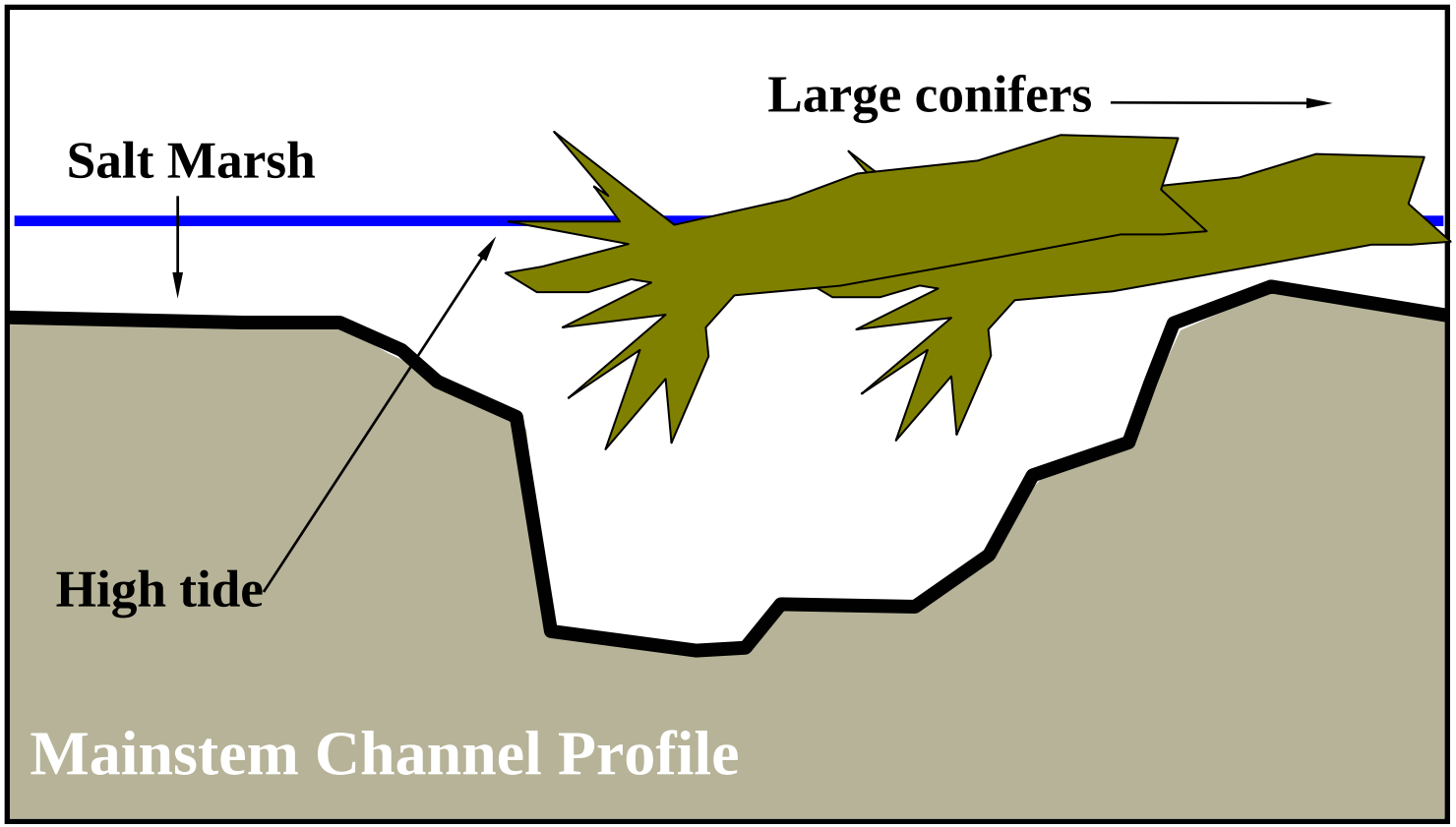
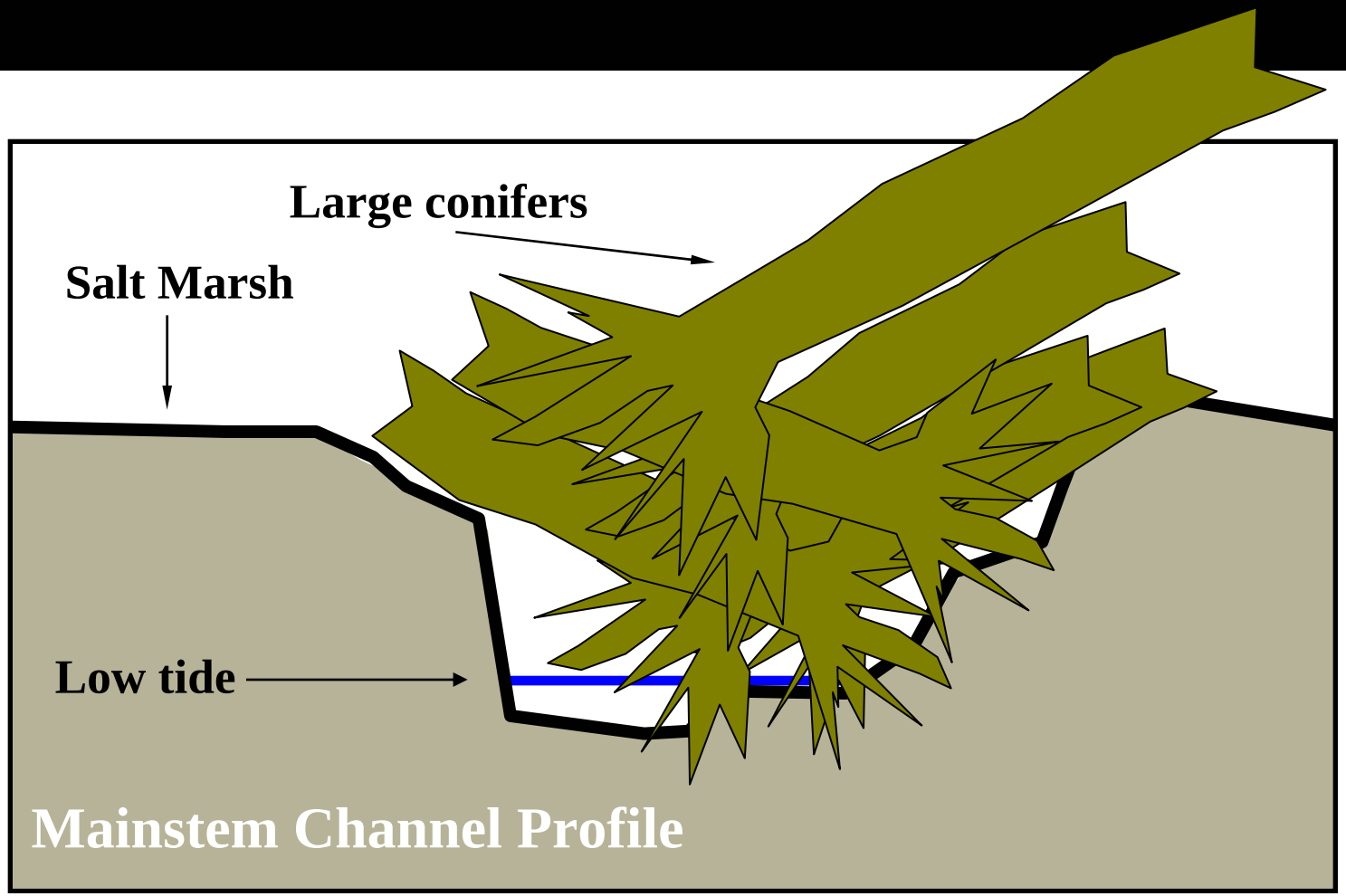
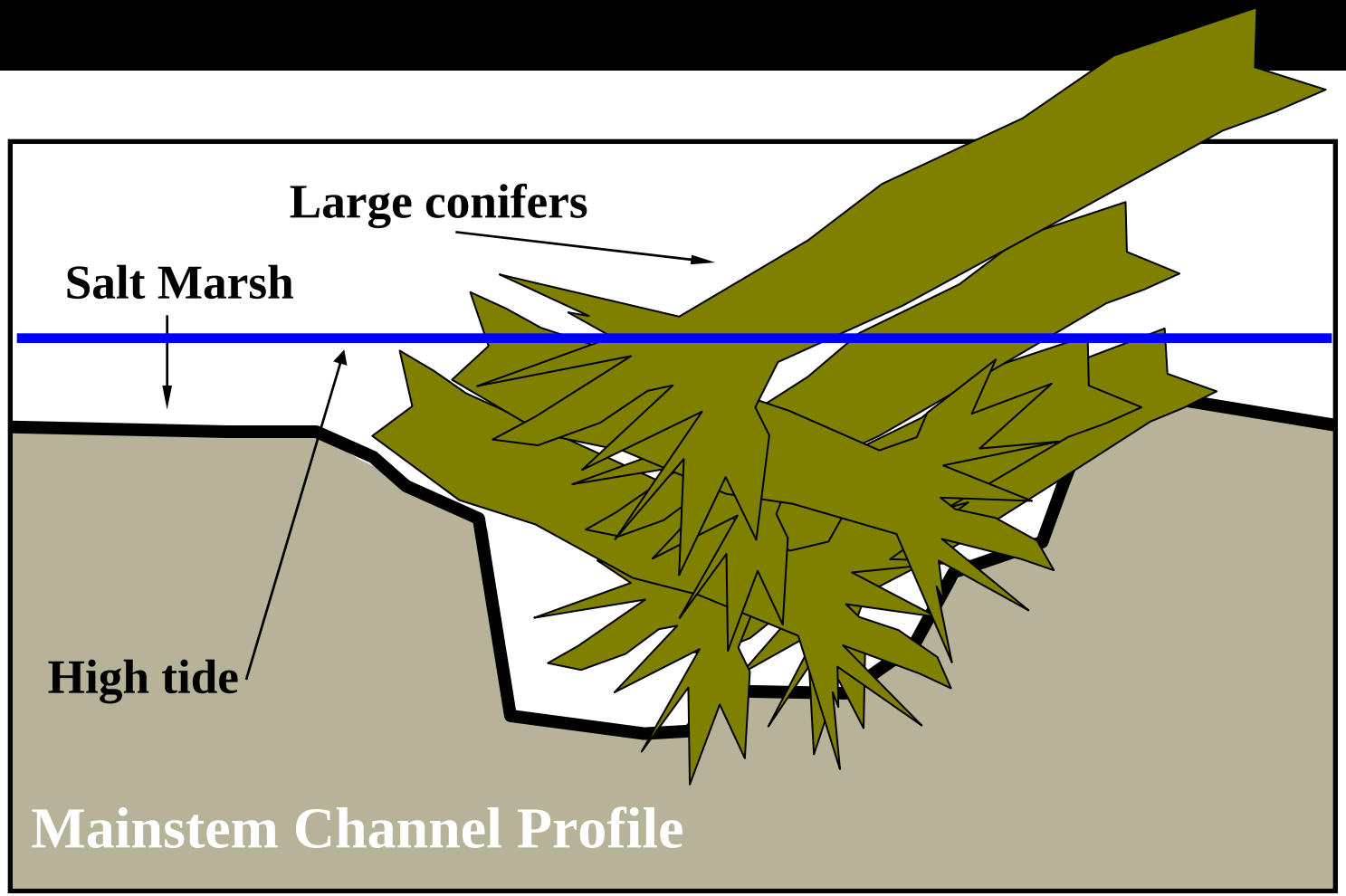
3. Large wood floats out of tidal channels and there’s a reluctance to secure wood in place. Suggest: 1) burying large wood in marsh/tidal channels; and 2) establishing more complex wood structures where the top and largest conifer is substantially above high tide elevation.


Large conifers
Salt Marsh
Low tide
Mainstem Channel Profile

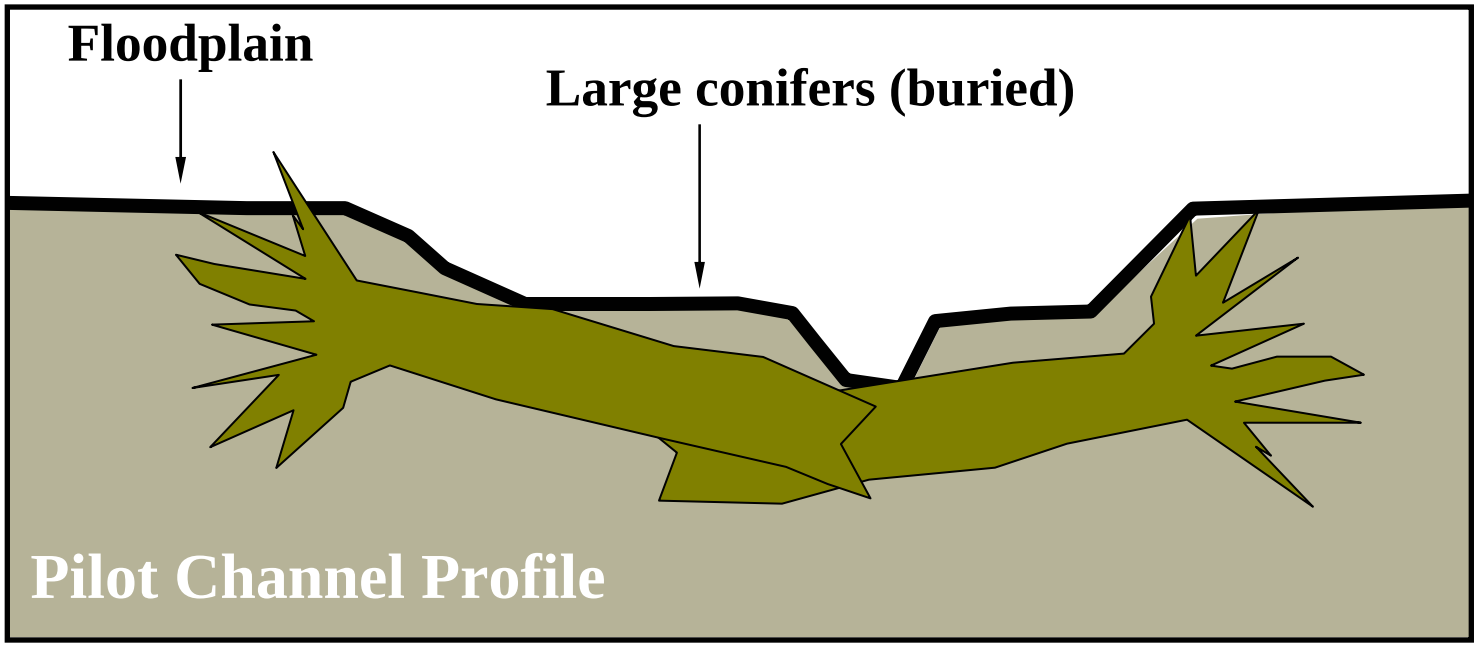

Large conifers
Salt Marsh
High tide
Mainstem Channel Profile

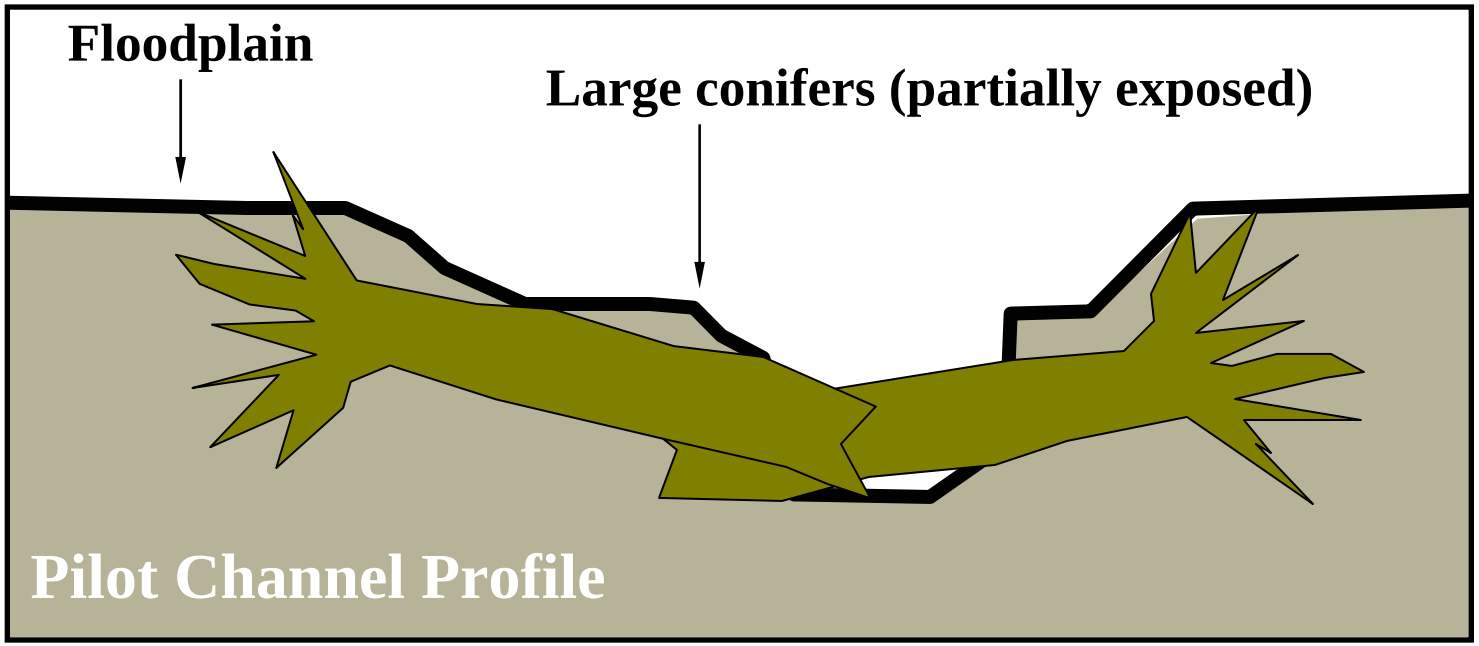

Large conifers
Salt Marsh
Low tide
Mainstem Channel Profile


Large conifers
Salt Marsh
High tide
Mainstem Channel Profile

WTRP Lessons Learned

4. In non-tidal channels and maybe tidal channels, some soils (clays) are resist natural hole formation even around large wood placed in the channel. Suggest burying most wood in and around the pilot channel and planning for the wood to become exposed by hydrologic action over time.


Floodplain
Large conifers (buried)
Pilot Channel Profile


Floodplain
Large conifers (partially exposed)
Pilot Channel Profile

WTRP Lessons Learned

5. Recommend “lightly” engineered pilot channel approach for constructed tidal and non-tidal channels- consistent with self design approach.

WTRP Lessons Learned

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6. Still need to know what the trade offs are between full dike removal and dike breaching

WTRP Lessons Learned

5. Recommend “lightly” engineered pilot channel approach for constructed tidal and non-tidal channels- consistent with self design approach.
6. Still need to know what the trade offs are between full dike removal and dike breaching
7. Advisory group process is routinely recommended to others……

Future Directions

- Maintain/improve, follow up, report on, and build on existing restoration monitoring
- New projects: Wasson Creek, Leslie Marsh Projects; others?
- NOAA/National Estuarine Research Reserve System Restoration Science Program to establish regional projects (demonstration projects, reference site datasets, outreach materials, training)
- Expand Reserve restoration efforts to include upland forests

Acknowledgements

Assistance with project funding, implementation and monitoring:

U.S. Fish and Wildlife Service

Environmental Protection Agency

Natural Resource Conservation Service

National Oceanic and Atmospheric Administration

Oregon Watershed Enhancement Board

Oregon Community Foundation

Ducks Unlimited

Seminole Environmental, Inc

Benny Hempstead Excavating Inc.

David Newton and Associates, Inc.

David Brown and Associates, Inc.

Oregon Department of Fish and Wildlife

Coos Watershed Association

Marzet Marine and Estuarine Research Co.

Dr. Bruce Follansbee

Green Point Consulting

Oregon Institute of Marine Biology

Boys and Girls Club of Southwestern Oregon

Oregon Youth Conservation Corps

Northwest Youth Corps

Shutter Creek Correctional Institution

Estuarine Wetland Restoration Advisory Group

South Slough Reserve volunteers!